SMART TEAMS

Iris Camps
0997876
B3.2 Report
June 2019

TABLE OF CONTENTS

EXECUTIVE SUMMARY

More and more technologies are being added into the sportsworld, since the impact on this market can be of a high level. Enhancing people's everyday living is a vision I wish to fulfill with my designs. For these two reasons I have created the product Smart Teams as part of the squad "Crafting everyday soft things" within the Industrial Design faculty at Eindhoven University of Technology. A product has been created that could enhance athletes' cognitive processing speed, anticipation and motor speed in team aspect. The final iteration of the product resulted in a cotton band with an integrated LED strip and vibration motor that the athlete clasps on his or her body. The coach of the team can control the colors of the LED strip with the use of an app, where he can choose a training form that trains a specific quality of the team and team players. The vibration motor integrated within the cotton band vibrates to create awareness for the wearer that his color has changed. The whole band is coated with a parachute fabric to protect the components from water damage.

This report first explores different forms of research that lead towards a finished conceptualization. Then a realization process starts where the fit of the product gets testes as well as electronics are explored. During this realization process two iterations are made. A ribbon with loose leds connected with conductive thread as well as a LED strip integrated ribbon. After the second iteration, the design of the app control is manufactured to complete the system. Finally the products gets tested during a two part validation process. The product is first validated in relation to the business perspective. Here I looked at the customer journey and business model. Afterwards a customer validation is explored during demo day as well as a field hockey training session. The report ends with a conclusion which summarizes the results.

PROLOGUE

Choosing a bachelor graduation squad was an easy choice for me. Ever since I started Industrial Design in Eindhoven, I have had a fascination for combining technology with wearables. The way something with such a soft connotation can be combined with something that feels like the opposite, inspires me to create innovation. I envision a future in which all wearables are not just for the function of warmth or fashion, but they can offer more than that. They should enhance people their ways of living.

Areas of design that I am really interested in are wearables, sports and business. During my graduation project, I wanted to combine all three. The crafting everyday soft things squad offered this possibility to me. Here I could create a sports wearable with integrated technology while receiving realistic feedback from experienced coaches about how such a product would exist on the market. To develop the business aspect even further, I contacted the company SmartGoals, who in partnership helped me develop Smart Teams. Smart Teams is a system of LED integrated ribbons designed for athletes in team aspect, that can grow their cognitive processing speed, anticipation and motor speed during several trainings. Designing this product has helped me realize my vision while evolving it even further.


SMART TEAMS 4

INTRODUCTION

The goal for my final bachelor project has been to create a product that answers the following question:
What device can help athletes improve their cognitive processing speed, anticipation and motor speed within a team? Research has shown that adding innovation to sports, that could not be done physically, can help evolve athletes further than before. By pushing the athlete beyond existing limits, competitiveness enhances opportunities for co-adaptation, innovation and creativity, which can lead individuals towards different performance solutions to achieve the same performance goal [Passos, 2016]. The product I designed called Smart Teams, is in a sense a simple solution for a complex situation. Each athlete is different and works in a team in a different way. Smart Teams can help players work together with every other player in his or her team in a flexible and quick way. It is therefore also created for each sports team of any level that are looking for a new way to elevate their level more.

DESIGN PROCESS

My design process can be split up into two categories: research and technology. That all come together within results. I was able to evolve each category through an iterative design thinking process [Dam, 2019]. Through this process, I was able to reflect within each stage to continue to grow my project in quality, which has been important to do quickly when working with a company that wants to release a new product to the market.

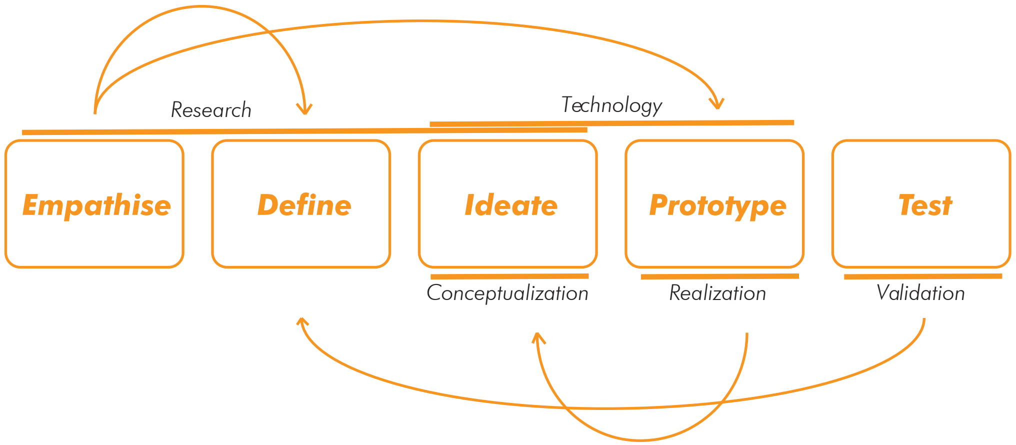


Figure 1. Process used during this project [Dam, 2019]

Throughout the whole project, I have kept a business perspective in mind. The reason I chose to work with a company has been to learn to design from a business perspective. Since I am an aspiring design consultancy owner, I need to start learning how to make choices differently based on what is realistic within a company. By combining this business perspective with an user centered perspective, I have been able to let the requirements from both sides meet.

Research

I started my final bachelor project wanting to create a wearable meant for sports that could elevate the athlete's performances. After seeing that the company SmartGoals was looking for graduating students to work on their new wearable concept, I knew it would be a good fit. This did give me a head start, since the concept was already there. However an idea still needed to be turned into something fit for the market. SmartGoals already made a prototype for their concept [Zijl, 2013], but it still had a lot of flaws. They attached LEDs to a bib by creating a V-shaped velcro attachment. This attachment consisted of red LEDs, thick cabling and a power source. There were still a lot of issues with their design, but the main point for SmartGoals to iterate further was the high production price.

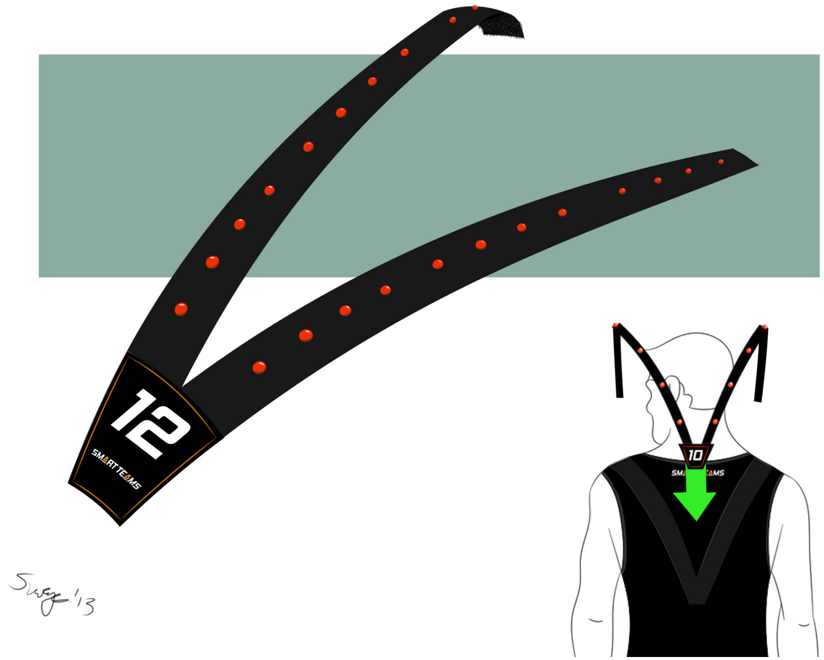


Figure 2. First concept Smartgoals (IMG SmartGoals BV)

Since I stepped into a concept of a company, I stepped into an iterative designing process that had already started. Research had already been done, user tests had already taken place and customer validation was there. Therefore I started of my design process with an analytical approach, listening to what the employees and customers of SmartGoals thought seemed fit for a future product. Here I quickly learned that they would like to see a wearable that would be way less expensive to produce and might be visible during daylight. I also saw a new opportunity here. Right now their product's lights could only go on and off, however by making the lights RGB, more training forms could be added. This could result in new exercises enhancing athlete's speed in a way that is not physically possible with the current products on the market.

My next step was therefore to look at the old user tests done with the old prototypes, and see were the weak points were. The user tests fortunately were video recorded, which made it easy to analyse. The user tests were all done in a qualitative way, because it is all about hockey player's personal views and thoughts of the product, to be able to dig deeper into the problems. My analysis of the results show that there are a couple of flaws [Appendix 1]. The system for personal color change awareness needs to be changed, awareness needs to be created for a color change of other players, the system should be made lighter and more contrast needs to be added for the lights to be visible properly. These flaws were all taken into account when iterating further.

Business perspective

Besides from the flaws, other requirements and constraints also arose. I looked at these requirements from a business perspective, since I had to keep constraints in my mind to eventually result in a realistic product. These constraints were divided into three categories; money constraints, electrical constrains and wearable constraints (Table 1). The first two for keeping the business point of view in mind and the second one for the customers who will experience the fit of the wearable.

