



Improving Practice

Development of an add-on to enable a football training tool to be used in new environments

Master of Science Thesis in the Master Degree Program, Industrial Design Engineering

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Abstract

This project was conducted as a master thesis at the Department of Product and Production Development at Chalmers University of Technology. It was written by Andreas Höglind and Morgan Berglund and performed as a final step before graduating from the master's programme Industrial Design Engineering in Gothenburg, Sweden.

The project was carried out in collaboration with Aracne AB who provided the research topic and objective of the project. The aim of this project was to attract more buyers by making their product compatible with more environments. The goal was to develop and add-on which would make the product compatible with environments where there is a wish to use this product.

Aracne has developed a sport concept consisting of a game and a physical product which aims to help football players practice their technique. The sport is called Futchi and resembles squash in that two players alternate in hitting a ball on a surface which returns the ball. Their product, called the Futchi Wall, is mounted in any 5-a-side football goal and enables the sport to be played by returning balls in a gentle arc. The company developed their product separately and launched it during the course of this master thesis.

A four stage process was employed in this master thesis to accomplish this goal and a complement to their product was developed which targeted home environments. The first stage was to study the contexts in which the product could potentially be used and find the characteristics thereof in order to be able to make the product compatible with them. This was the goal of the first stage in which competitors, environments, users and scenarios which could contribute to new requirements to the product were studied. The next phase was to refine the data gathered in the study into useful information and extract the requirements posed on the product. Options of which direction to develop the product were created and selected among to choose which market to target. Once decided through discussions with the company a set of requirements to work with could be agreed upon. These requirements were the basis for the two subsequent phases, the first of which was to create ideas for how to fulfill the requirements. Lastly, the final phase was to choose and combine these solutions into a final concept and test it by creating a prototype which could allow the company to continue the development and apply the solution to their product.

The master thesis resulted in an addition to Aracne's product which accommodates the needs of a larger user group than their current product and can be added to their product lineup in order to broaden their market. It consists of a frame that is inexpensive to manufacture but also quick and easy to mount and use. It complements their existing product to make it compatible with environments other than football fields, as well as address the requirements found during the study.

Keywords: product development, rebounder, sports utility, training tool, home environment, user studies, prototype, frame.

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Introduction

This chapter provides an introduction to the subject of football, rebounders, give an explanation of the purpose of this project, and how they will relate to each other to reach the desired outcome of this project.

1.1 Background

Football practice often involve an entire team meeting up and practicing together but can also be performed individually with the use of repetitive exercises. Improvements through repetitive excersies are common in sports although repetition can be somewhat boring. If competitive aspects and more freedom are introduced to these exercises many believe that they can be made into something which the players will want to do instead of a chore, especially during their younger years. In today's society the youth are spending more and more time indoors with their phones, computers etc. and parents are always looking for new ways to get their kids to spend more time outside. With today's increasing amount of stationary work, it is believed that parents are very supportive of their childrens' exercise. Simply being able to encourage their children to go outside and be active is believed to be worth a lot to parents and the health of today's youth. During the last couple of years a few products have attempted to target this demand.

1.2 Aracne

Aracne is a company founded last year, who recently launched a product which both targets the parents wish of getting children to play outside while also improving their football technique by encouraging other forms of football playing and outdoor activity. Their product is a type of rebounder which is mounted in a goal and returns a ball when kicked at it, and it is accompanied by a game as well as a community surrounding their product and new sport. The concept is called "Futchi" and the rebounder is called the "Futchi Wall".

When this master thesis project began, their development was in the prototype testing phase. The company's development of the Futchi Wall continued alongside this master thesis project up until its release during



Figure 1.1 Futchi logotype

the large football event Gothia Cup in June 2014. The intent of this launch was to create a starting point to spread awareness of themselves, let players try Futchi and register themselves in the Futchi community.

The company would like to expand their product range to better cover different user groups and enlarge their potential market. This desire was the basis for this master thesis and their description of the project can be found below:

"Futchi is a new innovative football concept targeting youths. The concept facilitates intense and fun training of technique through a physical product and a social network. In order to expand the use of the physical product beyond the football ground there is a need to investigate alternative settings in which the product can be used. Consideration should be taken to what ground materials the external settings have, general ergonomics and assembly methods of fixtures and product. It is of great interest to create a complementary home concept of Futchi which builds on the existing concept and develops it even further. The new concept should be designed to fit with the physical product and be suitable to play the sport of Futchi on."

1.3 Aim

The purpose of this project will be to enlarge the potential market by investigating the possibilities and problems in bringing it to a home environment. The aim of this

project will thus be to expand upon their product to no longer require a pre-existing goal frame to which the product has been attached. This will enable their product to work in environments other than football fields, such as public areas, gardens, driveways or any other place where the sport could be performed. This will allow Aracne to reach a larger audience and increase the number of potential buyers.

By investigating the context in which the product will be used, problems and demands can be found and addressed to improve the product and make it better suited for this environment. Possibilities to mount the product have to be investigated and solutions which fulfill the demands have to be developed and evaluated. This will involve mounting options, frames and attachment mechanisms, all while striving for the ideal experience for the end user and make their current product compatible with the demands this new environment puts on it.

1.4 Goal

The goal is to develop and create a prototype of a solution which allows their current product to be used in environments other than football fields or locations with existing goals. By studying the environment and users, data will be collected and analysed to extract the requirements. Solutions addressing these will be developed and condensed into a functional prototype which enables the Futchi Wall to be used without a goal.

During this project attempts will be made to answer the following three questions:

- In what context/environments where there are no goals available would there be a desire to use the Futchi Wall?
- How can the Futchi Wall be made compatible with environments where there are no goal frames available?

- In what contexts, if any, does the old product remain superior?

1.5 Deliverables

The end deliverable will be a prototype to enable testing and evaluation of ideas and to function as a base for future development. CAD models and basic production material will be included, as well as suggestions for future work. This information will be delivered collected in the form of a document.

1.6 Limitations

There were also a few initial limitations and requirements set by Aracne:

- The result should be compatible with their existing net. Minor modifications might be approved but not guaranteed.
- The product should be useable from ages 7 and older, but people age 13 and older should also be able to perform any often required mounting tasks (the tasks similar to when using the net in a 5-a-side goal).
- The cost of the product has to comply to a price range for the end customer set by Aracne, the validity of which will not be researched.
- Production technique and optimising manufacturing for cost will not be focused on.
- Aracne's new game Futchi will be considered and the product should be compatible with it, but the sport will not actively be worked with. Aracne will provide the rules and details regarding Futchi.

Theory

This chapter describes theory and knowledge which is relevant to the project and gives a better understanding of the reasoning behind the choices made.

2.1 Youth behaviour

With the increase in electronic entertainment in recent years, children spend more time stationary indoors in front of screens than before. The number one activity is watching TV and dvd, while gaming places second according to according to APN Newspapers Pty Ltd (2012). A key element in this is believed to be the lack of equipment outside in relation to entertainment inside. Because of this, the interest from parents in such equipment for kids has improved over the last couple of years. Trampolines were mentioned as tool to get kids outside when interviewing the parents of soccer players. Even though they may cause accidents, the parents spoke of them favourably. During interviews, parents also expressed worry because their children spent a lot less time outside than they did when they were young.

It is during the youth years that technique training is of most value to a football player. During these years, the foundation is laid out for the players and they are expected to have reached a certain level of technique in their upper teens when training switches focus to improving gameplay according to Niklas Allbäck (2014). Children in the lowest age are often not interested in boring and repetitive exercises and would much rather play games with a competitive aspect to it. Creating a fun way to improve technique would be beneficial for teams and individuals alike. Practice makes perfect and enjoyable exercises are likely to lead to more and better training.

2.2 Rebounder

The product Aracne has developed is a type of football rebounder. A rebounder is a product which is used to practice skills in various ball sports and is essentially a surface which bounces balls back. Some rebounders are marketed as multi-sport, and some focus on just improving skills in one

particular sport. By repeatedly bouncing the ball against it, a particular skill can be developed and because it does not require other players, it is possible to improve on your own. A rebounder enables the player to target and hone a particular skill which the player wishes to develop. They vary in size, mobility and price and although the amount of rebound can differ, the basic functionality remains the same. Most of the people who participated in our studies had not heard of any particular brand of rebounder although almost everyone recognised the concept. Many of them mentioned it being common for kids to play ball games against outer walls of buildings although they also noted the risk of property damage. A famous example of the benefits of repetitively hitting a wall is Björn Borg who is known to have practiced by hitting his garage wall as described by Pears (2005).

The benefits of using a rebounder compared to a regular wall are many. There are rebounders which offer the possibility of moving it anywhere and for instance bring it to a friend or to football practice and others which allows for adjustments to be made to customize the type of rebound. When stepping up to the more exclusive rebounders you also get functions such as sensors which work together with an app on your phone to create challenges. These competitive aspects can encourage the user to practice what would otherwise have been repetitive and tedious tasks by making a game of it and introducing novelties to their training

The thought is that the users are encouraged to use it because of the competitive action brought by the added game and that the players will keep practicing because it is fun, rather than viewing it as a boring repetitive training tool. Rebounders themselves have existed for some time and there are many competitors to the Futchi Wall. Some of them have been present in the market for some time and are established brands.



Figure 2.1 Futchi Wall prototype mounted in goal

2.3 Futchi Wall

The Futchi Wall is the physical product that Aracne has created which their game and community surrounds. In its current state it relies on its environment as it has to be mounted in a rigid 5-a-side goal. There is an elastic bungee cord which provides the rebound effect inside the fabric border which frames the net, and it has one safety hook in each corner which are attached to the goal as can be seen in the figure 2.1. The lower safety hooks are attached to the lower mounting devices which are wrapped around the goal-post and have a high friction inner surface which prevents them from moving once they are strapped tight as depicted in figure 2.2 and 2.3. The upper safety hooks are attached to the upper attachment parts which is wrapped around the back strut, as can be seen in the figure 2.4. These attachments are designed to be



Figure 2.2 Lower mounting devices



Figure 2.3 Attachment of lower mounting device

universal with a one-size-fits-all mentality to make them compatible with goal posts of varying design and size.

Once the net has been hooked to the attachments in the goal frame, it is tightened by pulling on the straps which run through cam buckles as depicted in figure 2.4. It is necessary to tighten it as much as possible, because only a few centimeters of tension less than optimal gives a much weaker rebound. A complete assembly takes about 5 minutes for an experienced adult and about 10 minutes the first time. The assembly is recommended to be done by an adult, but Aracne states that people as young as 13 years are able to assemble it.

When playing against the Futchi Wall, one quickly realise that the rebound is quite different to a hard surface. One might expect the ball to bounce out at the same angle as the angle of incidence, which isn't the case. The ball does not bounce straight out from



Figure 2.4 Upper mounting device

the net, but rather with a bias towards the centre. A ball which hits high on the net for instance will be directed downwards whereas a low ball will come back higher. A ball shot at the left side will go to the right and a ball which hits the right side will go left as depicted in the figure 2.5. The rebound is soft and also catches and holds the ball for a fraction of a second before returning it in a lobbed trajectory because of the angle of the Futchi Wall.

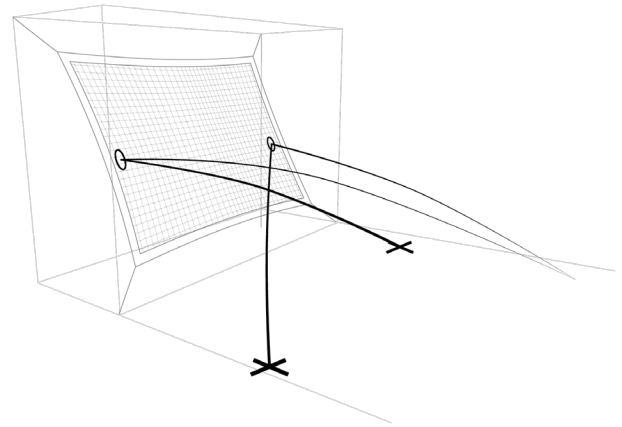


Figure 2.5 Rebound characteristics

In addition to the net and attachment parts, a playing field in the form of portable lines is also included. This is to be used when playing the sport called “Futchi”. Aracne has chosen to market their product as a football product only, because of their own sport which is based on football.

2.4 Futchi

The sport which Aracne has created is called Futchi and it is developed alongside their rebounder. Futchi is a game which in its natural form is played one-on-one in a squash-like fashion against the Futchi Wall. Two players alternate in kicking a ball at the

net and the ball is only allowed to bounce once on the ground in between their turns. The players are required to successfully hit the net without hitting anything else. Once a player fails to do this, the opponent is awarded a point and the game is recommenced with a serve. The objective of the game is thus to hit the net but make the rebound as difficult as possible for the other player by aiming so that the rebound will go far from the opponent yet still within the playing field, which can be seen in figure 2.6. The serve is made from behind the rearmost line after which both players enter the playing field. There are a few addition-



Figure 2.6 Two players playing Futchi on artificial grass

al variations, such as Round-Futchi which uses the same principle but allows for more players to participate. In this gameplay, you get a point every time you fail to hit the net and you are eliminated when you have reached a certain number of points. Once two players remain, the final is held as a standard Futchi game.

There is also a community in development to distinguish them from the competitors already present on the market. In this community the players are encouraged to share their experiences, compete amongst each other, compare their scores and create new fun ways to use the product by creating their own rule-sets. The players are left to use the product as they please and because of its versatility, new ways to play with it are likely to emerge. An increased awareness, reason to use the product and a way of spreading their product in the form of this concept is believed to make the product more enjoyable and more appealing, and increase their market penetration.

2.5 Ground/Playing field types

Listed below are some surface materials which football can be played on, along with certain notable characteristics and properties which could pose restrictions for products placed on them.

Grass

Regular grass is a surface which football is commonly played on. Access to lawns and parks with grass is common in Europe and America. In cases where the grass is not in the form of a dedicated sports field such as parks and home gardens the surface may be very uneven. Although objects may not stand perfectly stable upon it the soft ground provides the possibility to fasten objects to the ground using tent pegs or similar solutions.

Artificial grass

Another common surface on which football is played is artificial grass. Since it is built on purpose and often with intent to play sports on, it can be considered to be perfectly flat. Instead of soil there are various ways to replicate the feeling of grass, some of which may be damaged if anything pierces too deep or pulls at the straws. There may also be drainage and or heating systems underneath. Attempting to attach to anything to it, should be avoided as the field can be damaged and requires repair as it doesn't regrow naturally.

Dirt, gravel & sand

A hard surface and often densely packed and fairly even. Loose gravel might make something standing on it slide around if a sideways force is applied. A less densely packed sandy surface is more likely to be uneven but on the other hand it allows for objects to sink down a bit and level out which provides increased stability.

Asphalt & concrete

A hard and even surface which is uncommon for football use, but which might be the only available surface large enough in an urban setting. It does not provide possibility for tent pegs and does not absorb the energy of collisions or dampen bounces at impact.

Indoor multisport courts

A hard and even surface of either hardwood or plastic which is uncommon for football use except during winter. It does not provide possibility for tent pegs.

2.6 Corrosion

When working with metal, especially in an outdoor environment, precautions must be taken against different types of corrosion. Corrosion means that metals react with an oxidant (often oxygen) and creates oxidants. Corrosion is bad because it degrades

the strength of the metal and changes the aesthetics.

When two different metals (with different electropotential) have physical (or electrical) contact and are submerged in an electrolyte (e.g. water) galvanic corrosion can occur. In this case the metal with the lowest electropotential will be subject to degradation. There are a couple of ways to protect metals from galvanic corrosion. If it's possible to make sure that no physical or electrical contact can be made between the metals (e.g. with insulation between) no galvanic couple will occur. It is also possible to shield the metal from the possible electrolyte with paint or grease or add a sacrificial metal with a lower electropotential.

General corrosion is another common type of corrosion that attacks the whole surface. Unlike galvanic corrosion, general corrosion occurs when a single piece of metal comes in contact with an electrolyte. Although easily occurring, the general corrosion is very predictable and is therefore easily avoided e.g. with paint that hinders the electrolyte to reach the metal.

2.7 Methods of manufacturing

Some information on the manufacturing methods which mentioned in the project are listed below.

Press braking

Press braking is a manufacturing technique where a piece of sheet metal is bent between a matching punch and die. Standard tooling is cheap and accurate, even at low volumes (Thompson 2011). The punch has to be able to reach the corner which is going to be bent, which can in some cases limit the form. Although tools such as a gooseneck die can create more complex shapes, not all forms can be created. If standard tools are used the method is well suited for lower

quantities of production as no special tools have to be obtained in order to produce parts. Although the main cost is manual labour, this means that there is low to no benefit from having a larger series created. Press braking is also limited to using sheet metal as material.

Laser & water jet cutting

Laser and water jet cutting are both techniques to cut sheets into a shape suitable for press braking. They both require little to no tooling costs and scale up fairly well in production (Thompson 2011).

Injection molding

Injection molding is useful if parts are going to be manufactured at a high quantity. The starting cost is very high because of the need of a specific tool/mould for each part type, but each part manufactured only carries the material cost and an extremely low labour cost. To injection mold a part, material is heated up and then forced into a mold cavity where the material cools and hardens to the form of the cavity. Injection molding can be done with many different types of materials, but is most commonly used with polymers, glass and metal.

Extrusion

Profiles with a fixed cross-section can be created through extrusion. This is a cheap way to create extremely complex profiles. Like injection molding, extrusion demands a specific tool to be created, but the tool for extrusion is much cheaper than the tool for injection moulding. After the initial cost, each part only carries the material cost and a low labour cost. Extrusion is done by pushing a profile through a die of the specified cross section. The most commonly used material is aluminium, but extrusion can also be done with other types of metal as well as polymers, ceramics and concrete.

Swaging

Swaging is a technique where circular pipes

are deformed and stretched to change their diameter. Although tooling costs can be fairly inexpensive and the turnover rapid once production scales up, it limits the possible shapes of the cross section (Thompson 2011).

Powdercoating

One form of surface treatment is powdercoating in which the object is electrically charged coated with particles which stick to it, after which it is heated to form a durable layer.

Anodising

Anodising is another form of surface treatment which creates an oxide film which is light, hard, protective and self healing (Thompson 2011). There are thicker and harder varieties which also happen to be more UV resistant which, although more expensive and allows for a smaller range of colours, would be recommended for outdoor products which will be exposed to sunlight, wear and tear.

Methodology

This chapter describes the formal methods used in the project and the theory behind them. It provides a insight in the methods to better be able to follow the later descriptions of the procedure and how these methods were applied in this project.

3.1 Planning and Collection

What is most important in the early stages of a development project is to ensure that one has sufficient information to reach the most accurate conclusions and make the best choices surrounding the development of a solution. These are the methods used to collect the data and ensure sufficient information for the later phases.

3.1.1 GANTT schedule

In order to estimate the times for how long time each part will take and plan ahead, a GANTT schedule can be made. The schedule is drawn in a simple coordinate system, where the y axis consists of the activities and the x-axis represent time. Each activity is represented by a horizontal line, which corresponds to the time that activity will take to perform (Johanesson, 2004). This provides an overview of the time requirement for a project and its individual parts, especially in relation to each other. Stage gates can also be set up, which means that goals are set at specific parts of the project and the project will not progress past this point until that goal is met.

3.1.2 Observation

When performing observations the investigator is observing the situation that he/she is interested in, with his/her own eyes. These observations can be performed in real usage situations (in field) or in an arranged situation (lab) (Bligård, 2011). The purpose of observations is to gain an understanding of a certain usage situation, without interfering, and thus gaining knowledge of what the user actually is doing and not what the users think they are doing. If the observations are taken place in field, it is also possible to have the observed person unaware of the observation. This might be desirable in some cases where a user acting closer to a real life circumstance, causes more accu-

rate and true to life results to be attained. Observations are especially useful early in a project to gain a basic understanding of the problem and usage situation at hand.

3.1.3 Interview

Interviews are the most basic method of gathering information about people's thoughts, knowledge and experience (Bohgard et. al., 2008). It can be considered either a qualitative or a quantitative method depending on the structure of the interview and the number of interviewees. There are three types of interviews, structured, semi-structured and unstructured, all of which have different usage situations. Unstructured interviews are useful when looking for qualitative data and is based around free discussion with the subject. In a structured interview, all questions are set beforehand and is best when quantitative data is desirable. A semistructured interview consists both of questions set beforehand, but also open questions on which the interviewer has the ability to probe and ask follow up questions although it risks adding some bias to the answers. Saving the answer from the interview can easily be done through a form in the case of a structured interview or through sound recordings and transcripts. Taking notes is made far easier by adding interviewers where the tasks of interviewing and writing down can be divided.

3.1.4 Focus group

A focus group is a form of group interview with 6-12 participants representing their user group. The group is lead through an open discussion and they are encouraged to discuss their views and opinions on the subject, with a moderator that helps to keep the discussions stays relevant (Bligård, 2011). Mediating objects (e.g. sketches, images or other objects related to the usage situation) are often introduced during the focus group to stimulate discussion. The free cli-

mate of the focus group and encouragement to discuss, often lead to unexpected ideas or thoughts which build on someone else's idea. Ideas that might otherwise have been missed during a regular interview.

3.1.5 SWOT-analysis

To be able to create a product that fits the market, it is valuable to look at what currently exists, what they do well/bad and what this new product can do better than the other products on the market (Österlin 2007). A good way of assessing competitors is to do a SWOT (Strength, Weakness, Opportunities, Threats) analysis. With this method, strengths, weaknesses, opportunities and threats are assessed in comparison to different products on the market. Strengths are characteristics that gives the product an advantage over others. Weaknesses are what others do better. Opportunities are aspects that can be exploited to an advantage. Threats are aspects that could cause trouble or harm to the project. When a SWOT has been carried out, it is possible to analyse it to see how the product would fit on the market compared to its competitors and possibly change the scope to fit the arisen opportunities and handle the threats.

3.2 Analysis

The methods with which the data was treated can be found below. Tools for analysis and grouping the data to get a better overview are described. Methods for extracting the desired information from this data and condensing it to a more usable form which is easier to interact with and take in are also included.

3.2.1 KJ-analysis

After having performed data collection, KJ analysis can be used to group these large quantities of data into smaller categories. When all data has been categorised, head-

ings are put on each category and the data is sorted again to see if some of the data might fit better in another group. This creates a bottom-up strategy, starting with details and ending up with an overview of the data (Bligård, 2011).

3.2.2 Requirements list

The study-phase concludes with a list of requirements. The content of this list are the design criteria which will stand as the base when generating ideas and also a comparison to evaluate the final concept against (Österlin 2007). The requirements list is not something which is fixed, but rather to be seen as a living document that is allowed to evolve with the project. It's purpose is to concretise the problem, provide a unified view of the project, ensure that all stakeholders are taken into account and also work as support for decisionmaking.

3.2.3 Persona

A persona is used to create a representation of the user demographics, knowledge and limitations. It is a fictional representation of the target user group and can be used to gain a better understanding of them. The persona describes a person from the target user group with text and pictures to help gain an understanding and grasp an otherwise abstract user group (Bligård, 2011).

3.2.4 Scenario

Scenarios are often used together with a persona to also incorporate the users' relation to the product in some way. It is a fictive scenario in which the product is used, or problem being investigated, described in a text format. The purpose of creating a scenario is to gain a better understanding of the problem at hand and the user situation it is tied together with. A scenario describes the event from start to finish, contains factors that might affect the outcome and also the users' thoughts and feelings (Bligård, 2011).

3.2.5 Expression board

An expression board is used to describe the desired expression of the product by using pictures. Usually, a list of words which describe the intended expression is created first, and the expression board is later generated with the help of this. Having an expression board is useful because it provides a visual representation of the expressions the product aims at conveying. In later stages it can also be provided as a reference and evaluative tool, to see if the product fits next to the pictures and carries the same expressions (Bligård, 2011).

3.3 Creation

Herein a description of the methods used to generate new data can be found. These mainly consist of the methods used in the creative phases to generate ideas and solutions.

3.3.1 Workshop

Workshops can be performed in a number of ways, with different types of people attending depending on what the goal of that specific workshop is. The amount of people attending the workshop can vary widely but is usually between 4-15 people. A workshop is usually based around a need or a problem and its purpose is to find a lot of different ideas and solutions. The same way a focus group can help people find and express their opinions by building on thoughts by others, a workshop can help people build on other people's ideas and therefore get further (Österlin 2007).

3.3.2 Osborn's idea spurring method (Adjective/adverb listing?)

When it is hard to come up with ideas, Osborn's idea spurring method is very useful. Alex F. Osborn has worked out a large number of universal questions which can be used to improve upon ideas or explore problems. Examples of questions can be:

Enlarge, replace, combine, modify, add etc. and by applying them to an idea, parts of an idea or a problem one can forcefully generate new ideas or new perspectives to view things. Many of the things generated might not make sense or be good but they can help get the flow of ideas started again. This method synergises very well with brainstorming where no idea is a bad idea as they can inspire new thoughts (Österlin 2007).

3.3.3 Gordon method

The Gordon method is performed in a group where the people attending does not know the problem beforehand. Only the host which leads the event knows the full scope of the problem (Österlin 2007). The host starts a broad discussion around a subject that is of importance to the problem, and feeds more and more information to the group as the discussion progresses. When the group is close to a solution, the host reveals the problem at hand to help get more hands-on solutions. A big advantage with this method is that some inhibition can be avoided due to the free nature of the method.

3.3.4 Morphological Matrix

Morphological matrix is a tool to minimise the risk of missing out of any solutions. There is always a risk that a certain combination of solutions are missed when generating ideas. With this method, ideas are combined in different ways to spawn new ways of thinking and spur new ideas. All ideas are written down and the different combinations which can be made are tried out to create new permutations of the existing concepts (Österlin 2007). It only uses the available content and creates variations of it but the new combinations can still be different enough that they might be useful and might not have been noticed otherwise.

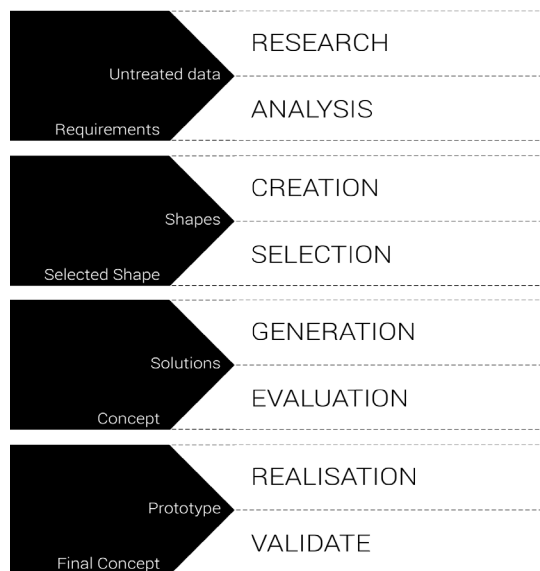
3.4 Evaluative

Once information has been gathered, analysed and found to be sufficient it is used for its intended purpose. The information is not only used during the creation of solutions to fulfill the requirements found but also used to evaluate the success of the solution.

3.4.1 Pugh

A pugh matrix is an evaluative method intended to weight solutions against each other and see which solution that best fulfill the set requirements (Österlin 2007). First, a reference solution is selected towards which all other solutions will be evaluated. After that all solutions are compared against the reference solution on all requirements and given either + (better than), - (worse than) or 0 (equal to). The sum can thereafter be calculated and the best solution can be selected.

Procedure



Below, the process is described in detail. What was done, how it was done and how it would contribute to the end result. The process was split into four parts (planning/ research, shape, concept and prototype phase) which provided clear guidelines and outcomes which defined each phase.

Figure 4.1 Process stages

4.1 Research (1st stage)

The first stage was dominated by the gathering of information. Some initial information was gathered at the very beginning to enable time estimations and planning of the rest of the project. After a plan had been set, the research commenced and eventually resulted in a range of problems that would need solutions, a description of the context and a requirements list against which concepts and ideas could be evaluated.

4.1.1 Plan

In order to ensure that the project is completed on time and with a successful result planning and a detailed definition of the the project has to be made. This is especially important in a project of this size where many deviations, even though individually small, can amount to large delays when added together. The information and results which ought to have been reached at various phases in the project should also be defined to be able to compare to and find out if the schedule is followed.