Money Constraints	*Electrical Constraints*	*Wearable Constraint*
Max of 15 euros a piece (set by SmartGoals)	LED's visible inside and outside	Flexibility of device necessary
Other Company working on similar device (EXER lights) --> Might have patents	Number of LEDs	How can you see your own color changes
Production costs	Power consumption	Aesthetics
Market research	GPS tracker option	Tight fit
Packaging costs	Easy control of wearable	Durability of electronics
	Easy charging system	Adjustability
	Producibility	Comfortable fit

Table 1. Constraints Smart Teams

Kano Model

Since I had a starting point of old iterations, I also looked at points where I saw more development possibilities in myself. Besides from this, I could see at which points customer satisfaction was lower. Looking at the previous research of SmartGoals, I also realized that so much more potential could be realized with a product like Smart Teams. Which is why concept wise, I started with the idea of a wearable that should shift color during exercises, however I did not restrict myself with just this possibility.

Using the Kano Model [Sauerwein,1996], I could see what requirements needed to be met in order to have a proper customer satisfaction. Besides from this I could see what would make customers really enthusiastic about a product like Smart Teams.

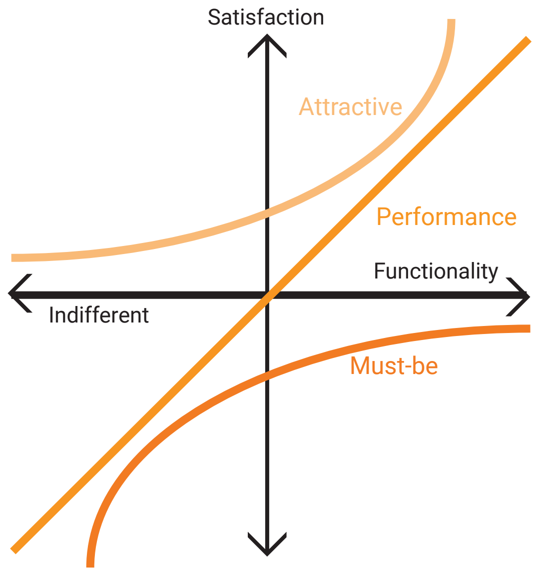


Figure 3. Kano Model [Sauwerwein, 1996]

The Kano Model shows it has to be size adjustable, visible during the night time (since that is when amateur teams train), waterproof and visible from all sides for other players. This last point brought me into another point of research, which has been to figure out the position of the product on the body.

* The Kano model is based on criteria by the client, as well as research done from previous versions of Smart Teams.

Must-be	Performance	Wow
Flexible but fit close to body	Washable	LEDs visible during the day
Adjustable to different sizes	Follows bodies movements, so extremely close fit	Different color change of LEDs
LEDs visible during the night	Pleasant body fit	Connection with smartgoals
LEDs visible from 360 view during athlete's movements	Light weight of the product	GPS tracker integrated
Control of device	Amount of LEDs high	Special new forms of exer-cises
Battery Power system	App control features	Aesthetics of product
Charging system	Battery size small	Packaging of the product
Awareness of own color change	Charging speed of the product	Data analysis
Low cost price of no more than 50	Small time and effort to put on	
Pleasant battery placement	Connectable to each other	
Shock resistant	Range of exercises doable	
Waterproof	Improves athlete' s cogni-tive speed	
Electronics concealed	Improves athletes' motor speed	
Battery life at least 30 minutes	Enhances athletes' sense of space	
Knowing which player is wearing which bib (num-bers)	Producibility	
Not interfere with existing products, like heart meter and gps tracker	Soft fabric on inside, sturdy fabric on outside, fabric choice (cost vs quality)	
Sweatproof, so ventilating		
Transportable and storable		

Table 2. Kano Model Smart Teams

Product Fit

Trying to figure out the best position of Smart Teams, first led me into using the rapid ideation technique to create different forms that could work on the body.

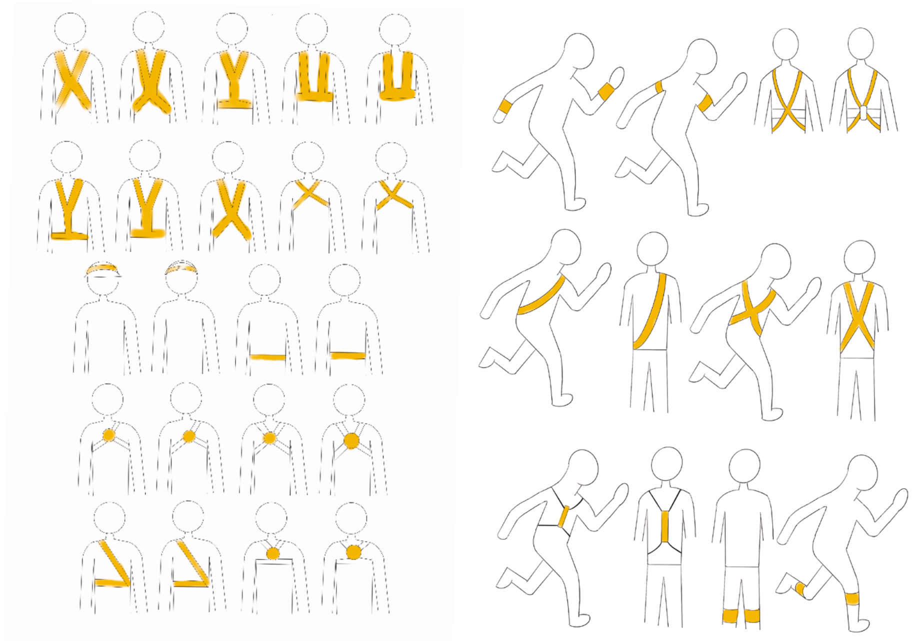


Figure 4. Rapid ideation product fit

After analysing the shapes in figure 4 and showing them to SmartGoals, we picked a couple of options that would be realistic to turn into a real product (figure 5). I used a mixed cotton and elastane fabric to mimic a sports material. I then created bands for each of these designs with the width that a sports ribbon would have (figure 6). Option 8,9 & 10 were also conducted in the study, however they were not photographed.

The shapes in figure 6, have all been tested from all angles during several hockey movements. The video [Camps, 2019] of this test shows that option 6 and 8 are always visible from all angles.

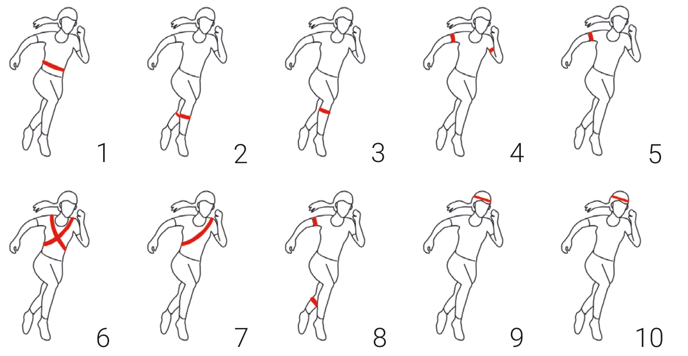


Figure 5. Realisitc product fit sketches

Figure 6. User study product fit

The next step for me was to discuss these two options again with SmartGoals to see what their business perspective would think of these two options. They recognized that option 6 would be the best fit since the cross is connected in the middle, which would make the electronics easier and less expensive to work. Since the right option would need a communication system from the arm to the leg strap as well. This would result in the design in figure 7.

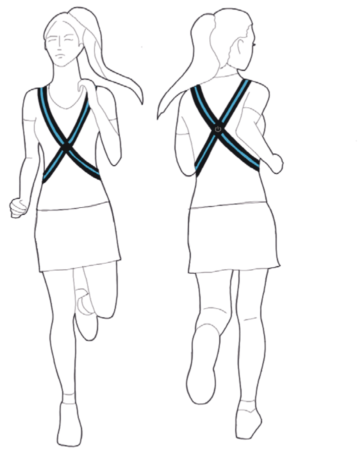


Figure 7. Intial design concept

However after a discussion with them later on in the prototyping phase, we came to the conclusion that one shoulder strap would be enough, since the only moments you would not be completely visible would be during a turn. The pros and cons about being visible at all times versus the higher price a double strap would cost did not way in. Therefore the decision was made to ideate further with design 7 in figure 8.

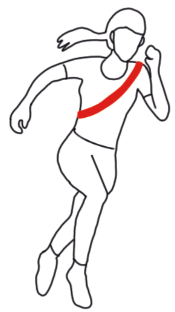


Figure 8. Realistic design concept

Benchmarking

The last step I took within the research process before moving forward with the technology of it all, was to benchmark my product with the current market [Furey, 1987].

1. The first product on the market that comes closest to Smart Teams would be Exerlights [SIT, n.d.]. Exerlight is a german company that produces LED integrated ribbons that can be attached to goals or be worn on the body. They retail starting at €999 for a set of 4 goal lights. They offer a new set of training forms just like Smart Teams would. The box in which the lights are carried sends out a signal with which the lights can be controlled through a smartphone. The weak points however are the fact that the lights only come in a red or blue version. This means they can only be their color or turned off which limits their functionality. Another weak point is their body position. The back of the product is placed directly on the position GPS trackers are worn by top athletes. The athletes use these trackers during most of their trainings and matches, it is therefore important to not interfere with this placement. Lastly is the price point for Exerlight still relatively high, which is something Smart Teams should go below.

2. Lumalive is a textile created by Philips research that can light up [Lumalive, 2007]. It is not specifically created for sports, however it could be used in this sector since the fabric is very flexible and could fit closely to the body. The aesthetical qualities of this product are high, however the color can only go on and off and the strength of the lights is unfortunately rather low. Therefore it would not directly be competing with Smart Teams yet.

Only these two companies come close to the concept of Smart Teams, which makes it a rather new concept. Therefore the conclusion can be made that the target market is rather big. The targeted market would include all team sports clubs in the Netherlands who are looking to elevate their level of sports through technology.

Technology

The first two opportunities I saw technology wise for Smart Teams have been the choice of light and the way the electronics are integrated into the design. The options for light have been carefully explored to make sure the brightest, most durable and best priced light would be chosen.

The following table was constructed to see the illumination options found as well as the ways of electricity to make it work (Table 3). The 'wearability' and 'other' show the requirements and constraints to think about when looking for the best option.

Illumination	Electricity	Wearability	Other
LED strip	Conductive wire	Visibility	Water proof
Loose LEDs	Powerbank	Price	Washable
EL wire woven	Battery	Comfortability	Shock absorbent
Laser Wire woven	Lilypad	Producibility	Bright enough
Luminous fabric	Amplifier	Band Width	
Sewable LEDs	Resistors	Adjustability	
VynEL		Lightweight	
Side optical fibers			

Table 3. Technological options

The first option I looked into was the one of weaving electroluminescent fibers into fabric, to create a completely illuminating fabric (figure 9). However I could not find enough research that addressed integrating this material into fabric for sports. Since the weaving process would take a lot of time and I would need it to be very durable and create a lot of light, I decided to contact a company called 'Ellumiglow' that creates EL wire amongst other light options.

Figure 9. EL wires woven with thread
IMG from Audrey Briot [Briot, 2015]

By getting into contact with Ellumiglow, I discovered two new illumination options that might have worked for my product. These options were called Laserwire and VynEL. The first one being a bright version of electroluminescent wire, called Laserwire, which also made it visible during daylight (figure 10). Laserwire could be woven very tightly into a fabric which could make it very aesthetically pleasing and high quality. It would also be washable by hand if you remove the battery. However the downsides were the small diversity of it. Since it would only be able to have two colors; on and off. This would make the product miss out on so many options. It was also 100 euros a meter, which would not fit our production price.

Figure 10. Laserwire
IMG from Ellumiglow

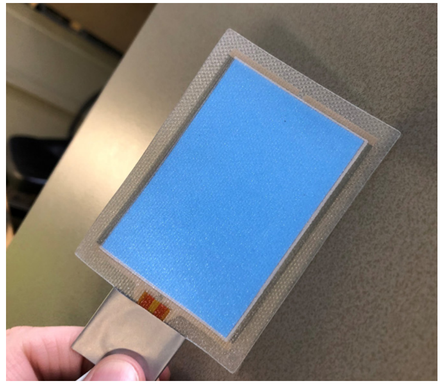


Figure 11. VynEL
IMG from C. Heger SmartGoals BV

Another option I came into touch with through the company was Vynel (figure 11). Which is a phosphor integrated panel, which makes it light up. It could be heat pressed onto fabric to integrate it fully into clothing in a flexible way. By maintaining a close contact with the company, I could ask them many questions, which is why I was trying to figure out if it would be visible enough during daylight. They told me it lost a lot of light during the day but would still be visible. Which is why I tried to gain a free sample from them with the backup of a company like SmartGoals. They offered us the sample, however we quickly realized it would not work since the phosphor in the panel makes it lose all of the light. It would also only be an on off situations like the laser wire, which is why I continued looking for other options.

Flirst Iteration

Then I came into contact with a person from the company Seeyew [Seeyew, 2007] , which is a spin off company from Philips among others, that has now ceased to exist. This person showed me the option of integrating LEDs into fabric by using very thin copper wire. This turned into a product easy to wash and durable for sports like running. Since the products of Seeyew are patented, I could not work further upon their work. Therefore I had to use my own approach inspired by their work. This also brought me to a more simplistic approach, by simply integrating LEDs into fabric using conductive thread. I chose conductive thread to power the whole system, since this loses the thick wiring used in the first version of Smart Teams made by SmartGoals. I wanted to use embroidery to carefully place the embroidered thread on a band to make it placed well, so it would not cause a shortcut. This however would not work because of the thickness of the strap I chose for the band, so I used a regular sewing technique to integrate conductive thread onto a cotton band. I chose a cotton band of 40mm as the base of my design, since it felt like a regular sports ribbon, that could easily be made adjustable with a clasp to fit the body tightly.

This resulted into my first iteration. A band with 7 rgb LEDs connected parallel with 300 ohm resistors to each circuit stream. This was in turn connected to my Arduino (figure 13).

Figure 11. First iteration band with 7 LEDs

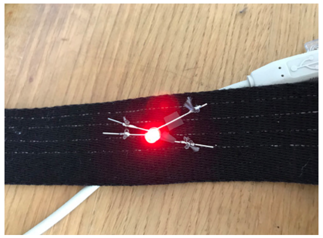


Figure 12. System works with conductive wires

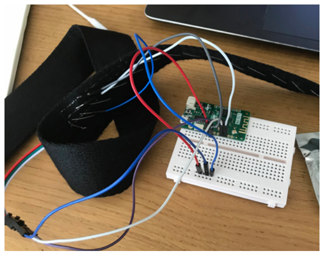


Figure 13. Arduino Connection

There were a couple of flaws in this design that were starting points for my second iteration. The first flaw I recognized was that the bulkiness of the LEDs caused for quick breaking points in the system. Half of the LEDs became lose even though they were soldered strongly (figure 14).

Figure 14. Connection between LEDs and conductive thread

This showed that more soldering or another technique needed to be used to fixate the iron of the LED towards the conductive thread. I also figured out that in a system with 7 LEDs, there is no need to add additional resistors, since the conductive thread already loses enough current on its own. The positive findings of this iterations were that the band fitted nicely on the body and the conductive thread could be used nicely within the system.

I also tested the position of the battery on a 20 year old field hockey player and asked her opinion of were it should be placed: “The battery should fit on my lower back, since here I don’t feel it and it does not interfere with my movements” (figure 16). This position was also tested with 4 other athletes who all confirmed this position as the best option.

Figure 15. Wearability test, affordance to put it on

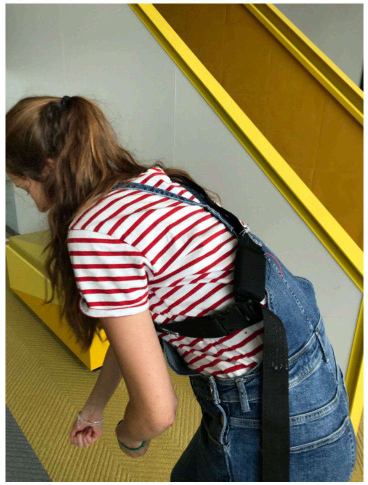


Figure 16. Battery placement on back, best option

Besides from the illumination options, I also had to look into the way awareness is created for your own and others' light change. I found three directions to move towards and tested these with multiple athletes who play in team aspect, like football and hockey players. [Appendix 2] The three options were: 3V-24V active buzzer, a Lilypad buzzer and a vibration motor (figure 18). The research showed that the active buzzer was very bulky and created a very convincing sound, however it would interfere too much with the other participants of the team because it could create confusion. The second option was already a better option, since the tones were softer and a personal tone could be created, however still it would distract too much. The last option which is the vibration motor seemed the best solution, since it gives of a small sound, and the vibration makes the actuator a personal product to create awareness.

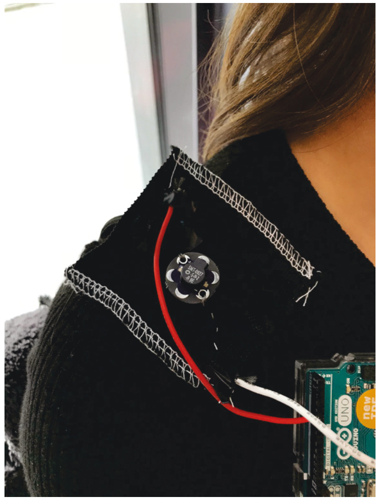


Figure 17. The user test was executed at the sample placement, the sensor would have in the final design

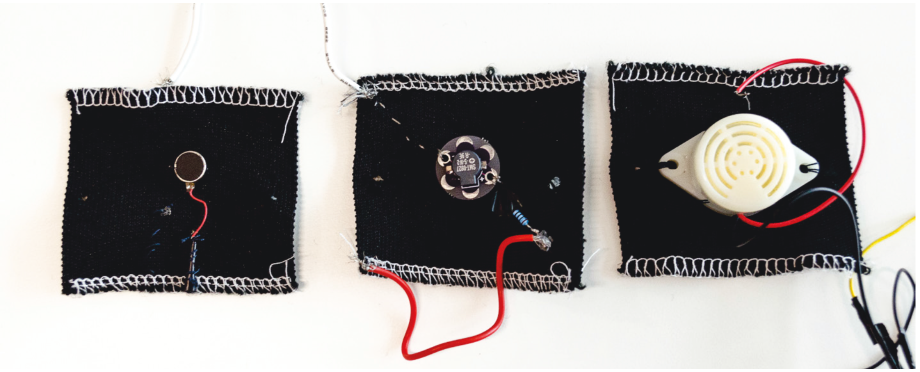


Figure 18. The three user study patches (f.l.t.r. Vibration motor, Lilypad buzzer, Active buzzer)

The vibration motor was however difficult to attach to fabric since it vibrates its wiring loose. Therefore I had to add a soldering board to the back to create a strong connection. This also resonates with the vibration motor to create a stronger signal (figure 19).