A stage gate approach was chosen and a GANTT-schedule was created to visualise this. The project was broken down into sub phases of planning, gathering, analysis, refinement and creative phases, the aims of each were noted down and requirements to proceed to the next phase were added as well. Tasks which could be used to reach the necessary goal of each phase were then generated individually for each phase. The tasks were evaluated as for how much they could contribute and the time they would take to perform, after which some were selected and placed in the phase in order to determine the estimated time to complete that phase.

Buffer was added to the GANTT along with important deadlines such as Gothia Cup and industry vacations. These were immovable events which our schedule had to

conform to in order to make the most out of them, and in the case of the industry vacations provided a deadline for a prototype to have been designed. As the project went along, of course revisions had to be made. If a phase once completed did not provide sufficient information to begin the next phase, the goals of the phase could be enlarged. In the cases where information came to light which required a change to the plan, the GANTT schedule could easily be adapted as it's one of the strengths of such a system. The vacations of the manufacturers varied a bit which when added to the GANTT schedule meant the order of a few tasks had to be changed to complete the ones required for different manufacturers.

4.1.2 Introduction to Futchi

At the very beginning of the project a basic understanding of the product type was required in order to begin. After a short introduction given by Aracne, their prototype was tested outside of their facilities and its functions was explained along with their concept of Futchi. This session was limited to first hand impressions and further testing was deemed necessary. There was a risk that the opinions formed in conjunction with the testing accompanied by Aracne could be biased. To ensure that a more unbiased opinion of the product could be formed, further testing had to be done and more first hand impressions had to be attained. The prototype was borrowed and additional sessions were held at local football field without Aracne's involvement in order to ensure a more objective experience and to let random people try it and give their impressions. The disadvantage of first getting a biased opinion and later trying to form a new one is that one might still be affected by the first. It was acknowledged that this could be the case, just as well as it might have the opposite effect in that the attempts to consciously try to form an unbiased opinion could lead to a negative stance towards the first impression and that over compensa-

tions could be made because of it.

The Futchi Wall prototype underwent extensive testing with the purpose of understanding all its characteristics and behaviour under different circumstances. The extensive gameplay experience proved valuable in determining the properties of the product and many different scenarios were attempted. During these early stages of the project the process was very much exploratory and information had yet to be found regarding how users would use it and what different potential scenarios could arise and what they might look like. Because of this, all kinds of possible scenarios and events which could be imagined were tested to cover all grounds. Once it was believed that a decent understanding of the product had been established the behaviour of the product in various untested situations could be predicted with some reliability, which proved useful in later stages. The testing then proceeded by introducing more people to the product, some of whom had previous training and experience in finding requirements and subtle differences.

It was also possible to measure the forces involved through the use of force gauges. Forces were measured both during assembly, during typical usage, and during certain high strain scenarios which are likely to arise on occasion during use. Not only were the forces in various point in the net studied, but also the force required from the user end when interacting with the product and how high the force exerted during particularly straining exercises might be to find requirements for the later concepts.

4.1.3 Market research

Once Aracne's product prototype had been investigated, focus turned to the competitors. Up until this point, the product had been evaluated without a point of reference. By providing something to which the product could be compared to, its position

on the market could be better understood, as well as potential areas of improvement where other brands were considered more successful.

Competitor products were found through resellers, online reviewers of football equipment and a SWOT analysis provided by Aracne. Focus was put on finding rebound competitors, but not exclusively since Aracne had early on pointed out that rebounders are part of a larger category where for instance trampolines are included. As both rebounders and trampolines are home products that can be used to activate children, they are targeting similar demands and purposes, and can thus be considered competing products as they compete for similar market shares. This realisation led to the addition of next step, the similar fields research, in which other product fields which could be considered competing were researched.

As for the field of rebounders, Aracne had previously acquired a Spot Rebounder which is a rebounder developed by Quick-play. It was used in this project during the user studies to provide a comparison to the Futchi Wall. This helped to find strengths of both the Futchi Wall and the Spot Rebounder, as well as their weaknesses.

Aracne shared their own competitor analysis which was used to as a complement to ensure that no competitor was left out and to get a another opinion on the strengths and weaknesses of the competitors. A SWOT analysis of their Futchi Wall concept was also included in order to evaluate the concept. The opinions of parents was also added the competitors analysis through interviews.

4.1.4 Similar fields research

It became apparent early on that there were other product categories which competes with rebounders. Since this product is likely

to be used by parents as a tool to activate kids and get them to play outside, other products which fulfill these goals also had to be considered and included in the analysis. A second reason for researching similar fields is that inspiration can be found within them when it comes to features and technical solutions. It is also possible to use them as comparisons for how well they fulfill the requirements which they share with rebounders.

The exploratory nature of this phase meant that focus at first was directed towards discovering the different fields which could possibly compete with a rebounder as well as unrelated fields which could still carry similar requirements, after which the identified fields were investigated further. It also meant that this phase was likely to be resumed at a later stage, when the requirements had been further defined.

It was also believed that by evaluating the products in relation to each other, a better understanding would be gained for the usage situation the new product was likely to be put in.

4.1.5 User studies

Through the studies of the competitors and similar fields, information had been gathered on solutions already available. This can however only get the product development so far as it limits the solutions to be rehashes and permutations of previous solutions. They can be valuable in that they provide examples of successful features or properties to avoid, but in order to surpass the existing solutions research has to be made on what the ideal solution would be. To be able to contribute something better, several user studies were thus conducted.

Since a lot of information had to be gathered, the user studies were divided into a few stages with different aims to better cover all stakeholders. Both parents and children

might have opinions which could result in requirements and affect the final outcome of the project. It was quickly determined that the best way to get in touch with larger numbers of children interested in football and their parents, was to approach football teams. They are essentially gatherings of exactly the type of people who might be interested in a football product and an obvious starting point. A plan was made to visit a team twice with slightly differing aims at each visit. Local teams were contacted and asked if they would be interested in participating in a study, test out a new product and speak their mind. A large organisation, henceforth referred to as Organisation A, with home field in central Gothenburg and multiple teams was chosen as a main research group since they could provide testing possibilities with teams of either gender and in various age groups (10-15 year olds).

Stage 1 - Organisations A

After the initial tests and introductions to Futchi, some data had been collected regarding players and their opinions. There was however less data representing the opinions of the parents who also ought to be considered as they too are important actors in the lifecycle of the product. In order to get in touch with the parents, a two phase approach was adopted with Team A. The first of the two phases had two objectives.

The first objective of this phase was to gather additional factors which could distinguish a rebounder, aspects in which they could be ranked and affect the success of a rebounder. This was done to provide additional differentiating factors other than the obvious ones to avoid the risk leaving out an aspect critical to the users which otherwise wouldn't have been studied. These factors would later be used in forming the questions in the user study and form a vocabulary in which users could express and rank their opinions. This process can be seen as being exploratory initially, first finding the

relevant questions to ask and later on have users answer the questions discovered. Preliminary responses and opinions were unavoidably gathered early on as well.

The second objective of the first stage was to create an interest among the players, encourage them to tell their parents, advertise the second visit to the team and hopefully make more parents participate during the second visit. It was believed that by announcing the second visit ahead of time, attract the attention of the parents through the excited children and spread awareness that more parents would attend the second visit. The aim of the second visit would be to gather the opinions of parents and their presence was necessary. To divide it like this where the purpose of the first phase was largely to ensure the presence of parents during the second phase was deemed necessary since the parents were thought to be harder to reach and harder to convince to participate in a study..

Stage 2 - Aracne accompanied tests

Aracne were themselves interested in the user opinion of their current prototype, how it could be improved, and to market their upcoming product. They had several meetings with various teams lined up which provided an excellent opportunity to gain some quantitative research. More importantly, the teams got to test the Spot Rebounder alongside the Futchi Wall and additional people there to organise meant that the testing could be more efficient and provide more data. The downside was that there was little control of the structure and timeframe of the tests. The questions found in the first stage were however tried out and there were many opportunities to improve upon our study to continuously enhance it so that later studies without the company present and with full control could be as rewarding as possible.

Time measured assembly of the Spot Re-

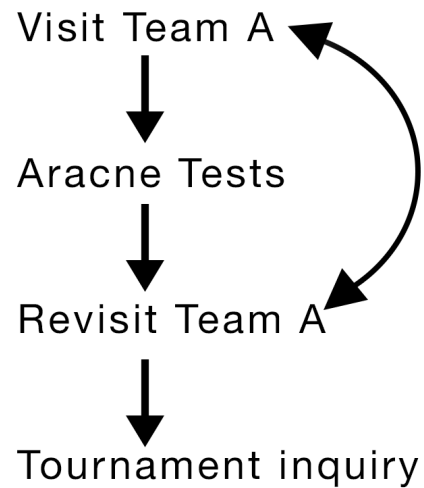


Figure 4.2 User study phases

bounder was also performed where many users got to try it, both after having first seen it assembled, with and without instructions and alone as well as in groups. Issues they had assembling it, parts assembled wrong and their thoughts, which they were asked to express during the assembly were noted.

Further comparison between the spot rebounder and futchi wall was also carried out during this stage, along with interviews with parents and trainers to gain a basic understanding for how a product like this would fit best into their home environment.

During this stage, approximately 60 youths of both genders between the ages of 10-18 years were interviewed in smaller groups.

Stage 3 - Revisit of Organisation A

Since such a large focus had been on the children up until this point, it was confirmed that the initial intent to spend a lot of effort to get in touch with parents was warranted. Initially this revisit of Team A was supposed to be a focus group with parents. Unfortunately, no parents arrived due to an error in communication between the trainer and parents. Instead of the focus group, trainers were interviewed during the practice and shorter, non-structured interviews were held with parents coming to pick up their kids after the training. The research

however still lacked information from the parents after these short interviews, and more parents had to be questioned.

The preparations which had been made for this event had however not been made in vain. An interview guide had been made based on the response of the first visit which would come in useful during stage 4. The aim was to have a focus group with parent during this visit and a mediating object had been brought to help them describe their thoughts and more easily express ideas and opinions. This meant that this visit could still be salvaged as the mediating object was a competitor's rebounder, and it could be further tested and evaluated as an extension of stage 2.

Stage 4 - Tournament inquiry

There were less parents present than anticipated in stage 3 but it was discovered that Organisation A were going to host a tournament at their location where several other teams had been invited to compete. During an entire weekend these teams gathered there to play with many parents present, especially parents of teams which had travelled there and who had come to cheer on their children, accompany and help out the coaches of those teams. This provided a unique chance to collect the thoughts and opinions of parents. Some precautions had to be made since bothering parents when they were spending time with their children was deemed a bit insensitive. Parents to interview and have focus groups with were selected based on the teams currently playing and whether they appeared busy or not. No negative attitude was met and all parents which were asked happily agreed to participate in the study.

The parents were asked to describe themselves and were then shown images depicting a few different anonymous rebounders. They got to describe and discuss them one by one, and also make comparisons between

them. Ranked lists were also made where the rebounders were ranked from best to worst in aspects identified to be of importance to the users. In some cases, probing was used based on the questionnaire to ensure that the questions on it could be filled out.

Some parents were interviewed in pairs or groups but all in all about 20 parents participated. Information was gathered on environments and context, stakeholders and competitors to provide a full picture of what the product would come in contact with. Throughout the studies, many stakeholders were discovered and these groups had to be defined and analysed.

4.1.6 Stakeholder mapping

Identifying the stakeholders was fairly straightforward since many of them had been mentioned during the user studies. The data was refined a bit to further define and differentiate the different stakeholders and make the data easier to use. The characteristics which distinguish them were noted down along with their individual relations to the product and to each other. They were ranked in accordance with their estimated importance and how much of an impact their opinions should have on the final product. The requirements which had been discovered were also later assigned to the stakeholder(s) responsible for them.

4.1.7 Requirements identification

The comments and opinions found in the studies were organised based on their field. Knowing which stakeholder they came from allowed them to be ranked in importance, which also depended on the frequency of responses as well as the way they had been expressed. A KJ analysis was made and several distinguishable fields began to emerge which led to categories in the resulting requirements list. In addition to the requirement list, scenarios and personas were

created to illustrate the distinct user groups which had been identified and further define the requirements.

4.1.8 Guideline generation

Requirement specification is a way to summarise the demand and bridge the gap between market opinion and concept generation but the gap which remains between requirements and concepts can still be hard to overcome. A number of design guidelines were created based on the requirements in an attempt to bridge the remaining gap. Some of these were well known guidelines of how to express certain values while others were general ideas of how to fulfill one or more requirements in the requirements specification. These were collected into a list in order to facilitate later idea generation phases and bridge the gap between requirement and solution. Product development can be described as the bridging of the gap between demand and product to reach a solution which fulfills that demand. By introducing middle grounds, the steps can be made smaller and the phases easier to undertake. It also provides additional points where stage gates can be put to confirm that you have completed the process to a satisfactory degree up to that point.

Guidelines were first generated through brainstorming surrounding the requirements. Some were learnt throughout the education and had to be confirmed through literature studies. This led to additional research in literature and prior research where many guidelines can be found. For example in the fields of semantics, semiotics and expression, there are many tips to be found. This allows the use of the results of prior studies in order to not have to repeat a similar or identical study oneself. It is however important to be careful when applying the findings of a study made in a different context as it might not apply to all cases and scenarios. This is why one has to be careful and evaluate the validity of a given finding

in a particular field before assuming that it is valid there too and apply it without caution. It should be confirmed that it is valid in the other field too, or set a limit to findings general enough to be believed to be applicable everywhere, or those researched in the very same field, context and circumstances. The advantage of using prior results is of course that extensive research is not necessary to reach a given finding and the process can be sped up greatly. There is some redundancy towards the final stages of the process where concepts are evaluated and it becomes apparent whether a feature or idea panned out as intended and contributed as was expected from the research which had led to it.

Some of the requirements and guidelines which had been listed at this point dealt with the semiotics and expression of the product. Although they had been expressed through words and formatted in the same fashion as the rest of the lists their visual nature meant that they were harder to grasp. In order to more easily be able to quickly retrieve the information, a visual tool was adopted to convey these guidelines and ensure that people involved in the creation process would have a unanimous view of the product and what it should express. An expression board which consists out of images which depict and represent the desired expressions could convey them faster than words, as well as be a tool during its creation around which discussions could be held regarding the desired expression. Not only does it work as a tool during the later stages, but when creating the expression board the exact meaning is ironed out and the details regarding the expression are discussed, something which isn't done to the same degree when simply putting it into words.