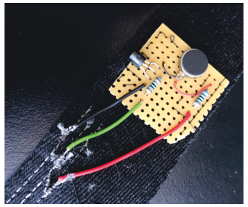


Figure 19. Soldering board vibration motor

Second Iteration

After showing my first iteration to SmartGoals, we discussed some further iterations again. I also brought part of a ribbon were I simply placed a LED strip on the band. This gave us a new and improved vision. Why not simply integrate a rgb LED strip onto the same cotton band used before and work on from that. Which is a very simplistic approach to designing a wearable, however it has been the best design choice, since it let us meet all of the requirements created with the Kano Model. The first iteration of this simplistic approach was simply attaching a waterproof LED strip onto the fabric. This however had no integrated feel, which is why I started exploring further. This came to the option of using a rgb LED strip and then placing water resistant see through fabric over it. This diffuses the light, to make the single lights less harsh and gives it a more integrated feel. The best fabric choice for this has been parachute fabric, since it is very sturdy, waterproof and is not fully transparent. This way the electronics are not fully visible, which could make it feel more secure for some users to wear.

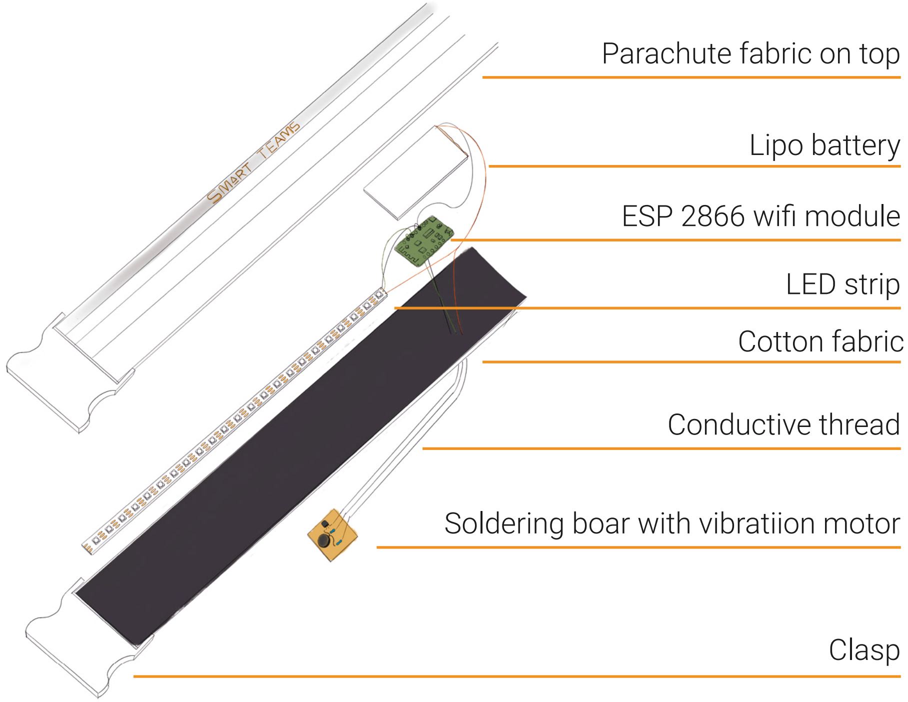


Figure 20. Blown up vision of second iteration

The following electronics were used in the system:

- 1 meter RGB neopixel LED strip
- Vibration motor 2.5-4V
- Wemos Lolin ESP 8266, wifi module
- LIPO 1500mAh battery
- Resistor 1k ohm
- Resistor 300 ohm
- Conductive thread

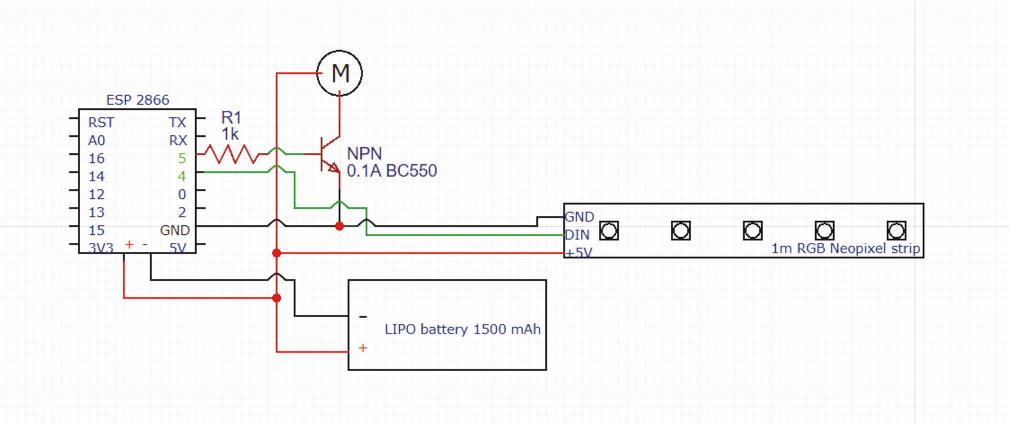


Figure 21. Electronical cirtcuit second iteration Smart Teams

The system pulls 200 Ampere as its maximum current, so it could last for a max of 7.5 hours given the battery is 1500mAh, which is far more than enough needed for a training session. Since the training sessions would last a maximum of two hours. It has been a challenge of mine to get the prototype to work, since I did not have a lot of experience with any of the electronics used. However with some help, I figured it out. The system can be operated through wifi with the help of the hotspot on your phone, or with the help of a router. I have then created an interface with the help of an ESP 8266 tutorial online [Santos, 2019]. To be able to test the actual concept, I created four prototypes, with all the same functions. By creating a code [Appendix 3] that will first let the motor vibrate, after which a color appears with the motion of colorwipe on the neopixels, awareness is created for the user itself but also the other team players. The color wipe has the effect of subtly changing a person's color without drawing too much attention to itself that could pull the athletes out of focus. With the use of the interface on either your phone or computer, you can turn on each led stip by choosing the right IP address, since each module uses a different number. For now here you can choose the colors red, green or blue, however with an easy adjustments all colors could be added.

By looking at the color wheel, a maximum amount of colors can be chosen that have enough contrast towards each other. The colors red, blue, yellow, green and purple all lay far enough from each other as team colors. This would create a maximum of six teams, since turning the lights off, could also be a state's color.

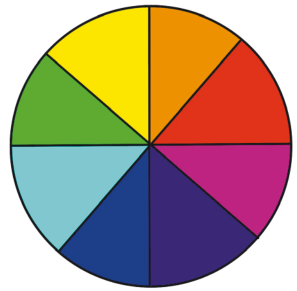


Figure 22. Color wheel showing best contrast

Alongside making the system work, I also looked into creating an app that would go along with the product so the coach can control it in an easy way. Since time was off the essence, I first drew out the options the app should have (figure 23), after which I created an app mockup using Adobe XD.

Figure 23. First app iteration sketch

The two main training forms designed in the app are switching teams and switching attack and defense. The 'Koninklijke Nederlandse Hockey Bond' states 1/3th of the goals within field hockey matches are caused by a quick switch between attack and defense [Staak, 2014]. It is therefore of high importance to train this at a high level. This could be made possible by adding a training session with Smart Teams during which the coach constantly switches team players between attack and defence.

After the quick sketch, Adobe XD was used to create an app that is inline with the branding I created for Smart Teams (figure 24).

Figure 24. Final Iteration Smart Teams app for coach

Results

After making the electronics working, I added branding to the back of the ribbon and top of the battery case with the help of a sublimation printer. This technique has been chosen, since it gives of a very sporty look which heightens the qualitative feel of the product.

This resulted in a sturdy thin high quality band with a light feel. The prototype facilitates three colors now which can offer two training forms already. These training forms are switching teams and attack vs defence. During which athletes will improve their playing speed as well as ability to switch mind set between being an offense player or defence player.

Figure 25. Final product Smart Teams, ging from blue to green state

Figure 26. Final product Smart Teams, almost in blue state

Demo Day

During the demo day, the results have been shown to the public. Here I have received a lot of feedback that could elevate this product towards a higher level. The first feedback received comes back towards one of the first points being researched during this project, the fit. I had a discussion about the tightness of the product and the way I wanted to have double straps during the first iteration. The feedback provided stated that I could also create one strap with LEDs and the other one with fabric, creating a tighter fit.

Other feedback had to do with the sturdiness of the whole band. Now the band is very flexible, however if athletes would act rough with the bands by folding them, the LEDs could get damaged, therefore silicone could be added on top of the LEDs to make them more durable and less prone to bending.

Thirdly I got the feedback that more affordance could be created on how to put the product on, since now the product might be seen as too simplistic to know how to wear it. To tackle this point I could enlarge the vibration point so people know to place that part on their shoulder. This would indirectly tackle another point of the vibrational power being too low.

Other feedback received was all positive. People stated they forget they are wearing the band because it sits so nicely on their body. Which has been one of my main requirements, since it is very important to create a wearable for athletes that they do not feel on the body, so they will not get distracted [Dellasera, 2014]. If they would get distracted the product would only decrease the level of training instead of heightening the athletes' performances.

Validation

Business Validation

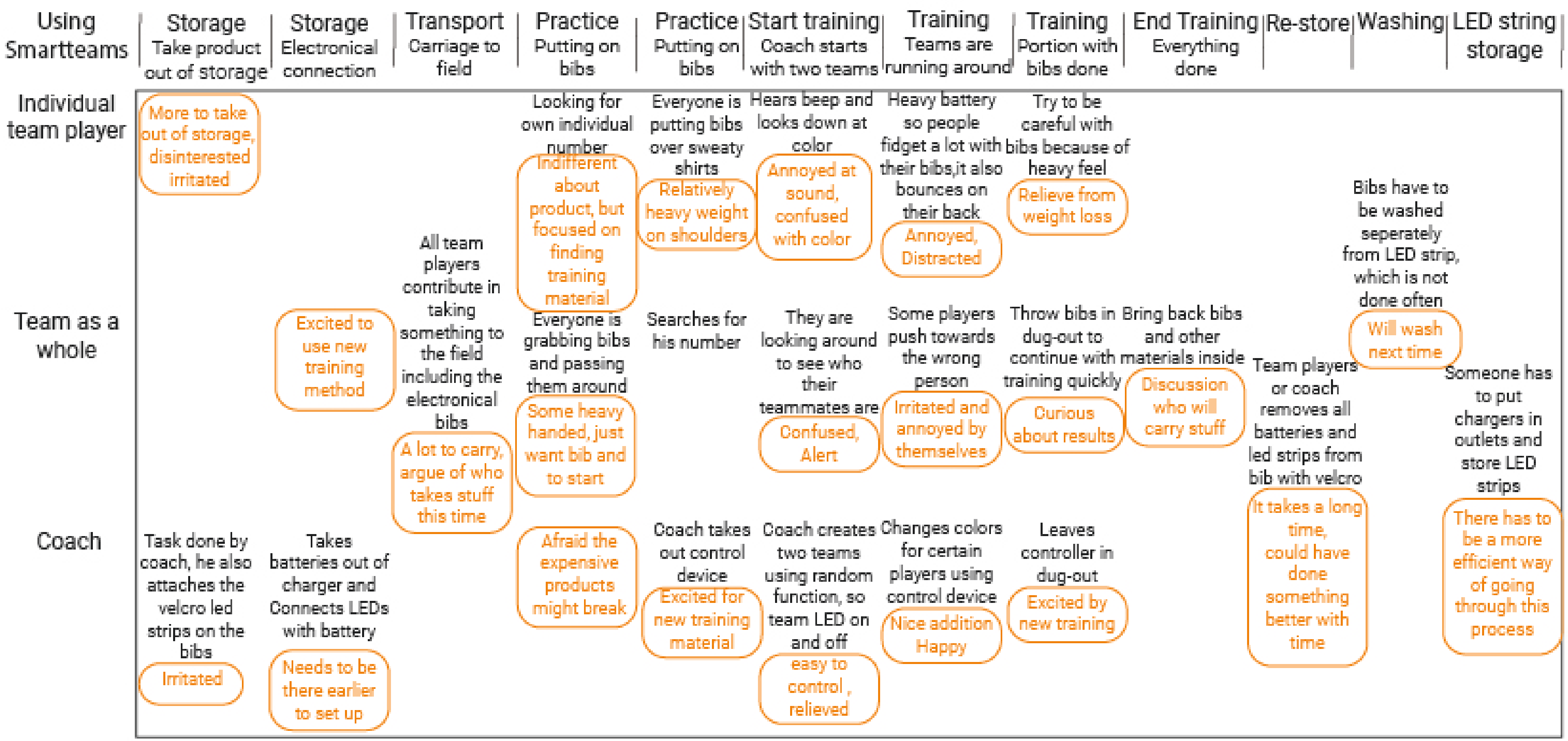
The first step to validating my new design has been to create a customer journey from the old Smart Teams version and the new version created by me, to compare them for improvements. These figures can be found on the next two pages.

Figure 27. Demo day set up, shows all 4 working prorotypes

Figure 28. Hockey demo given during demo day

Experience Flow

Old Smartteams design



Pain Points:

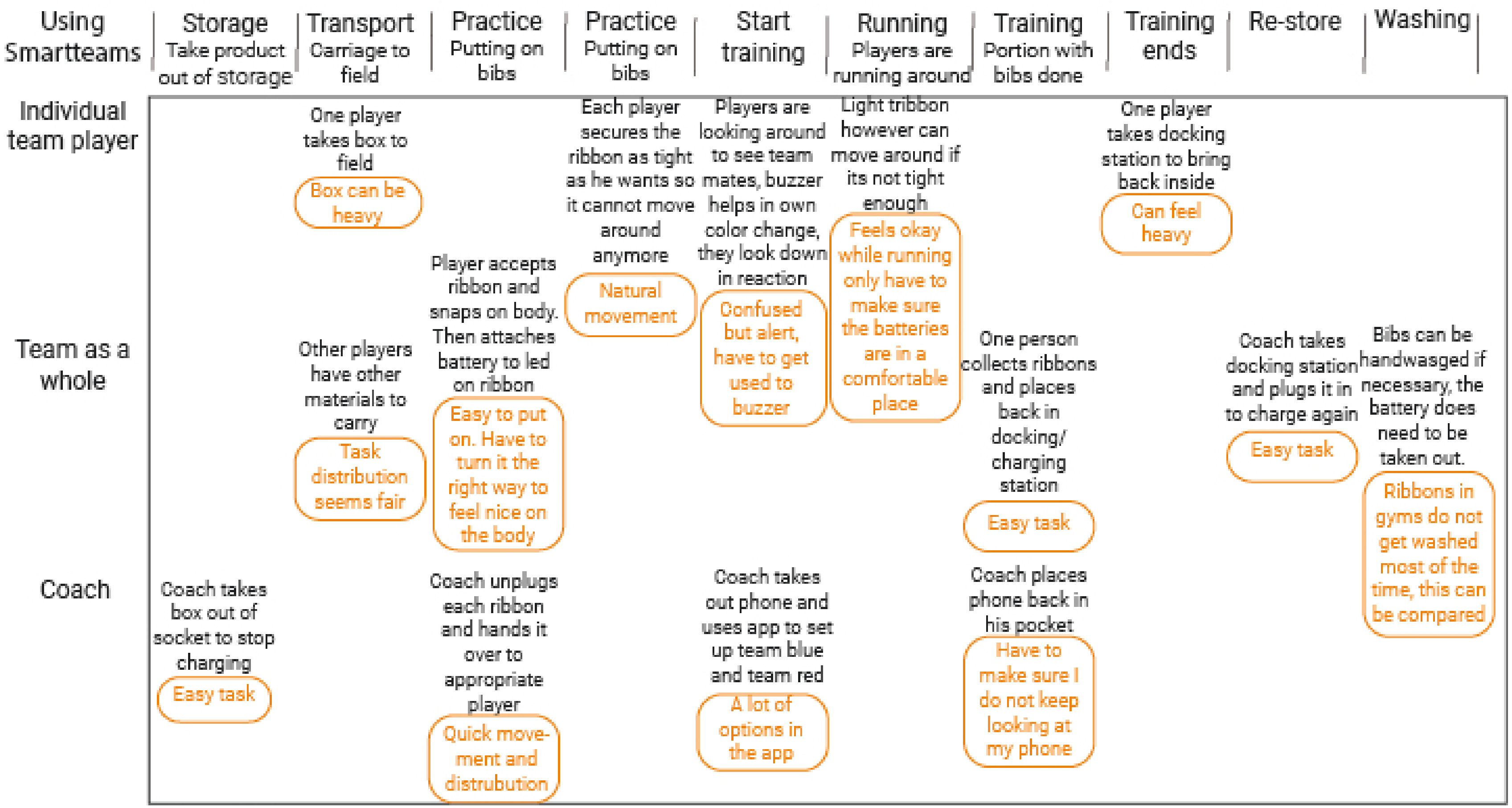
- Bibs heavy to carry with electronics
- A lot of work to attach LED strips with velro
- People use the bibs in a rough way
- Coach has to focus on control device, so can get distracted from training
- Heavy battery which moves a lot while running
- Annoying beep when color changes
- Not immideately visible who your team mate is
- Washing takes a long time

Thought bubble consumer

* This data is based on Smartgoals' user test videos and related field hockey user studies

Figure 29. Experience flow first version Smart Teams

Experience Flow
New Smartteams design



Pain Points:

- People use the ribbons in a rough way
- Coach has to focus on control device, so can get distracted from training
- Heavy battery which moves a lot while running
- Ribbon can move around if it is not secured well enough

Thought bubble consumer

* This data is based on Smartgoals' user test videos and related field hockey user studies as well as real life situations

Figure 30. Experience flow my final iteration Smart Teams

Figure 29 and 30, show that the new version has only one main pain point. This comes down to making the ribbon as tight as possible. For future iterations, the extra cross strap from fabric could solve this problem.

Another main reason SmartGoals chose to iterate further with their concept, was their price point. Previously the material cost for 12 bibs would be 1658 euros. This would make the price of one bib 138 euros. One ribbon of my design would be 34,86 [Appendix 4]. This price is based on my prototyping costs, which would mean the price will become significantly lower when ordering in bulk, which could even bring the price to 20 euros. Therefore the new design is definitely an improvement from the previous version price wise.

Even though SmartGoals has already validated that there is a big customer group, I still explored the business model canvas [Osterwalder, 2013] for this product, to evaluate all partnerships.

The business model show the importance of keeping close relations with sports clubs. Since they will make sure our product will be properly validated and their usage will give additional feedback on additional training forms that could be created for Smart Teams in the future.