An expression board was deemed an appropriate tool to accomplish all of this and images were collected and selected in order to collectively represent our envisioned prod-

uct the best. The selection process increased the depth of these requirements further and the information had to become more detailed in order to narrow down and choose images.

The resulting expression board summarised the desired expression of the end product and could ensure coherency in all the visual aspects of the product through the subsequent creative stages. It collected a lot of information into a single page of images which would otherwise have been ungraspable had it been written as a page of text.

4.2 Shape (2nd stage)

Once the gathered information had been analysed and summarised in the form of a requirements list, persona, scenario and design guidelines, the creative phases could commence. Through ideation, workshops and evaluations, a set of generalised shape concepts were created and presented to the company. With the help of Aracne and an external design company, a selection was made of which shape to develop further.

4.2.1 Concept sketching

A plan was made to host a workshop and to be better prepared, sketching sessions were held beforehand. By generating ideas beforehand areas in which less ideas are found can be identified. Later workshops can then be focused towards these problem areas to ensure the most usable outcome from the workshop and to generate ideas which better complement the ones already found. During the ideation sessions, a lot of methods could also be tried out and evaluated to find methods and tools which could be useful for the workshops. Pre-made tools such as sheets with Futchi Walls in different angles were printed out to facilitate and speed up the sketching and creation of concepts. This prevents the need to hold a new idea in memory while you write the current one down in a case where you get



Figure 4.3 Concept generation and sketching

ideas at a fast pace and decreases the risk of an idea being forgotten and lost. Osborn's idea spurring method was used extensively throughout and the ideas were sorted in categories using KJ analysis make sure solutions were generated on all problems.

4.2.2 Workshop at IDE Master's Programme

People with experience in product development and ideation workshops were invited to a workshop where they were provided with papers, pens, pre-made sheets with printed nets in various perspectives and inspirational images. The workshop had been planned beforehand and consisted out of a few steps where the six participants performed different tasks. The layout was heavily inspired by the Gordon method where the participants were introduced to infor-



Figure 4.4 Workshop with preprinted nets

mation slowly and their awareness of the problems slowly increased.

The first round of ideation during the workshop was a warmup meant to get the participants started in thinking creatively and introduce them to the subject. A brief introduction to rebounders in general was given and they were asked to brainstorm on the topic of “how to attach a net in a garden”.

In the next round, the concept of a frame was introduced. The participants were divided into 3 pairs which were allowed to discuss together while sketching and generating ideas. By allowing small discussions, the risk of getting stuck is decreased and ideas can be developed further by spinning off each others’ ideas. Two people will be able to see more possibilities with an idea than just the creator alone. There were still 3 groups however, to avoid the issue where the ideas converge and the variety is decreased. The pairs were introduced to problems by being given a requirements to solve. Different requirements were given to each group and only one at a time. The requirements and their order can be found below.

Group 1

1st - The user does not want to wear the lawn at the same spot over and over, and be able to keep the lawn nicely mowed.

2nd - The user wants to bring the product to their summer home.

Group 2

1st - The user wants the product to stand firm when in use

2nd - The user wants the product to feel safe to use(both look and express safe as well as be safe)

Group 3

1st - The product should take no more than 15 minutes to assemble

2nd - No special tools should be required to assemble the product

The groups were given time to come up with ideas based on the introduction of their first requirement, time to discuss and then repeated with a new requirement presented to them. At the completion of these rounds, the table was opened for an inter-group discussion where they got to present their ideas and discuss them. All the requirements of the other groups were then introduced to the participants. Another session of idea generation was held now that they were aware of all the problems, after which a final discussion of the results was held.

4.2.3 Shape Generation

The workshops and prior idea generation had yielded a large number of ideas, some addressing only small aspects or very loosely described and others more refined. They were used as basis and inspiration for the generation of shapes and once this source had been exhausted, a morphological matrix was employed to further combine ideas into new shapes.

To enable a more impartial representation and to better be able to evaluate and present the shape ideas were all depicted equally using sheets with the same net printed on it. A schematic view of the shape was drawn in line-style and they were all scanned and placed on a sheet with numbers to display them as impartially as possible in coming evaluations.

4.2.4 Shape Evaluation (Workshop with Propeller design and Aracne)

While creating the shape ideas, it was hard not to also evaluate them at the same time. Upon reaching this stage, an opinion had already been formed to some degree through the discussions had when creating them.

After an initial evaluation of the shapes had been made, a workshop was held with Aracne to allow them to check the progress of

the project and provide input on the concepts created thus far. An external design firm was also included in the workshop since they had previously been hired by Aracne to design the company profile and help them develop the Futchi Wall. The design firm attended the workshop through a video call and material, images and an agenda was sent prior to the workshop for them to look at and print to have available during the session. The design firm was also asked to prepare a short presentation on branding and their involvement in the development of the Futchi Wall.

The session began with a case presentation of this project and its purpose, after which the design firm got to hold their presentation. Once introductions had been completed, the shape concepts were discussed mainly in terms of their expressions. This was done early on with no further information provided by us in order to maintain focus on their expression rather than other advantages and disadvantages of the concepts or what would be the ideal expression. Once this impartial evaluation had been made, each shape concept was presented with the pros and cons we had found as well as possibilities they had for further improvement. The target expression and the requirements we had found in our research was then presented to evaluate against.

There was a possibility that their opinions on the expressions of the shapes would have been biased had the results from our study been presented. By first presenting the shape concepts at the workshop without additional information, they were judged solely on their overall shape and expression. This excluded other factors which could affect the outcome of the evaluation and isolated their impressions which was the main purpose of the different shape ideas. Finding which shape best corresponded with the desired expression without them knowing the desired expression allowed for a more impar-

tial evaluation. The design firm was used for this evaluation because of their knowledge and experience on the matter.

The participants were then introduced to additional information and the change in how they perceived the shapes could be observed. Once introduced to the requirements list, the users through the persona and scenario, and the evaluation of the shapes made prior to the workshop, the company was allowed to make up their mind again. This was an additional advantage of this procedure as the change of opinion and how good a concept now appeared could be correlated to the new information presented, the demands of the users. This was done to reach a more unbiased evaluation as the personal opinions of the participants could be distinguished from their evaluations with the users' opinions in mind. The first evaluation they made was based on their own opinions and formed a baseline, whereas the changes in the latter evaluation were caused by their new knowledge of the users' demands and were more representative of what the users think.

Once first evaluation had been made, the additional information presented, and the shapes reevaluated, the selection process could begin. Suggestions for ideas to combine between different concepts were found and the number of shape concepts were narrowed down through discussions and selection. Once a few remained, it was decided that one of them was to be further developed and a few others kept as back-up ideas.

4.3 Function (3rd stage)

A mock-up was built to further evaluate the chosen shape and also review the desired functions and possibilities this shape had to support. It allowed functions generated and problem areas to be investigated in more detail using. The objective of this phase was

to create, combine and evaluate functions and all their permutations. This phase resulted in a selection of functions which were found to be suitable to evaluate further and which required a more elaborate test rig.

4.3.1 Function generation

When the shape had been set, the next step was to generate the necessary functions and apply them to suitable parts of the general shape. This was mainly done by posing the requirements as questions, e.g. “How can you provide different angles for the net”. Osbourne’s idea spurring method was also used a lot during this phase to try and re-think the problems posed and force new ideas to be thought of.

Most of these functions and ideas were sketched out on paper, although some of them were created and tested through quick and dirty models to give an idea of how and if they would work in reality. The functions deemed necessary were then further improved into basic solutions for evaluation by using a mock-up.

4.3.2 Mock-up

A mock-up was made to better understand the behaviour of the frame and its interaction with the Futchi Wall during play. The dynamics of the net are difficult to predict or make calculations on. The characteristics of the impact of the ball on the net, how it transfers its energy and the net’s specific characteristics are complex and largely undefined. It was deemed easier to test it using a simple physical mockup rather than to simulate the conditions and scenarios.

The creation of a mock-up was also necessary to provide an idea of its size and handling. This is something which sketches and scale models do not provide, which also makes it harder to assess the feasibility of different solutions. An easy way to apply solutions or to quickly evaluate their

feasibility during a discussion by using the mock-up was later found to be very useful as well. Working with a tangible representation instead of ideas sketched on an abstract level no longer prevented ideas from being discussed and evaluated in detail which allowed the solutions to become more detailed.

4.3.3 Usage evaluation

Most of the evaluation at this stage resulted from people testing to play Futchi on it. This provided a good basic understanding of what worked and what needed improvement regarding the regular usage situation of the product.

Because stability was found to be an issue on many of the competitors products, a stability test was deemed necessary to evaluate how the product would behave during usage. A ball was systematically kicked towards the net at specific locations for a specified number of times to simulate a game of Futchi, the distance the mock-up moved was measured and the average calculated. The test was then repeated with weights added to different parts of the mock-up to find out how this affected the dynamics of the frame and the movement. Blocks were also added under the back legs and moved to find the point at which the frame started to tilt backwards. This was done to estimate the required length of the back legs. The strength of hits were exaggerated a bit throughout these tests to be able to ascertain that the test results would valid under all circumstances. Some additional results concerning the usability were also received from handling and interacting with the mock-up during these tests.

4.3.4 Manufacturing technique evaluation

The functions and solutions generated thus far required various manufacturing techniques to be feasible. Evaluations of these

functions and future solutions thus depended on knowledge of manufacturing techniques. An advantage or drawback of a manufacturing technique is in extension also an advantage or drawback of any solution which depends on that manufacturing technology. This favours solutions which can be made using several manufacturing techniques. When functions and solutions were created the manufacturing techniques which were tied to them were investigated as the need arose.

Manufacturers involved in their respective fields were contacted and interviewed to find out more. People and companies dealing with several techniques were of particular interest since they could provide comparisons and were believed to be less biased towards their technique compared to a company only working with one. Other than expert consultations, research online and in literature was performed to find the characteristics of manufacturing technologies, cases when they are best suited as well as to discover techniques previously unknown to us.

The techniques investigated did not only revolve around part creation, but the entire manufacturing process which included assembly, different extrusion profiles, welds, fasteners and materials. One of the main objectives was to evaluate the plausibility of a part being created within a reasonable budget. General knowledge and familiarisation also proved useful in later stages to quickly assess the feasibility of a solution in relation to the allowed cost.

4.3.5 Cost estimation

In addition to familiarising with various techniques, cost estimates had to be made which required specific examples. In some cases it was done through trial and error by trying out different solutions to get an idea and make it possible to estimate costs in the future when more specific solutions

had been created. When possible, a formula was created of startup cost and per unit cost along with any variables such as thickness or size which could be of importance. There are also cost estimation tools such as which greatly aided in this process such as the one by CustomPartNet (2014).

In order to ensure that the cost of the end product remained within the limits set by the company, a cost estimate had to be made. The cost estimation was done using Excel sheets where data was continuously added as information was gathered. In the early stages of the project, a max/min approach was used where estimates were made regarding the minimum and maximum cost of potential components and expenditures which when added yielded a max/min value for the final cost. As more and more information was gathered and more choices were made, the data became more accurate and less reliant on the initial estimates. The range was narrowed down throughout the project and made more accurate until the prototype was ordered where actual figures were determined. The cost estimation sheets affected choices during the project where certain options would increase the upper limits a lot, vary in price greatly or be dependant on order volume for instance. There were also other excel sheets which addressed the issues of mass production volumes, different concepts and various options such as the selection of corner solution and manufacturing location.

4.3.6 Solution generation

During the solution generation, the necessary problems and problem areas had to be specified first. These problems and problem areas were mostly derived from the testing of the mock-up and comments recorded during the user studies. A sketch overview of the whole concept was created to easier plot out the different parts of it that would need solutions generated. Once again, Osbourne's idea spurring methods were used

along with posing a question based on a requirement related to the problem that would need a solution.

4.3.7 Solution selection

When solutions had been generated, they had to be evaluated. They were mainly evaluated with concern to price and feasibility, because of the narrow budget. Thanks to the mock-up created earlier, if it was unclear whether a solution would be feasible or not, the solution could be tested on the mock-up and evaluated.

All of the feasible solutions were then evaluated with Pugh matrices, where price weighed heavy. Both the best and the cheapest solutions were brought along and considered worth testing in the final prototype, although the cheap solutions were prioritised in the cases where it was not possible to apply and test them both. Whenever possible, additions were made to enable several solutions to be tested simultaneously in the one prototype.

4.4 Concept (4th stage)

In order to evaluate and work out the solutions on a more detailed level, a fully functional prototype closer to a finalised product had to be built. Detail solutions which had been generated and evaluated earlier had to be refined to work with the selected manufacturers. They were applied and a CAD model was made, ordered and assembled to undergo further testing.

4.4.1 Prototype manufacturability

During the detail CAD there were continuous discussions with the suppliers, particularly in regards to the sheet metal parts. Adjustments had to be made in certain cases where the particular tools and machines of the manufacturer weren't able to make the desired operation. Pricing and availability also limited the choices somewhat and the

nearest dimension had to be chosen and the appropriate modifications made to accommodate this change in the other parts.

4.4.2 CAD, part selection and Ordering

The prototype was designed and drafted in Pro/Engineer Wildfire 4.0 with a significant amount of intermittent sketching to discuss and solve problems and clashes which arose during the finalisation of the design. Some issues became apparent when actually viewing the design in its entirety and moving the flexible joints around. These details had to be sorted out as well as some adaptations applied to allow for more tests to be made and make the product easier to assemble.

Catalogues were browsed for useful solutions to apply and solutions were in some cases switched out to similar enough standard components. This to use the advantages of mass production wherever possible. Some of these replacements were compromises and not ideal, but they allowed for testing the principles of the solution without having to make custom parts simply to test the feasibility of it. In the future, there is the choice to either make the custom solution or stick to the standard component depending on the results of the test.

The orders for the different parts were placed largely in order of their estimated delivery times as far as it was possible. Availability of standard components was checked and items which weren't in stock were ordered early to keep the waiting times to a minimum. There were four main categories of components; aluminium profiles, steel profile, custom sheet metal parts and standard components.