Business Model Canvas

Organisation: **Smart Teams**

Key partnerships	Key activities	Value Propositions	Customer Relations	Klantsegmenten
	Design of the wearables	Design	After sales by selling loose pieces	Clients ranging 8-40 within sports clubs
Partnerships with sport clubs as clients and test groups, (football, field hockey, handball) PSV, HC den Bosch, NMHC.	Quality control	Performance	Customer care online to keep close relation to sports clubs	Amateur team sport clubs
	Outsourcing Manufactering	Innovative product	Warranty for first year	Top Athletes ranging 12-30
	Key resources		**Channels**	
Production Factory partnership = VDL	Partnerships with sport clubs to have intel on training forms and design		Website sales point	
			Sport retail stores in the future	

Cost Structure	Revenue Streams
Product manufacturing	Each wearable with a cost of 20 each
Shipping service	Sales for lose pieces
Marketing	Sales for sets
	Rental

Figure 31. Business model created for Smart Teams

Product Validation

During the demo day, I saw an opportunity to do a first validation test with my product. I asked people walking by my stand if they wanted to test the product by playing a small game of field hockey. Luckily three groups of people were willing to participate. This were two groups within the age range of 18-21 in which everyone was either a field hockey player or indoor soccer player. The other group were two girls with an age of 9 who played field hockey. The feedback received has been very positive, each person who wore the product said they forgot to be wearing it during a match. They did say the vibration was not strong enough for each prototype, which shows that the consistency of working with conductive threads might not be high enough. They did say the colors were very clear and the design was easy to wear.

Figure 33. Two 9 year old fiel hockey players testing Smart Teams

Figure 33. Three 21 year old football players testing Smart Teams

After these tests at the demo day, I decided to do a proper user test in a real life setting, which resulted in a field hockey training session at the Student Sport Center Eindhoven. For this I asked four users who all do sports in team aspect. First they had to sign a consent form, to let the study go in an ethical way [appendix 6] The study started with a ball possession game. First two teams were created in which they could pass the ball along to each other. During the game I changed people's colors so the teams would be distributed differently.

Figure 34. First test: right of attack

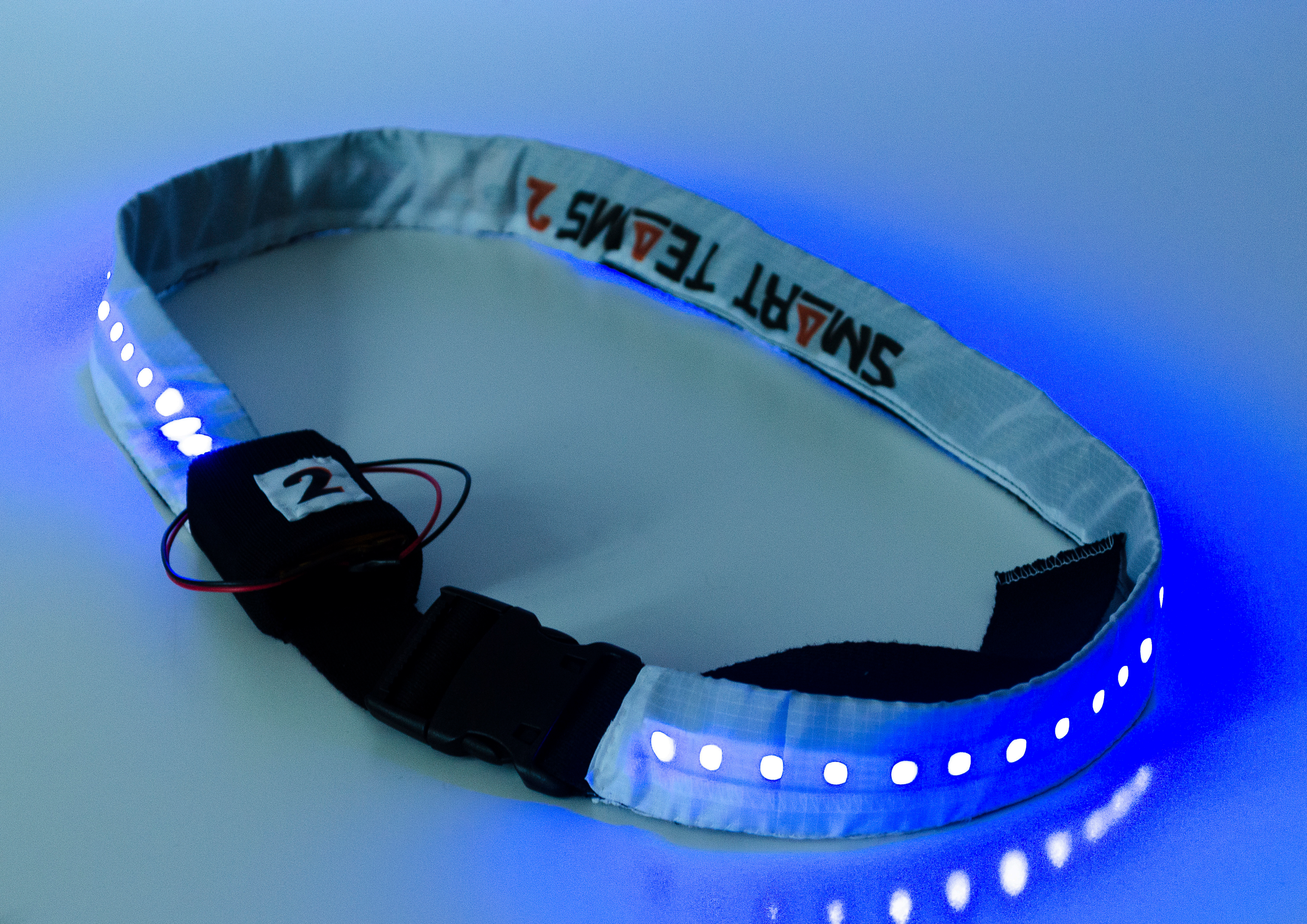
Then another game was explained, which could train their attack vs defence switch. Here I divided the two teams in an offense team and a defence team. The offence team would try to score in a goal while the defence team tried to stop this from happening. During this game I changed the offense players into defence players during their attack, to train their cognitive processing speed.

Figure 34. Second test: Attack vs Defence switch

During both games I viewed a lot of communication between both teams about the team division. I also recognized that the players really enjoyed doing a training session with the product. However the battery placement still was not perfect, since it could slit out of the pocket during a sprint.

After the training session I asked the participants how they experienced training with Smart Teams. The feedback could be summarized in a couple of points. First of all was it really recognizable for the players when someone changed teams, but the speed at which the colorwipe happened could be heightened. Next to that did they recognize their playing speed and mental focus went up during the game, however they would want to see what would happen during a more focussed training session. Then they told me the band was not always tight enough, adding an additional fabric layer across their other shoulder could fix that. Lastly was it sometimes quicker for the other team members to see someone's color change then themselves. This resulted in a positive increase in communication within the team. Still it would be good to recognize your own change quicker. An additional comment should be made here that the vibration motors stopped working as stable, so vibrations were not always felt before a color change.

This feedback can be seen as positive starting points to go further with this concept, given that people did see a change in their focus and did enjoy the product.


SMART TEAMS 2
2

DISCUSSION

The concept Smart Teams created in this report is a high fidelity prototype, that could be used to validate actual improvements in the quality of field hockey players with regard to cognitive processing speed, anticipation and motor speed. However a lot of limitations in this process have still occurred.

First of all, it has been impossible to test the actual improvement results of Smart Teams, since proper analysation of this would be a long process. Hockey players qualities do not grow overnight, this would take a least a month to properly test. This results into a limitation for the process, since the high fidelity prototype has only been finished 10 days prior to the finalization of this report. Therefore in the future, the final result of this project can be used for user studies done by SmartGoals at several sports clubs.

Another point still open for discussion is the actual design of the product. Even though the fit is rather tight, there is still a lot of improvement in terms of stability on the body. Therefore a new iteration could be made with a double shoulder strap to improve upon this current model of Smart Teams further. Another design improvement point would be the actual casing of the electronics. Right now, a waterproof fabric has been added to protect electronics and to keep sweat out of the product. However seams without adaptation, will let fluids through, therefore a glue lining should be added to these seams. This would create a more safe housing for the electronics. Another design point could be the extreme flexibility at this point. The product can be bend into any corner, which could eventually break the LED strip. Therefore the sturdiness of this product could be heightened.

The control of Smart Teams goes side by side with its design. A point still necessary to explore for this design is the control app. First of all a discussion should be held with a coach to explore new ways of training with the help of Smart Teams and the control. Afterwards, a user interface study should be conducted, to test the affordances of the app.

Most findings in this report have been plausible, which is a logical argument given the fact the customer validation already existed prior to this design. Therefore the results from this process are expected. However a surprising element has been the actual design of the product. All closely integrated fabric illumination options were considered, yet the most simplistic version met most requirements. This does show that the solution within a design process can be more simple then expected.


2
SMART TEAMS 2

CONCLUSION

During this design process, the answer to the question: “What device can help athletes improve their cognitive processing speed, anticipation and motor speed within a team?” has been explored. First a research of older versions of a changing sports team allocation trainings system has been conducted. Afterwards the limitations of this product have been used to create the constraints and requirements of the new iteration. This ended in a user fit test, after which different technologies have been explored to succeed in creating a higher quality version. This resulted in a final prototype that could be worn by all team sports players. The purpose of this product has been to increase athlete’s playing speed during a training and eventually match. The validation results of the user tests do show that the system trains the athletes brain to respond to changes in the game quicker. In the future, a more sturdy edition of the last iteration of Smart Teams should be created, after which in field customer validation can be done again. This will hopefully evolve in a new technology focused trainings process within sports clubs all over the Netherlands.