4.4.3 Assembly

Because of time constraints which required the orders to be placed and shipped before the industry vacation, some features on the

parts had to be skipped and manually added during assembly. There were a few faults made by the manufacturer as well which had to be corrected. This included tapping a few holes, deburring edges and smoothing out sharp corners, rounding off places where they had approximated using the closest press braking tool the manufacturer had available and where this caused a problem. The holes in the profiles had to be drilled as the supplier of them only offered to cut them to the right lengths.

In order to facilitate assembly and require less tools, screws nuts and bolts were used instead of rivets. These had to be cut to the correct lengths in certain locations where a specific length was required, this in order to remain within the range of commonly available lengths.

Plans had initially been to powdercoat the entire prototype. After some initial tests held outdoors prior to powdercoating it, early signs of rust began to appear and the prototype was sanded and hobby spray paint was applied to protect it.

4.4.4 Prototype evaluation

In the early stages of the requirement listing, considerations were made for later evaluation stages by adding criteria for the fulfillment of the requirements. Although the measurement and criteria were saved in the requirement list, the specific way in which they should be tested had been left for later as this might depend on the outcome of the project and the design of the prototype.

Once the evaluation stage of the project had been reached, a prototype had been made and the tests could be designed on a more elaborate level. The testing procedure can be found in appendix I but a summary thereof can be found below. Tests were designed, one for each requirement except in the cases a test could be used to verify several requirements at once. The results of the

tests were then compared against the criterias in the requirement list to check whether the product had successfully fulfilled the requirement or not.

Mobility

The main objective of this test was to assess the ease of movement for the product when assembled. This would fit a scenario where the user wants to move the product a short distance quickly, for instance when mowing the lawn. Users were made to carry the product a short distance in a mounted state with either the steel bar and aluminium bottom bar to evaluate if it had an effect.

The product was also disassembled and carried. Dimensions of the product when unmounted was recorded as this is the likely state in which the product will be stowed away when stored for longer periods of time.

Safety

It is difficult to estimate what possible dangers might arise with usage of the product, and although attempts can be made to misuse the product or treat it carelessly, one cannot be sure that all possible hazards have been discovered as this test is of an exploratory nature. Ensuring that a product is able to do something is as simple as finding a way in which it can, whereas ensuring that a product isn't able to do something involves finding all possible ways it can happen and evaluate if they can.

More elaborate testing of the safety was thus left as future work, especially since this field is dominated by regulations and standards which the testing ought to conform to. What can be determined is that it would be advantageous for the product to be licensed and certified to fulfill the official standards there are concerning safety and child use, for instance "Leksaksdirektivet 2009/48/EG" and any other similar ISO standards there might be.

Functionality

Sessions were made using the prototype where Futchi was played with it in different environments. It was assembled next to a 5-a-side goal where a Futchi Wall was mounted to provide a good comparison and a yardstick to which the Futchi Frame could be evaluated. A few people were invited to play Futchi against each product and then the other to compare. This yielded relative evaluations where either product was described in terms of differences to the other. To ensure that people did not get accustomed to one of them first and then tried the other, which could have skewed the results in favor of one of them, some of the people started with the prototype frame whilst others began with the Futchi Wall mounted in a goal.

The distance which the products had moved during the session was measured and attempts were made at shooting as hard as possible on the Futchi Frame and Net to see if this caused any unacceptable movement. Criteria for the allowed movement had previously been determined based on what would be required to disturb a game of Futchi.

Assembly

People were made to assemble the product and the time taken was measured. In order to discover as many potential problems as possible, several people were selected from a background of product development with experience in problem finding and problem definition. They were given no instructions, and a few different scenarios were played out. Some had previous knowledge in that they had seen the product assembled. The starting points were also made a bit different among them. Some just started with a bundle of all the parts jumbled randomly together, whereas others had the parts placed out upside down or laid down in their approximately correct locations. This

was done to prevent any bias which might have been caused by the arrangement of the test preparations. Any faults made were also noted during the testing as well as the order in which they assembled the parts.

Expression

Pictures of the prototype as well as some of the main competitors were printed on paper and people were asked to rank them based on perceived quality, stability, professional and price. They were also asked to evaluate how the expression changes when the net was attached and when the prototype was standing alone.

Durability

The strength of the product was evaluated through several playing sessions where it underwent many typical usage scenarios and where force was exerted on the frame. The timeframe for the testing was severely limited and long term testing is required to confirm how the results will stand over time. Some calculations were made initially to ensure sufficient strength of the core structure, but grit in mechanisms, rust or any other potential deteriorations which might accumulate over time was only estimated.

Main function

Since the main objective was to have the net attachable to the frame, and therefore also easy to confirm. Is it possible to attach the net to the frame, yes or no?

Results & Analysis

This chapter will present the findings from the research phases and the analysis thereof. The results are presented in four blocks, one for each stage in the process. Requirements are extracted from our findings and resulted in concepts which were evaluated, refined and finally resulted in our prototype which is presented next.

5.1 Research (1st stage)

The first stage deals with the result of the research, and summarises much of the information gathered throughout the project. It describes our early findings and the results from the studies which were performed prior to our own content generation.

5.1.1 Competitors

During the research part of the project, a lot of competitors which focused on various price points were found. These ranged from the cheapest low-quality products aimed towards home environments, to more expensive products targeted towards the more professional segment and larger football clubs. Price, quality, mobility, size and extra features are some of the aspects in which they differ, but the function remains largely the same. Some of the products were easy to disassemble and move to a different location, e.g. bringing it to the beach or vacation home, whereas some had more of a permanent installation. Another common occurrence is that many rebounders are marketed not only for one sport, but that they can be used for a large variety of sports.

When the Futchi Wall was compared to the Spot rebounder, some weaknesses of both were found. When kicking the ball against the Spot rebounder, it quickly became apparent that it was very unstable. During play, bags filled with sand which were included with the product, had to be placed on the bottom parts to keep it from falling over. The test subjects disliked this and it was perceived as a lower quality product because of it. The stability provided by this extra weight also appeared to be insufficient. When comparing the weight of the two the Futchi Wall and the Spot rebounder were approximately equally heavy. This led to the conclusion that a separate mounting solution for the Futchi Wall would have to be extremely light in order to compete in the same market, which in turn would probably

amount to an unstable product which could imply low quality.

The competitor analysis concluded in dividing up the market in three parts to allow for future investigation when user studies will show which part of the market to penetrate. Below are representative products presented, once for each price bracket.

Spot rebounder - Low end

The spot rebounder is considered dominant in the lower price brackets. It is smaller in size and mounted on a light and flexible tube frame which flexes under the tension of the in comparison more inelastic net. It is lightweight and it's possible to mount it in about 2 minutes which makes it easy to transport and assemble. It gives a freedom in usage since it can be used pretty much anywhere, stored away easily, and does therefore not need a specific place outside all the time. Because of its low weight, it is also easy to carry it while walking or riding bicycle. The spot rebounder has a big red dot in the middle of the net, which was appreciated (especially by younger users) because it provided something to aim at.

What it gains in ease of access because of its low weight it unfortunately loses in stability. Parents with larger gardens that own the spot rebounder stated during interviews that "it's bothering that it isn't stable on its own" and "I have to use sand bags and tent pegs to make it stable" which would indicate that the added weight of the included sandbags isn't enough.

In conclusion, the spot rebounder is preferable when you don't have or only have a small garden and don't want to, or can't, leave the rebounder out at all times. It is aimed towards private home environments and not teams.

TEKK - Mid end

The TEKK Trainer is a bigger and heavier

product, aimed towards being more permanently installed. It is still possible to fold it together into a package to allow easier storage and transportation, though it is not a product which you carry down to the beach or similar (like the spot rebounder). Because it's weight is around 20 kg, any longer transportation requires a vehicle. Since this product could not be acquired during the project it wasn't possible to make a comparison of stability. Based on reviews and videos of the product it was assumed to be fairly stable.

In conclusion, the TEKK Trainer is a higher quality product than the Spot rebounder (better stability and expression although sacrificing some mobility) and it also has a larger net area to aim for. It is not as portable as the spot rebounder, but because of this it's a lot more stable and does not need tent pegs to keep it in place. The TEKK Trainer is aimed towards both home environments people as well as teams.

Munin sports - High end

Munin Sports Pro rebounder is in the top-most price bracket and a top of the line product, but also the largest and heaviest of the ones listed. It is equipped with wheels which allows it to be moved around. It is however not possible to easily disassemble it to allow for storage during for instance off-season. Some of their products also have a phone holder, where you place your phone and run their app which can then keep track of the hits as an added feature.

Because of it's price, size, and weight, it is almost exclusively aimed towards teams or people with large gardens that can accommodate a bulky product like this. Munin sports is also one of the few companies that tries to create something extra around their product.

Similar fields

When it came to products which are simi-

lar in application and purpose, trampolines and swing sets were the most notable. The information of relevance to this project was that people tend to dedicate about half a day for assembly of a trampoline and it isn't disassembled until winter. It was therefore concluded that having an extremely fast assembly would not be of highest importance for a product which will be left mounted during the summer, i.e. put up during early spring and taken down during late autumn. Some products such as swing sets are commonly even left partly mounted during winter.

5.1.2 Stakeholders

Two distinct user categories were found into which most users can be sorted into. They differ in how they live and would use the product. The two groups are characterised by their living conditions, where the first lives predominantly in apartments in cities whereas the second lives in suburbs or in the countryside. Storage possibilities and access to goal frames are two key areas where the two groups differ and which are relevant to this type of product. The distance to the nearest football field, and in extension a five-a-side goal frame, is generally shorter in the city and there are usually also better means of travel provided. On the other hand, there is often less storage space, no garden or lawn, and no place to store a large product when not in use.

The target audience, in terms of buyers, were identified mainly to be parents with children who have an interest in football. Parents of less active children were considered as possible buyers since they might want to buy it to get their children to exercise, but less attention was put on this group considering the Futchi concept. It was believed that a larger interest in football would result in a stronger adoption of the Futchi sport and higher chance of actively joining the Futchi community. Using the product as means to get an uninterested child to play outside was believed to be more short-lived

and less likely to lead to a deeper involvement in the Futchi movement.

Since the product is geared towards children and youths, a distinction can be made between user and buyer or owner. In the lower age bracket, it is likely a parent or coach that buys the product for the child or team who then uses it. The product has different purposes for these groups. A parent is for instance likely to get the product to activate their child outside or to support the child to help him or her to develop in something they enjoy. A coach is likely to purchase the product partly to help the team develop their technique and partly to offload the trainers by occupying part of the team in a task which doesn't require supervision. Similarly, institutions such as schools and youth recreation centres might buy one to provide more things for the children to do and require less supervision.

There is another type of stakeholder which combines many attributes by being both the user and owner. These particular stakeholders are adults or children in the upper age bracket who buy the product for themselves. This group is predominantly found in the apartment-living group described above.

Other stakeholders include the production chain consisting out of the company which developed the idea and invested in it, Aracne themselves, the manufacturers and subcontractors hired to build the product and the distribution and logistics responsible to get the product to the retailers who sell and deliver the product to the customers. Design for manufacturing hasn't been worked with much during the course of this project other than to fulfill the cost requirements since it was considered outside of the scope of this project. These three stakeholders have added requirements such as the maximum cost, size of the packaged product and ease of manufacturability but no detailed

research has gone into investigating any other specific demands they might have.

5.1.3 Personas and scenario

Some demographics and stakeholders are not represented in the personas since they contribute no extra requirements or value. For instance the parent of a child in an apartment is less affected by their child using a rebounder as they will be using it elsewhere. Listed are 5 key actors who are significant in that they come in contact with the product extensively and all have demands on its design and usage.

Older player

Fredrik is 17 years old and lives in an apartment in central Gothenburg with his parents. He has football practice 4-5 times per week and also plays a match once per week. During the season he does not have much time to play outside of practices, but during the off-season he regularly takes his bike down to the closest football field. He is usually there from 30 minutes to 2 hours, and sometimes plays alone to practice shooting and improve his technique, and sometimes with friends.

Younger player - urban environment

Kristin is 11 years old and lives in central Stockholm. She has played football since she was 6, and her father is the trainer of her team. She has no football field close to her home, but she has some open grass areas that are close to her apartment. Her friends does not live very close to her, so she can't go down to the field and play with them whenever she wants to. Her father likes to play with her but he is very busy and rarely has the time for it.

Younger player - countryside environment

Hans is 13 years old and lives in a house with a large garden in a small village. There are plenty of empty fields around and the soccer fields are rarely booked. The large garden accommodates his needs however,

and he can play soccer at home. When he is playing alone at home he likes to make tricks and play against a wall of the house. The only times when he travels to the soccer fields to play is when he wants to play with friends and they can't all fit in their garden, or they want to have a competition which requires goals.

Parent

Eva lives with her husband and her three children in a house in the suburbs. To encourage their children to stay active and go outside of the house, leaving ipads and computers, they bought a trampoline which they leave standing in their garden during summertime. The children also play soccer so they have also recently bought a rebounder for them to play with. When the lawn needs to be mowed they have to move these large objects which can be cumbersome. The rebounder in particular causes the lawn to be worn in front of it so they regularly move it in their yard.

Coach

Kenneth is a 43 year old coach for a local soccer team where his own child also plays. He does this in his spare time and does not get paid for it. It can at times be difficult to get enough help from other trainers and his team of 17 young boys can be a handful. He tries to keep up and part of the reason why he does it is to keep himself active, although he enjoys watching the players develop their skills as well.

Villa garden and/or summer house

In the garden, the rebounder is used a lot like a trampoline. It is assembled in the spring and disassembled in the autumn and brought in for storage. The rebounder could be left mounted during the winter and only the net would be brought in for storage if the product could withstand the weather during winter.

When the product has been assembled, it is

only moved around when the lawn is being mowed or to avoid wear on the same place during the whole summer. Users with summer houses will probably bring it with them when going there.

Users would also like to be able to quickly disassemble it for hiding when they have guests (not necessarily a complete disassembly), and later quickly reassemble it so that the kids can play with it.

With the product in the garden, it will be used both for shorter and longer periods of time. It will also be used for both technique training while alone, or with friends playing Futchi or similar games.

Apartment

Since there is no access to a garden or lawn, the rebounder has to be brought along to nearby soccer fields. Since it takes some effort to get there, the user seldom plays alone and is often accompanied by friends who all planned to meet up at the soccer field beforehand since they all lack gardens. The rebounder is assembled there and played with until the users are tired which means quite long sessions. Once done, the rebounder is disassembled and brought back home. The rebounder can't take up much space once disassembled since they have limited storage capabilities in their apartment's storage unit.

At Practice

A soccer team owns a rebounder which the coach brings to practices. He mounts it before the practice begins and the players get to train with it as they arrive, as some usually arrive early and have been training a bit at the soccer field already. Once the players have all arrived, the practice can commence. Sometimes the coach also incorporates the rebounder in the training, either by letting a part of the group use it while he is occupied with the other parts, or as a direct tool used in a particular exercise. The rebound-

er can offload some work from the coach and he doesn't have to depends as much on help coaches and additional leader figures. Once the practice is over, he disassembles the rebounder and takes it home with his car again, along with all the other training aids he brought.

5.1.4 Requirements list

Below is a summarised version of the requirements. The complete requirements list can be found in appendix V.

Assembly

The assembly should be a "quick and pain-free" experience, as expressed by parents who had experience with similar products which were troublesome to assemble. The factors mentioned to be of importance in order to judge the ease of assembly was the time required, additional tooling required, ergonomics and forces needed, and the number of adults which would have to be present. Once initial assembly has been made, an adult should not have to be present during mounting and use in order for it to offload a coach or for parents to allow it to be left unattended in the garden.

Mobility

The demands on mobility varied greatly between the two user groups characterised by their living environments. The ones who live in an urban environment need the product to be easy to carry to and from the apartment or a storage facility and fast to assemble once at a suitable location. Users living in houses in the countryside with ample space and a garden claimed they would likely leave it mounted in the garden during the entire summer. There are competitors for both these fields, but most notably, Aracne's current product with its high mobility, targets the former user group due to their easy access to goal frames. Developing yet another product aimed towards the same market segment was deemed unwise and to instead extend their product range

to better cover the second user group would better fit their product portfolio instead of competing with their own product.

Upon studying this user group, it was found that the demand for mobility was indeed fairly low as our initial studies had suggested, but there were a few demands still. The mobility required is limited in distance as it will mostly be moved shorter distances on the lawn as well as in and out of local storage. The parent, or owner of the garden, wants to prevent damage to the lawn which might occur if the product remains in the same spot. To prevent a certain area of the lawn to be worn out, it would be desirable to be able to move the product a little every now and then. Enabling the lawn to be mowed leads to much the same requirement which confirms its necessity.

Some of the interviewed parents stated a wish to bring it with car to a summer home, or in a caravan/camping bus to a camp site. This led to the conclusion that the product would need to be disassembled to a manageable size. The other stakeholders also contribute some to these requirements. There are logistic requirements from the company and distribution chain which limit the size of the product when packaged. Since Aracne's distribution chain has yet to be developed, the exact criteria for this requirement remained unknown, but the maximum length as well as weight were limited.

There are also cases where the garden needs to be used for another purpose, for instance when having people over, and parents expressed a desire to be able to make the product unintrusive. That objective can be accomplished in several different ways. One could make the product blend in into the garden, make it foldable to remove it from sight or easily moved out of the way. This requirement was thus kept on an abstract level to not exclude any solution to it.

Durability

The durability requirements are also linked to the choice of which user group to target. Since the product will be left outside for extended periods of time, it needs to be able to withstand weather, wear and tear. This includes both damage which occurs during play but also that which it might be exposed to when simply standing there not in use.

This is to be considered as a premium product and given the price range, it needs to both look, feel and be durable. Research showed that if the product expressed durability it also expressed quality and these are two expressions which the product needs to embrace.

Design

The fact that it needs to both be durable and express durability leads to the experience of the product. Congruence between properties and expression was interpreted as an important aspect to the parents and coaches. When shown images of and discussing competitors, it became apparent that a product could cause distrust by appearing durable or user friendly and letting the user down because it did not meet expectations. There needs to be coherency among the different expressions as well. Users mentioned examples of products which attempted to target several market groups and failed because of an incoherent end results which no one liked. Additionally, there was a wish from Aracne and the design firm they use to have the frame be discreet and emphasise their Futchi Wall net.

Safety

The requirement to fulfill safety standards was not explicitly expressed but made obvious by the parents' desire to keep their children active and healthy. If the parents and coaches are to leave children unsupervised with the product, they need to trust that the product can't injure the children. Along with mandatory legal requirements on safe-

ty which of course must be fulfilled, there are additional standards which are optional and which the product could be certified to as a selling perk.

Functionality and manufacturing

Many of the requirements in this category stem from complaints the users had with rebound of competitors or properties which they considered important to the experience. The product needs to stand securely and feel solid when shot on. If it moves during a Futchi game, it could interfere with the match. Since the product needs to be compatible with the company's current product, many of these requirements are fulfilled simply by securely and properly mounting the Futchi Wall. Functions such as incorporated sensors and an app were

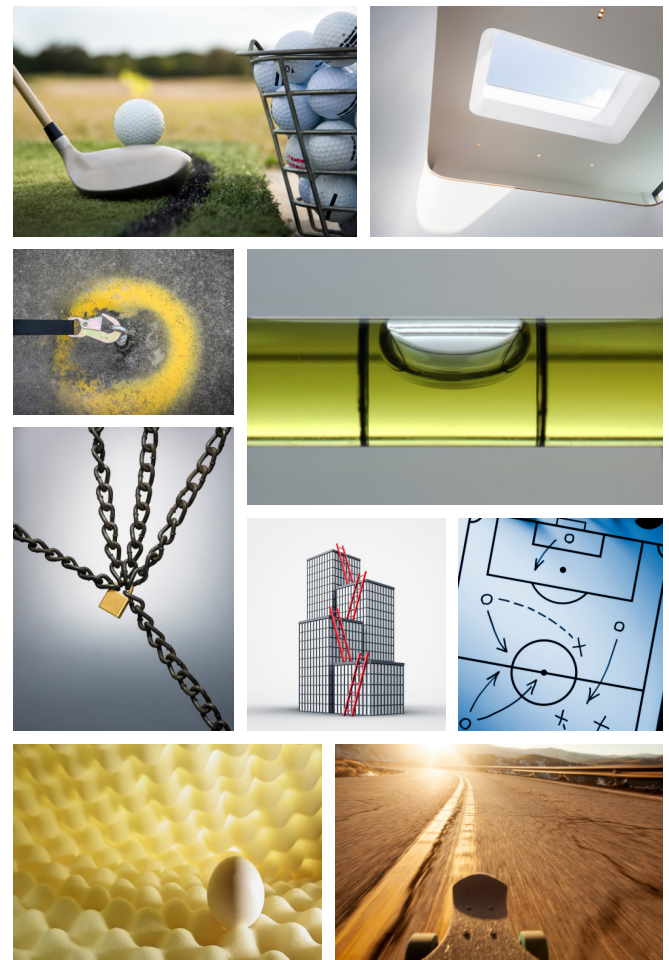


Figure 5.1 Expression board

discussed but dismissed because of their cost. They could however be kept in mind to allow them to be added in the future.

5.1.5 Design Guidelines

An expression board, depicted in figure 5.1, was created to better convey the visual design and properties which the product should carry and express. The images collected depict the expression of strength, durability and safety which the product should have. It should be professional and minimalistic, emphasizing the Futchi Wall as the main product and not claim much attention itself. Since the product is used to practice and improve oneself to reach new levels of skill and performance, the product should also reflect this.

5.2 Shapes (2nd stage)

The second stage focuses on deciding the overall shape of the product. Early on, there were many different ways to mount the net to choose from. In order to be able to focus the development and reach further in this project, the alternatives had to be narrowed down and a choice had to be made fairly early. This chapter describes the results of these creative phases and the evaluation and selection of which shape to work further with.

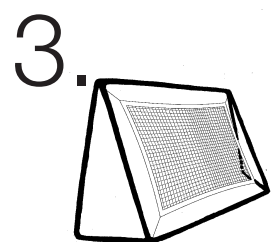
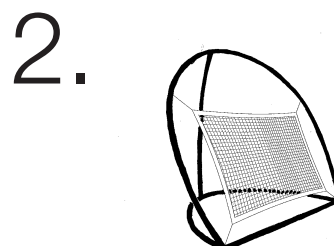
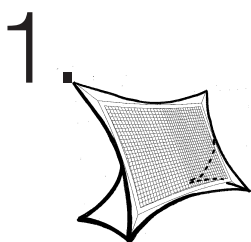
5.2.1 Generalised functions

One of the first areas investigated was the ability to make the product contract and ex-

tend into various states. It will likely be necessary for the product to arrive unmounted to the customer in some fashion, and be able to be made smaller again for storage and a bit added mobility. The abstract ways in which this could be done were defined in order to always have them present for consideration in later stages. These were: parts can fold in and out with a hinge like mechanism, parts can slide into and out of one another in a rail-like fashion, and parts can detach and be reattached to split the product into smaller units.

These concepts were further defined by adding examples of products which have used them and more specific variations of them. A wall of inspiration was made by attaching interesting examples found onto it.

There are for instance flexible tables which use a mechanism consisting out of a few folding links, and one sliding. The sliding part runs over a set of which prevents it from folding back in one direction until the end of the movement has been reached as can be seen in the image. Gym equipment which was also used as inspiration for functions as they often have to be adjusted through pins and simple mechanisms. Slacklining is an activity which has gotten increasingly popular during recent years. The objective is to balance on a long strap of fabric with high tension. It is often attached between two tree trunks and there are a few methods for how to easily tighten it in the field, both through knots, pulleys and other



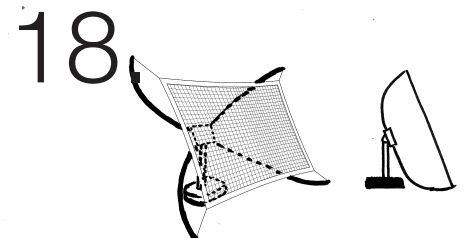
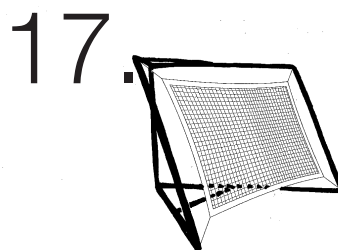
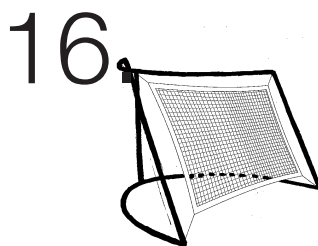
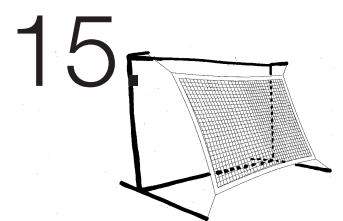
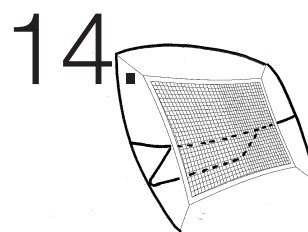
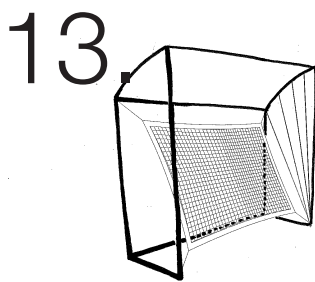
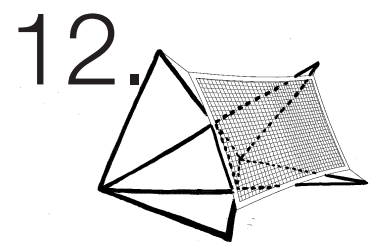
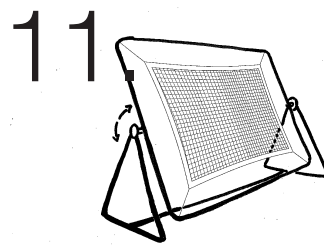
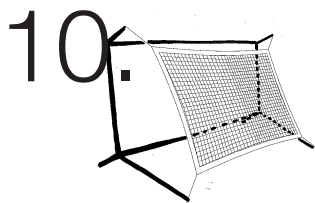
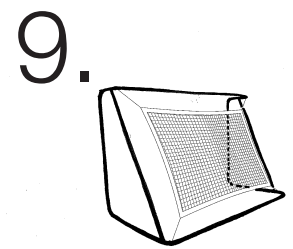
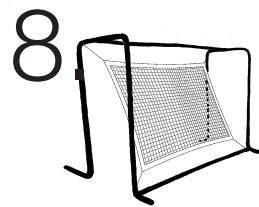
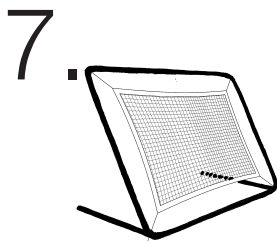
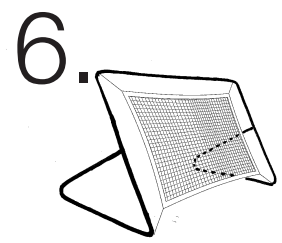
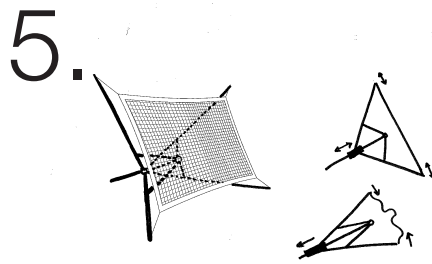
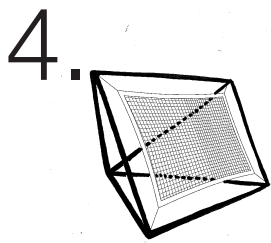


Figure 5.2 Shape concepts

small mechanical devices. Additional inspiration can be taken from manufacturers of aluminium profiles who want their products to be used and provide compendiums full of examples of how to accomplish various functions using aluminium profiles and catalogues from manufacturers of proprietary assembly systems.

5.2.2 Shapes

During the generation of the shapes, focus was put mostly on trying to create interesting shapes and ideas. Therefore, manufacturability was not the main focus. Presented below are all the generated concepts.