REFLECTION

Looking back on my process, I have definitely explored all three areas I was looking for. I have created a wearable meant for sports in partnership with a company. In this reflection I will reflect on my progress in each of these areas and how they have evolved my vision.

Creating a wearable has been something I already did in my B2.1 project, where I created a jacket for lasergaming. Looking at the progress I made from then until now, I can truly say that my quality has increased tremendously. I have learned how to work with fabrics that respond differently to different techniques. Next to this have I been able to explore wearables more in relation to the expertise area 'Creativity & Aesthetics', which is something I focused on less in the previous wearables project. Now I really wanted to learn how the aesthetics of the product can already tell a user what target group it is created for. I believe I have succeeded this well since people really saw it as a sports wearable.

'Technology & Realization' is an expertise area I saw myself lacking in before this project. Therefore I wanted to create a real emphasis on this area during my FBP, to get it on the same level as my other expertise areas. I believe I have been able to do this by combining technology with a wearable to create a sports product. By creating electronics for sports, a lot of requirements arise. Therefore my electrical quality had to be high as well. I have been able to evolve this expertise area as far as I wanted by creating not one, but four working prototypes. By creating this many prototypes that all had to interact with each other, I was able to gain a large amount of knowledge about technologies that were new to me, like using wifi in your product.

The last area I really wanted to explore was to learn looking at the design process from a business perspective. To be able to do this properly, I knew I wanted to contact a company to collaborate with for my FBP. Therefore I was very glad to hear SmartGoals was going into the same area I am very interested in. Through this partnership I learned that the thought process before prototyping begins, grows tremendously when thinking of your company. Will the production costs be high, will the market be big enough, can we lower the prices, do we have enough partners, where can we produce this technique, are all questions that arise even before creating a prototype. Since going into the wrong direction can cost a company a lot of money. I have also asked my coach at SmartGoals, Chris Heger, for feedback, to see if he could also see my growth during the process [Appendix 5]. I have a received a very positive feedback, in which he states that I have worked in a professional matter and really created something valuable for their company. I am therefore very proud of the progress I have made by doing a project on my own. Another point in which he saw me progress has been my confidence. One of the reasons for me to get some experience at a company has been to gain more confidence in my own work. By working in partnership with SmartGoals, I have been able to see myself in a working situations, which has helped me to see how much I have grown throughout my bachelor.

Looking back on my process, I can say I worked on all expertise areas to heighten them to a level that I feel proud of to finish of my Industrial Design bachelors. By working on a project on my own, I learned to explore each part of the design process. This project did mean a lot for my vision as well, since I learned that I am interested in all types of wearables. I recognized that integrated technological techniques in your wearable production process can be interesting for all types of wearables. Which is why I want to focus on everyday wearables for my first master project.

Acknowledgements

This project has been part of the "Creating everyday soft things" squad at Eindhoven University of Technology. I want to thank C. Heger for all of his guidance during the creation of Smart Teams. I also want to thank A. Hupfeld for always letting me see a different perspective during this process. Also I want to thank all of the users that participated in the studies necessary for this product to evolve.

REFERENCES

Audrey Briot. (2015). Retrieved from http://audreybriot.fr/versatile/

Camps, I. (2019, March 12). User test fbp 1. https://youtu.be/Y06ZSAkvEEc

Dam, R., & Siang, T. (2019). 5 Stages in the Design Thinking Process. https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process

Dellaserra, C. L., Gao, Y., & Ransdell, L. (n.d.). Use of integrated technology in team sports: a review of opportunities, challenges, and future directions for athletes. 2014: National Strength and Conditioning Association.

Home. (2007). http://www.seeyew.com/home.html

Lumalive - Textiles that light up. (2007, May 18). Retrieved from https://crunchwear.com/lumalive-textiles-that-light-up/

Osterwalder, Alexander; Pigneur, Yves. (2013). Business Model Generation. Hoboken, NJ: Wiley.

Passos P, Araújo D and Davids K (2016) Competitiveness and the Process of Co-adaptation in Team Sport Performance. Front. Psychol. 7:1562. doi: 10.3389/fpsyg.2016.01562

Santos, S. (2019, May 12). ESP32 Web Server using SPIFFS (SPI Flash File System). https://randomnerdtutorials.com/esp32-web-server-spiffs-spi-flash-file-system/

Sauerwein, Elmar & Bailom, Franz & Matzler, Kurt & Hinterhuber, Hans. (1996). The Kano Model: How to Delight Your Customers. International Working Seminar on Production Economics. 1.

SIT - Sport Innovation Technologies GmbH. (n.d.). Start | Exerlights - The revolution of training. Retrieved from https://www.exerlights.com/index.html?lang=en

Staak, C. V., Brenninkmeijer, L., Schröder, E., & Wouv, A. V. (2014). De kunst van het omschakelen. Nieuwegein: Hockeyvisie.

Timothy R. Furey, (1987) “Benchmarking: The key to developing competitive advantage in mature markets”, Planning Review, Vol. 15 Issue: 5, pp.30-32, https://doi.org/10.1108/eb054202

Zijl, T. V. (2013, November). Samenstelling teams verandert met één druk op de knop 14 november 2013. Retrieved from http://www.sportknowhowxl.nl/achtergronden/archief/nieuwsberichten/item/91338

* All images and graphs without credits are created by me

APPENDICES

Appendix 1: User Tests SmartGoals

Hockeyclub Push Oktober 24th, 2013
Tests done by Heren 1
Conclusions after seeing flaws

- People look down to their color a lot
    - Create a better awareness system for the users
- Sometimes push towards the wrong person because they thought they were their color
    - Also look into the way awareness for other players color change can be made
- The sound and beep helps players to understand their color, however the beep makes others aware of change as well which is why they think their own color changes too.
    - Create something more personal so others won't be distracted by your personal signal
- The battery can still be very heavy and uncomfortable, people fidget with the battery pocket a lot to readjust it. You can also see it bouncing around as they run
    - Create a better spot for the battery to live as well as make the whole system lighter
- The v shape with leds is very visible during the night
- It is hard to see the difference between a red and black team during the day.
    - More contrast should be made.

Appendix 2: User test awareness options

Actuators	Lilypad buzzer	Buzzer	Vibration motor
Recognizable	3 (ice cream truck sound)	3 (annoying for others)	5
Sound	3	3	2
Feeling	1	1	5
Size	3	1	5

User test done by: 21 female football player

Actuators	Lilypad buzzer	Buzzer	Vibration motor
Recognizable	3	3 (annoying for others)	5
Sound	3	3	4
Feeling	1	1	5
Size	4	1	5

User test done by: 20 female hockey player

Actuators	Lilypad buzzer	Buzzer	Vibration motor
Recognizable	4 (however others can hear too	3 (annoying for others)	5
Sound	4	4	4
Feeling	1	1	5
Size	3	1	5