5.2.3 Shape evaluation

The evaluation of the shapes began with one performed without any involvement from people outside of the project. Advantages and disadvantages were discussed and how possible they were to get rid of easily in the concepts. The conclusion reached was that concept 6 and 7 were most capable to fulfill the demands set by the customers. Concept 3, 6, 7, 9 and 12 were found to be very desirable since they allowed placement around otherwise interfering objects. By placing the product around a large bush, manhole cover or tree, one can better utilise the space available. Concept 7 also had the advantage of high flexibility in the manufacturing process which could greatly speed up the results. Once this initial evaluation had been made a workshop could be held with the company where these results could be presented and their thoughts on them discussed.

Since the selection of a basic shape to work with was an important gateway for the project to proceed, and a choice which has such a large impact on the outcome of the project, a large part of the final choice was left to Aracne. Aracne in turn relied on the advice of the external design firm which was present who had previously developed Aracne's

brand identity, graphic profile, and been involved in creating the net.

The external design firm were adamant that the shape of the frame should be kept simple and unintrusive in relation to the Futchi Wall. Aracne's brand identity consists largely out of the Futchi Wall and its dominant shape which can also be found in their logo. The shape of the Futchi Wall is easily identifiable from a distance and interference with this icon/symbol could decrease the brand recognition. It was thus desirable for the area behind the net to be free from bars, and for the shape of the frame to follow the shape of the net to blend in and merge the two.

Another desirable property affected by the choice of shape was flexibility in prototype and production which favoured 7. Concepts with straight parts are likely to require less standard parts. Fewer and less complicated joints were also noted for their cost advantage. The requirements on mobility gave an edge to the shapes which were able to fold down, although most of them had potential to be changed to a compact state.

Concept number 7 was chosen but concepts 3 and 6 were noted as having features of interest which could be considered and applied to concept 7 to add their strengths. 7 was chosen on the premise of simplicity and opportunity.

5.3 Function (3rd stage)

Once the shape had been decided the functions could be treated on a more tangible level and generation of functions and evaluations could proceed with quick and dirty prototyping, mock ups and tests. The results of these generations and tests are the main topics treated in this chapter.

5.3.1 Problem Areas

The shape chosen to develop further was

a rectangular frame supported by two legs extending backwards and connected to the frame with supports to keep the frame upright. Some key areas were identified where problems had to be solved and functions added. Some of the problem areas were necessary simply to enable assembly, for instance the corners where the side sections meet. Since these areas already required parts to be made using a manufacturing technology which could provide more complex features, additional functions could be added without much extra cost. Functions that were not forced to be at a specific place on the frame were thus moved to these areas to minimise the amount of complex parts needed. By collecting functions at problem areas, other parts could be kept simple and cheap. These problem areas can be seen in figure 5.3 and the problems and functions associated with each are presented below.

1 Upper corners

The main function of the upper corner is to allow for the upper bar and the side bar to be attached to each other. It also needs to provide a place to attach the hook of the Futchi Wall.

2 Lower corners

The main function of the lower corners is to allow the side bar to connect with the lower bar and rear legs, and allow them to rotate like a hinge. It should also provide a place to which the hooks of the Futchi Wall can be attached.

3 Top middle

The top bar has to be split in two because of the limits imposed by logistics during transport. This meant that the top bar has to be able to be made smaller, something which requires the top bar to be split, folded or contracted in some fashion.

4 Bottom middle

The bottom bar has the same problem as the top section, although there are less de-

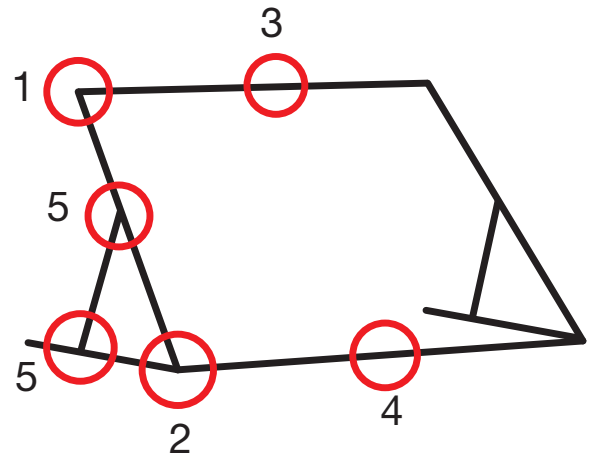


Figure 5.3 Problem areas

mands on strength, and a similar solution has to be found.

5 Support leg attachment

The support legs are required for stability reasons and have to attach to the rear legs and the sides in some fashion. Because the frame should be able to fold up into various angles this attachment has to provide the possibility to adjust the attachment.

5.3.2 Mock up

With the problem areas defined, a mock-up was designed with rudimentary solutions chosen for these problem areas to test them and be able to work on a more tangible level. When building the mock up, it became apparent that the product would become far bigger than imagined. Still, the size of the mock up was slightly too small vertically and when mounting the net in the way first thought of, it was not possible to reach proper tension in the net. This mishap turned out favorable as it forced new ideas of how to fasten the net to be thought of and through this managed a way to decrease the distance between the frame and net was found.

One idea was to wrap the attachment straps around the top and bottom bars with a pulley and fasten the attachments on the rear side of the frame. A few issues were howev-

er discovered with this solution. Since the cam buckles are located near the net at the lower corners, while they are located outmost on the straps on the upper corners, they behave differently when fastened on the rear side of the frame. Wrapping the upper straps around the top bar essentially reverses the cam buckles. The straps which exits the cam buckles which were previously pulled in a downwards motion to tighten now have to pulled upwards, making it significantly harder. In the case of the lower attachments, the cam buckles are close to the net and don't get flipped around the back and reversed when the attachment strap is wrapped around the bottom bar. This means the direction in which the strap is pulled to tighten it remains the same. This set of solutions was discarded on the basis that the top corners become more difficult to tighten and increased the cost for a very little benefit.

An additional strap used to connect the upper and lower attachments points of the Futchi Wall together on the rear of the frame was also investigated but discarded for being troublesome. A large lever inspired by net tightening solutions commonly used in badminton nets was also examined.

The cost was a deterring factor and although for instance a lever could be used with some success, it too was discarded as it would only make the Futchi Wall a bit easier to tighten, something which isn't necessary since it already fulfills the requirements set by Aracne.

It was also discovered that a lot of the resistance when pulling the straps and tightening the net came from the cam buckles, which are very restrictive. It may be the case that they aren't excessive, as they need to endure a lot of tension in the other direction, but they were nonetheless found to be the main source of resistance which at first was believed to come from the tension in

the net itself. Even if a pulley system was added to each corner in an attempt to decrease the force required to tighten the net it was found that they wouldn't accomplish much without making changes to the cam buckles. This possibility was thus excluded and it was deemed sufficient that the Futchi Wall be as easy to mount in our concept as it is in a goal frame.

When using the mock up the many vibrations through the frame eventually led to a nut being loosened. If nuts are to be used in the final concept, vibration proof varieties would be advised. The hinges used in the mock up were simple and crude which allowed the rear legs of the frame to move and wobble about a little in directions not intended by the hinge. This could be alleviated by either adding support brackets across the corner, having tighter tolerances at the hinge or adding a bar across rear ends of the support legs.

5.3.3 Stability

The mock up had been made light in order to provide a low baseline which weights could be added to in order to find the point where it became stable. It was far easier this way rather than to make a heavy mock up and try to reduce the weight to find the points where it became unstable or began to move. It was believed that shots to the frame would, because of a harder return and shorter contact time and in turn a higher impulse, make the frame move more than shots to the net. The difference was quickly established to be negligible however.

A stability test was performed with shots fired at the frame to evaluate the movement with different weights attached, the results of which can be found in appendix II. The most notable conclusions which can be drawn from it was that adding weights decreases the movement of the frame by a large degree while the positioning of the weight had a far lesser effect. A small advan-

tage could however be found if placing the added weights further down when it comes to the tendency to tip over or even lift from the ground.

Another stability test which was conducted was to add blocks underneath the support legs to find the tipping point of the frame when shot at. This effectively simulated support legs of various lengths to evaluate their impact on stability. This later became the basis for the size of support legs in the final prototype.

5.3.4 Functions

During the interaction with the mockup the problem areas identified earlier were investigated and functions which were re-

quired by each area were discovered. These functions are ways in which the problems in these areas can be solved and also act as requirements which have to be fulfilled by the detail solutions generated in each area later. The functions are listed below and can be viewed as small additions of requirements to each problem, where they all still have to fulfill the requirements such as safety and durability set by the requirements specification.

1 Upper corners

The upper corner should be compatible with the attachment mechanism of the Futchi Wall, which it would be favourable from an expression standpoint to conceal. To be able to decrease the size of the frame the corner has to allow the top bar to detach

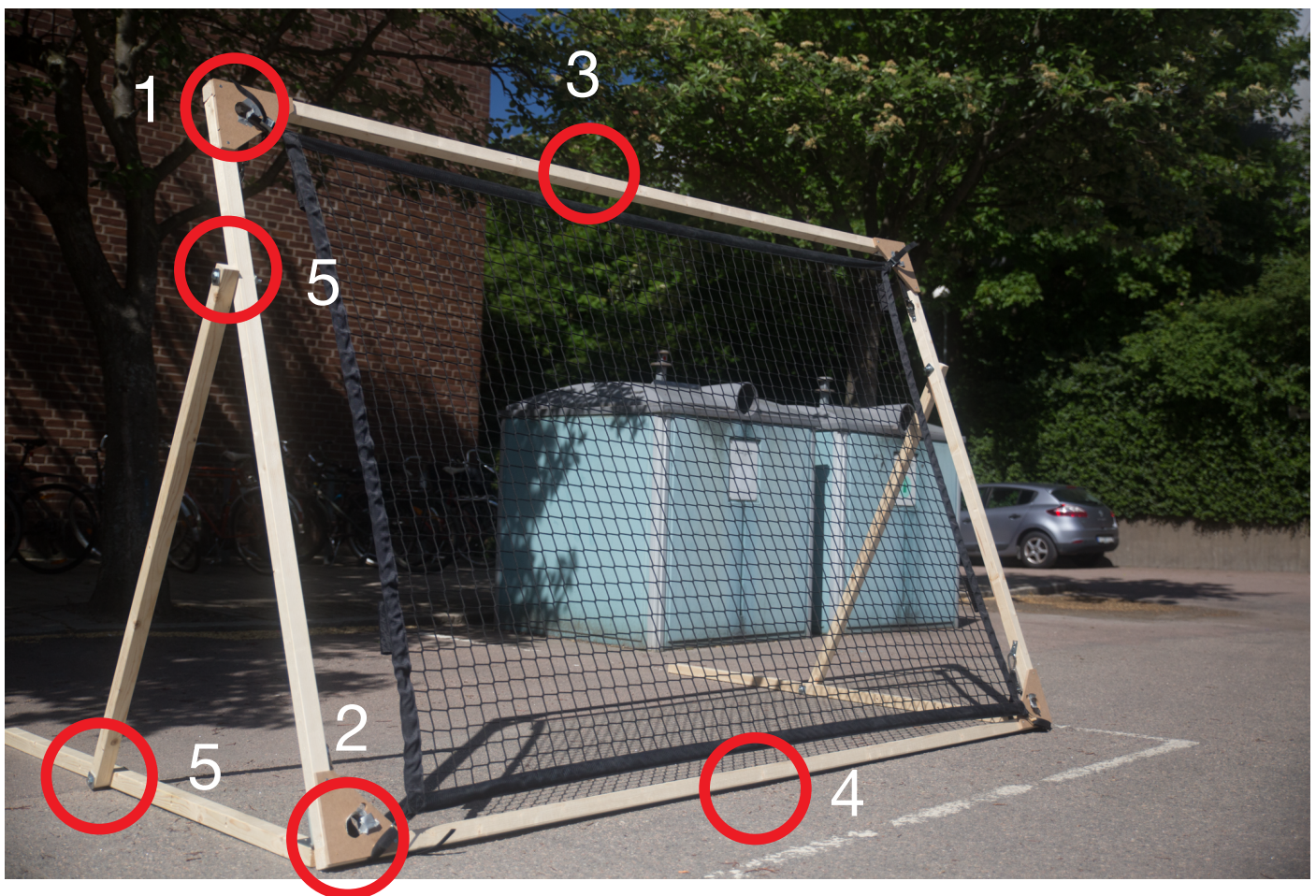


Figure 5.4 Function areas and mocup

from the side bar or allow it to fold down. It should be possible to mount and fixate the corner at a right angle to facilitate the later alignment of the top bar. Since this is a surface located high it is a favourable position to put branding features.

2 Lower corners

The lower corners should attach the side bar to the rear legs. Although the bottom bar can be attached anywhere to the rear legs, putting it near the front increases rigidity and allows the lower corner part to be smaller in size. Placing the attachment further back requires the lower corner part to be larger, or an entirely new attachment part to be added, but it decreases the risk of hitting the bar with a ball behind the Futchi Wall however. The lower corners is where it is the most crucial to mount the Futchi Wall attachments far out since the gap between the Futchi Wall and the ground is the gap between net and frame which is the most important to keep small. The bottom bar also needs to be detached or foldable similar to the top bar. As was noted during the mock-up tests, uneven ground favours fewer contact points and the lower corner should provide points on which the frame can stand. It needs to either act as or enable a foot to be mounted.

3 Top middle

The attachment at the middle of the top bar has to be durable and withstand a lot of force, but at the same time not be very large as the point of it is to decrease the length of the top bar by splitting it into two sections. It needs to either detach the two sections or fold them to a shorter length.

4 Bottom middle

The function of the bottom bar is much the same as the top bar with similar requirements. It does however not require as much durability as it lies on the ground and its purpose is largely to hold the two sides apart once the force of the Futchi Wall is applied.

5 Support leg attachment

The support legs have to attach at both ends where one or both ends also have to allow different settings. If both ends are allowed to rotate it is sufficient to have one end attach at multiple positions, or for the support leg to contract and extend. The ends do not have to rotate if both ends can attach at multiple positions. An additional problem which was discovered with the mock-up was that holding both the side bar and the support leg to align them when attaching it was difficult, and a function which could align it for the user would be beneficial

5.3.5 Materials and Manufacturing

Manufacturing technologies were evaluated next to provide limitations for later detail design work. Since cost was an important concern it was the primary objective when investigating the alternatives for materials and manufacturing techniques to be used.