User test done by: 21 female hockey player

Appendix 3: Product code

```
////http://esp8266.local/*********
Code inspired by wifi tutorial created by R. Santos from http://randomnerdtutorials.com
As well as Adafruit's Strandtest neopixel example
//*********/

// Load Wi-Fi library
#include <ESP8266WiFi.h>

#include <Adafruit_NeoPixel.h>

#ifdef __AVR__
  #include <avr/power.h>
#endif

// Which pin on the Arduino is connected to the NeoPixels?
#define LED_PIN    4

// How many NeoPixels are attached to the Arduino?
#define LED_COUNT 59

// Declare our NeoPixel strip object:
Adafruit_NeoPixel strip(LED_COUNT, LED_PIN);
// Argument 1 = Number of pixels in NeoPixel strip
// Argument 2 = Arduino pin number (most are valid)

// Replace with your network credentials
const char* ssid     = "iPhone van Iris";
const char* password = "hoihoihoi";

// Set web server port number to 80
WiFiServer server(80);

// Variable to store the HTTP request
String header;

// Auxiliar variables to store the current output state
String output5State = "off"; //RED LEDs
String output4State = "off"; //GREEN LEDs
String output3State = "off"; //BLUE LEDs


// Assign output variables to GPIO pins for vibration motor
const int output5 = 5;
//const int output4 = 4;

void setup() {
  Serial.begin(115200); //set port
```

```
  strip.begin(); //initialize the led strip
  strip.show(); // Initialize all pixels to 'off'

  // Initialize the output variables as outputs
  pinMode(output5, OUTPUT); // state pin 5 as output for vibration motor
  // Set outputs to LOW
  digitalWrite(output5, LOW); //state output for pin 5 is low to start without vibration

  // Connect to Wi-Fi network with SSID and password
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  // Print local IP address and start web server
  Serial.println("");
  Serial.println("WiFi connected.");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());
  server.begin();
}

void loop(){
  WiFiClient client = server.available();   // Listen for incoming clients

  if (client) {                             // If a new client connects,
    Serial.println("New Client.");          // print a message out in the serial port
    String currentLine = "";                // make a String to hold incoming data from the client
    while (client.connected()) {            // loop while the client's connected
      if (client.available()) {             // if there's bytes to read from the client,
        char c = client.read();             // read a byte, then
        Serial.write(c);                    // print it out the serial monitor
        header += c;
        if (c == '\n') {                    // if the byte is a newline character
          // if the current line is blank, you got two newline characters in a row.
          // that's the end of the client HTTP request, so send a response:
          if (currentLine.length() == 0) {
            // HTTP headers always start with a response code (e.g. HTTP/1.1 200 OK)
            // and a content-type so the client knows what's coming, then a blank line:
            client.println("HTTP/1.1 200 OK");
            client.println("Content-type:text/html");
            client.println("Connection: close");
            client.println();

            // turns the GPIOs on and off
```

```
//If RED is pressed in interface on mobile/web make LEDs red
if (header.indexOf("GET /5/on") >= 0) {
  Serial.println("RED on");
  output5State = "on";
 // header.indexOf("GET /4/off");           //make sure green is off
 // header.indexOf("GET /3/off");           //make sure blue is off
  Serial.println("GREEN & BLUE off");     //feedback to serial monitor
  output4State = "off";                   //show in browser green is off
  output3State = "off";                   //show in browser blue is off
  digitalWrite(output5, HIGH);            //turn on buzzer
  delay(2000);
  digitalWrite(output5, LOW);
  colorWipe(strip.Color(255, 0, 0), 100); // Red
  strip.show();
} else if (header.indexOf("GET /5/off") >= 0) {
  Serial.println("RED off");
  output5State = "off";
//  digitalWrite(output4, LOW);
  digitalWrite(output5,LOW);

  //If GREEN is pressed in interface on mobile/web make LEDs green
} else if (header.indexOf("GET /4/on") >= 0) {
  Serial.println("GREEN on");
  output4State = "on";
//  header.indexOf("GET /5/off");           //make sure red is off
//  header.indexOf("GET /3/off");           //make sure blue is off
  Serial.println("RED & BLUE off");     //feedback to serial monitor
  output5State = "off";                   //show in browser green is off
  output3State = "off";                   //show in browser blue is off
  digitalWrite(output5, HIGH);
  delay(2000);
  digitalWrite(output5, LOW);
  colorWipe(strip.Color(0, 255, 0), 100); // Green
  strip.show();
} else if (header.indexOf("GET /4/off") >= 0) {
  Serial.println("GPIO 4 off");
  output4State = "off";
//  digitalWrite(output4, LOW);
  digitalWrite(output5, LOW);


 //If BLUE is pressed in interface on mobile/web make LEDs blue
} else if (header.indexOf("GET /3/on") >= 0) {
  Serial.println("BLUE on");
  output3State = "on";
//  header.indexOf("GET /5/off");           //make sure red is off
//  header.indexOf("GET /4/off");           //make sure green is off
  Serial.println("RED & GREEN off");     //feedback to serial monitor
  output5State = "off";                   //show in browser green is off
  output4State = "off";                   //show in browser blue is off
  digitalWrite(output5, HIGH);
  delay(2000);
  digitalWrite(output5, LOW);
  colorWipe(strip.Color(0, 0, 255), 100); // blue
  strip.show();
} else if (header.indexOf("GET /3/off") >= 0) {
  Serial.println("GPIO 3 off");
  output3State = "off";
//  digitalWrite(output4, LOW);
  digitalWrite(output5, LOW);
}

// Display the HTML web page
client.println("<!DOCTYPE html><html>");
client.println("<head><meta name=\"viewport\" content=\"width=device-width, initial-scale=1\">");
client.println("<link rel=\"icon\" href=\"data:,\">");
// CSS to style the on/off buttons
// Feel free to change the background-color and font-size attributes to fit your preferences
client.println("<style>html { font-family: Helvetica; display: inline-block; margin: 0px auto; text-align: center;}");
client.println(".button { background-color: #195B6A; border: none; color: white; padding: 16px 40px;");
client.println("text-decoration: none; font-size: 30px; margin: 2px; cursor: pointer;}");
client.println(".button2 {background-color: #77878A;}</style></head>");

// Web Page Heading
client.println("<body><h1>SmartTeams Control</h1>");

// Display current state, and ON/OFF buttons for GPIO 5
client.println("<p>RED - State " + output5State + "</p>");
// If the output5State is off, it displays the ON button
if (output5State=="off") {
  client.println("<p><a href=\"/5/on\"><button class=\"button\">RED ON</button></a></p>");
} else {
  client.println("<p><a href=\"/5/off\"><button class=\"button button2\">RED OFF</button></a></p>");
}

// Display current state, and ON/OFF buttons for GPIO 4
client.println("<p>GREEN - State " + output4State + "</p>");
// If the output4State is off, it displays the ON button
if (output4State=="off") {
  client.println("<p><a href=\"/4/on\"><button class=\"button\">GREEN ON</button></a></p>");
} else {
  client.println("<p><a href=\"/4/off\"><button class=\"button button2\">GREEN OFF</button></a></p>");
}
```

```
          // Display current state, and ON/OFF buttons for 3
          client.println("<p>BLUE - State " + output3State + "</p>");
          // If the output3State is off, it displays the ON button
          if (output3State=="off") {
            client.println("<p><a href=\"/3/on\"><button class=\"button\">BLUE ON</button></a></p>");
          } else {
            client.println("<p><a href=\"/3/off\"><button class=\"button button2\">BLUE OFF</button></a></p>");
          }

          client.println("</body></html>");

          // The HTTP response ends with another blank line
          client.println();
          // Break out of the while loop
          break;
        } else { // if you got a newline, then clear currentLine
          currentLine = "";
        }
      } else if (c != '\r') {  // if you got anything else but a carriage return character,
        currentLine += c;      // add it to the end of the currentLine
      }
    }
  }
  // Clear the header variable
  header = "";
  // Close the connection
  client.stop();
  Serial.println("Client disconnected.");
  Serial.println("");
 }
}

// Fill the dots one after the other with a color
void colorWipe(uint32_t c, uint8_t wait) {
  for(uint16_t i=0; i<strip.numPixels(); i++) {
    strip.setPixelColor(i, c);
    strip.show();
    delay(wait);
  }
}
```

Appendix 4: Price analysis Smart Teams

Product	Price
Wemos Lolin ESP 8266	8,50
Lipo battery 1500mAh	10,00
Vibration Motor	0,90
LED strip 1 meter	10,00
NPN transistor	0,06
Conductive thread	1,00
Wiring	0,10
Resistors (2)	0,10
Ribbon 1 meter	1,00
Clasp	2,50
Fabric (10x100cm)	0,65
Sewing thread	0,05
Total	34,86

*Costs based on my prototype

Appendix 5: Feedback SmartGoals

Feedback Iris Camps.

I came to know Iris as a very professional student. She communicates well, is always on time, sets realistic goals and is a real maker. She uses a process of making and experimenting to move forward in the process.

For the SmartTeams project the idea was already there, but the current prototypes were too difficult / expensive to produce. It was Iris her assignment to do a redesign of the concept and product to see if we could find a better way to get the idea into the market/world. This is a challenging assignment because to get there a whole set of requirements was created. She needed to find a balance between: production costs, product price (which is a big factor!) visibility of the changing colours during the day, comfort, safety, strenght, aesthetics, battery life and operating the system.

She took a head-on approach and started experimenting straight of the bat. This was great. Initially these experiments mainly led to discovering methods that would not work for us for all kinds of reasons: too much power consumption , dangerous to wear, not visible during the day, too expensive, technology not available yet, etc. But by elminating all these options the process guided her to a design direction that I believe works for us. The process also guided her to a form direction that could work. In the end basically she designed a, in size adjustable, team ribbon with a LED strip attached to it.

Some of her coaches thought that this was a too easy / straightforward solution. For us it was the best direction we could find and it made us really happy. We believe that with this design direction all design requirements can be met in the end and we hope it can lead to a product that we can launch on the market somewhere in the next year.

After the intial idea of the design she kept on experimenting with the details; kinds of fabric, how to attach the electronics, where to place them on the body, etc. With these steps we are getting closer and closer towards a product of which we can produce a first small series to test it in the market. We are not there yet, but Iris did show us the way and we plan to continue with her direction to work towards product launch. So great job.

I think you can become a great designer if you keep putting in the work. As a tip for the future I think you should try to stand by your idea and choices a bit more. There are good reasons why you made those choices. You are the designer of your products, not me or your coaches, so when you get feedback use it well, be critical on your on work, but don't let it overule your own ideas to easily. If you don't agree with the feedback, speak out, explain why and defend your choices.

Chris Heger
Founder SmartGoals BV

Appendix 6: Consent form

This Consent form was created by V. Gunatilleke.and used with permission

Informed consent form

This document gives you information about the "Experimentation of the lighting behavior of Smart teams" study. Before the study begins, it is important that you learn about the procedure followed in this study and that you give your informed consent for voluntary participation. Please read this document carefully.

Aim and benefit of the study

The aim of this study is to evaluate a concept regarding interactive team vests that light up

Procedure

The study includes testing a prototype and a small discussion about whether it would add value to sports trainings

Risks

The study does not involve any risks or detrimental side effects.

Duration

The study will last approximately 30 minutes.

Voluntary

Your participation is completely voluntary. You can refuse to participate without giving any reasons and you can stop your participation at any time during the study. You can also withdraw your permission to use your data up to 24 hours after the study is finished. All this will have no negative consequences whatsoever.

Confidentiality

For your information, this study involves the response recording.

The information that we collect from this study also is used for writing scientific publications and will only be reported at group level. It will be completely anonymous and it cannot be traced back to you. Neither your name nor any other identifying information will be used in presentations or in written products resulting from the study without your written consent.

Further information

If you want more information about this study, please contact Vimukthi Gunatilleke (Contact email: s.k.m.v.gunatilleke@student.tue.nl).

Certificate of Consent

I, **(NAME)**.. have read and understood this consent form and have been given the opportunity to ask questions.

I have the following responsibilities: perform experimental tasks, and answer the questionnaire to the best of my ability.

Signature Date