Sides

It was early on determined that the lengths which the frame would mainly consist of would have to be made of metal profiles of some kind. This was due to the fact that it would have to withstand much wear and tear from both usage and environment, while also being strong, rigid and stand stably on the ground. Considering that the bulk volume of the frame would consist of these frames the price was a primary concern when selecting the material and manufacturing method.

Different kinds of profiles were looked into and an estimated price per kilo was found for each. The price per kilo of extruded aluminium was estimated to be around 28 SEK with an additional cost of approximately 15.000 SEK in tool cost if a non standard profile was to be used (Tobiasson 2014) . The price per kilo when using steel (warm or cold forged) was estimated to be around 15 SEK. This was combined with strength

calculations to find the minimum cross section required and the table of prices could be converted to a price per meter for each solution which can be found in appendix III. While steel is admittedly cheaper than aluminium per kilo, it's worth noting that aluminium has about $\frac{1}{3}$ of the density of steel. This means that when comparing two profiles with the exact same dimensions, one in aluminium and one in steel, the one in aluminium will still be cheaper per unit length. However, because steel is a stronger material, the steel profile would in that case be stronger and could be made smaller. Steel came out favourably once formulas for optimizing strength against cost were used, but it required the steel profile to be very thin. The availability of thin steel profiles was sparse and no steel profiles thin enough to make them cheaper than aluminium were found. Smaller outside dimensions were also excluded as the product no longer appeared durable. Additionally, steel is more vulnerable to corrosion and harder to work with in the prototype if modifications needed to be made which favoured aluminium profiles. Aluminium also proved more flexible in terms of available profile shapes and offers the possibility to make a custom one. Since the frame consists of one profile shape, the volume increases and the tooling costs can be distributed which makes it relatively small.

Problem areas

The parts which connect the sides were made crucial since functions had been collected there to keep the profiles simple. A flexible manufacturing technique which would allow them to provide all the necessary functions was thus required. Many techniques were evaluated of how to join the sides and a summarised list of pros and cons of the evaluated manufacturing techniques can be found in appendix IV. In the end, injection molded plastic parts and bent sheet metal parts remained as possible techniques which could reach the set price goal, as well

as allow for a professional expression and the required functions to be implemented. The sheet metal alternative could either be stamped, cut with waterjet or with laser and thereafter bent through press braking but their limitations are largely the same. Waterjet and laser allows for some shapes to be cut out which stamping does not.

When comparing press braked sheet metal and injection molding, the latter was found to be more flexible in terms of features but only cost effective if the production series exceeds 2000 units because of the high tooling cost which is approximately 215.000 SEK (Klint 2014). No universal part which could be used at all problem areas could be created which meant that several different parts and molds was needed. Additional tools for each problem area would make the investment cost very large which led to this manufacturing method being discarded for being too expensive. In addition to this, it would also have taken longer to develop and offered less flexibility for the continued development of the product. Sheet metal parts was thus chosen and after getting approximate quotes from a few manufacturers, a firm which press brake sheet metal parts was chosen to make the parts for the prototype, based on their price. It was considered favourable to have as few different types of manufacturing techniques as possible to bring the price down even more because of larger volumes and less logistical issues.

Press braking poses some limitations in terms of limited minimum inner radii at bends. Some manufacturers have machines able to create very small radii but if compatibility is to be kept towards most press braking firms, some radii should be allowed. Another limitation is that there is a limit to how deep the tooling can reach to perform the bend, ie a U-shape cannot be too deep or the tool can't reach down to perform the second bend. However, this is only a problem if both the sides of the U are long.

These are examples of compromises which were made to adapt the design in order for a particular manufacturer to be able to manufacture the part. It should be noted that no changes were made which restricted parts to particular manufacturers and that these only made the parts easier to make and allows for a larger number of manufacturers to be chosen among and thus the potential to find a cheaper one.

Surface treatment

Considering different ways of coloring the

frame where steel and aluminium are the dominant alternatives, anodisation and powder coating were looked into. Powder coating was however chosen in the end due to it working well with both steel and aluminium while also providing a layer of protection against corrosion. It would also be easier to match the expression of steel and aluminium parts if both are covered with the same powder coat rather than mixing different techniques.

The possibility of using a tumble finish or

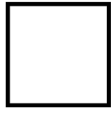

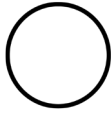


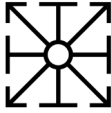

Profile	Advantage	Disadvantage
Square 	+Prevalent	-Uncomfortable -Harder to mount things flush to surface because of sharp edges
Rectangular 	+Prevalent +Durable in selected direction	-Uncomfortable -Harder to mount things flush to surface because of sharp edges
Circular 	+Prevalent	-Difficult to brand -Difficult to attach simple shapes and hinges to
Obround 	+Combines multiple desirable expressions +Durable in selected direction	-Uncommon
Elliptic 	+Durable in selected direction	-Uncommon -Difficult to mount things to -Difficult to brand
Brand specific, eg MS40+ 	+Durable +Advanced functions and components available	-Expensive -Uncomfortable -Dependency on a manufacturer
A custom profile 	+Durable +Match desired expression exactly +Endless possibilities +Resource efficient, only uses the material required	-Expensive tooling required -Requires larger volumes to be efficient -Requires development and time

Figure 5.5 Profile shapes

similar for improving the surface and edges of the press braked steel parts was considered but left out for now as the additional cost and time required would have delayed the project. This was deemed unnecessary to test in the prototype as it doesn't affect the overall function but considered to be recommended in the final product. It would enhance the expression and reduce the risk of exposing the user to uncomfortable edges. Evaluations should be made for the final product whether powder coating or cutting the sheet metal with waterjet or laser might be sufficient to alleviate this problem.

5.3.6 Solutions

Once the boundaries of the techniques and materials were known and a few selected as suitable to work with, detail solutions could be created which provided the needed functions of each problem area, which are listed below.

Extrusion cross section

Once extruded aluminium had been chosen for the sides the question of which profile to use remained. The profile cross sections and their advantages and disadvantages can be found below.

Sheet metal parts to connect the side sections with came out favourably in the earlier evaluations and the profiles with flat sides work well with that solution. It allows them to sit flush with less complicated bending operations required on the sheet metal parts which makes them cheaper to produce. The minimum radii of the sheet metal parts did however impose some restrictions on the profiles. Sharper outside edges on the profile prevents the sheet metal parts from sitting flush against the profile if they are bent around multiple sides. Figure 5.6 showcases how the inner radii of the outer part clashes with the corner. One side can sit flush as seen in the left example but not both at the same time as the middle example illustrates. The right example shows how a rounded

outer edge on the profile can alleviate this and comply with the required minimum inner radii of the outer sheet metal part.

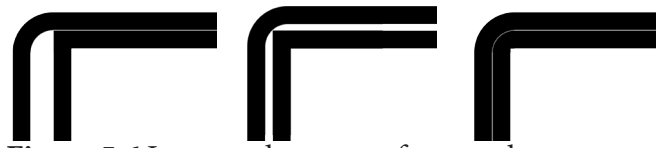


Figure 5.6 Inner and outer surface at edge

Other than rounding the edge of the profile, other possible ways to avoid the issue is to only mount the sheet metal part flush to one surface, insert a washer or standoff to bridge the gap, not bend the sheet metal parts and only use flat sheets, or to restrict the possible manufacturers of the sheet metal parts to only those capable of achieving small enough inner radii.

In the end a custom made rectangular profile was chosen for the final concept with rounded corners. Because a single frame uses more about 15 meters of profiles, once a few units are ordered, the total length of profiles quickly rises to levels where the tooling costs become small. 100 frames will need 1.5 kilometers of profiles and 15.000 SEK distributed on these only add 10 SEK per profile, or 150 SEK per frame. This added cost enables the use of far more manufacturers of sheet metal parts and was determined to be worth the cost in terms of cheaper sheet metal parts and improved expression and comfort for the user.

Usability and Flexibility

Regarding usability, focus was put heavily on having a straightforward way of assembling and using the product, mainly because a goal was for users to be able to assemble the product without using an instructions manual or prior knowledge. Because of this, the target was to have as few different parts as possible, and to have as few interaction points as possible for the user. This led to the product mostly consisting of joints that creates a foldable mechanism which

is harder to misinterpret during assembly. Where parts had to be separated, a univocal solution was put to allow for quick feedback and error recovery for the user. At the assembly points, eccentric locks was favoured over pins (where possible) to ease assembly. Pins require multiple hands to hold the parts in place and then be accurately inserted, whereas eccentric locks pull themselves in position.

To decrease safety risks, the interaction points was put as far away from bending areas as possible to avoid users from pinching hands and/or fingers in areas that could possibly be hazardous.

The number of hands required was taken into consideration at each step in the assembly process to keep them to a minimum by holding objects in place while the user manipulates others. Angles and guides were also added to direct details into their correct positions with less accuracy required by the user. Hinges which fold in only one axis was the preferred type of joint since the user can rotate it and it will pass the correct position, whereas joints with more degrees of freedom will require several axis to align at the same time.

Eccentric locks are used to pull parts until they stop at their correct position and do not need alignment or accuracy from the user. The pins are employed in such a way

that a constant force can be applied to it when placed in a hole and once the hole of the corresponding part underneath passes, it will slot into place.

The user is encouraged to interact at ends of profiles instead of the points where they meet since the forces to move are lower further away from the hinge. This keeps the users hands from the hinges and places where parts meet and there is potential to get pinched. Additionally, the accuracy when moving the parts is lower if manipulated close to the hinge. The hinges themselves were also shaped to avoid meeting edges which could potentially shear limbs or cut the user. In the cases where parts closing up are required to reach a smaller package size, larger flat surfaces which distribute the force over a larger area were preferred. Introducing a gap between two parts near the hinge limits the pinch hazard to only at the ends where the parts meet, rather than along the entire part as they close up as can be seen in figure 5.7.

The point of contact is moved further from the hinge and the risk of getting fingers pinched close to the hinge where the force is greater is eliminated and the only place the user can get pinched is at the contact point at the ends, where the force is far lower, as well as the consequence of getting pinched.

Assembly should be done permanently by the factory as far as possible while maintaining a manageable size of the unmounted product. The assembly done by the factory should also be tamper proof.

5.3.7 Prototype manufacturing

The solutions created were tested by ordering a prototype. Since it was a first prototype and it didn't have to be fully representative of the final product, some compromises were made to the design to speed up the process and allow for extra flexibility. Multiple solutions were added in certain areas

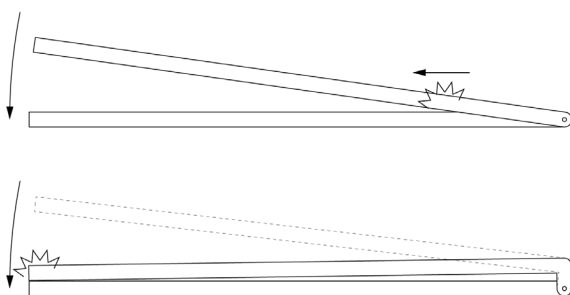


Figure 5.7 Preventing contact close to hinge

to test them all out using the one prototype. Instead of using rivets to fasten the parts, screws and bolts were used which enabled modifications to be made. Parts of the manufacturing was done manually to not have to wait for additional manufacturers and some additional compromises were made to facilitate, speed up and make the the first prototype cheaper to produce.

The first compromise was to use the standard aluminium profiles closest to the desired shape available in stock. The edges were rounded at the ends where sheet metal parts were attached to simulate the use of a rectangular profile with rounded edges. The expression gained by rounding all the edges was tested by the use of digital renders. End caps used to plug the ends of the profiles were also rendered digitally with branding features whereas the prototype used standard blank end caps to keep the cost down. 3D printed end caps could have been used but were postponed for now as they can be added at any point without running the risk of affecting the overall function much. In order to be able to reach the screws and more easily perform adjustments, the end caps were only added at one end of each profile as this made them easy to poke out from the other end of the profile.

The sheet metal parts were left untreated after being cut and press braked. By manually rounding the sharp corners the cost could be kept down and the time schedule less dependant on manufacturers. Although magnelis or stainless steel could be used for added durability, their added cost was a drawback and to test if steel would be durable enough it was used in the prototype. Since the powdercoating firm were fully booked with other orders at the time and up until their vacations, hobby spray paint was used instead to evaluate the colour and how much some paint could prevent rust. Since powder coating would be more protective, if this paint passed with sufficient results so

would powder coating. The particular manufacturer chosen to produce the sheet metal part for the prototype limited the design somewhat as they were unable to bend deep u-shapes and the upper corner was split in two parts to avoid the issue without compromising the structural integrity, function or expression to any notable degree.

The profiles were machined manually at the limited workshops available in the university department which caused some fairly inexact tolerances in terms of holes in the side sections. These holes would instead have been machined with CNC had it been the final concept and had the production volume been larger.

The axles used were larger than intended because of limited stock of the smaller dimensions. The excessive dimension used was also only available in the length required in a more expensive hardened steel, whereas the final concept will use a cheaper and thinner dimension. The cotter pins used on the axles were of a simple hairpin variety instead of using a more expensive axles with automatic latching at the points where the user has to interact with the axles. The same pins were used at the factory mounted axles even though there are more tamper proof solutions with finer tolerances available. This was done to keep the solution the same everywhere in the prototype, to keep the cost down and because of availability and delivery times. Availability also limited the choice of eccentric lock to be used in the prototype, but however provided sufficient function to be able to evaluate the concept. Better eccentric locks can surely be found if more effort is spent on locating them, but this was deemed unnecessary for the purposes of evaluating the concept of eccentric locks in this prototype

The above compromises where applied along with some of the solutions which were found to best provide the functional-

ity in each problem area defined earlier. The price target of the prototype was met and the parts for the prototype were ordered, some modifications made and it was assembled at the university department.

Final Concept

The outcome of the project will be presented in this section. This includes a detailed description of the prototype and final concept. Results of the evaluation and how it fulfills the requirements will also be presented along with future work and how to proceed with the concept.

6.1 Futchi Frame

The product created is a rigid construction called the Futchi Frame. It can be assembled quickly from a compact elongated form into a frame large enough to be compatible with the Futchi Wall. It measures three by two meters in size once mounted and the height is approximately 2 meters depending on the angle it is set to.

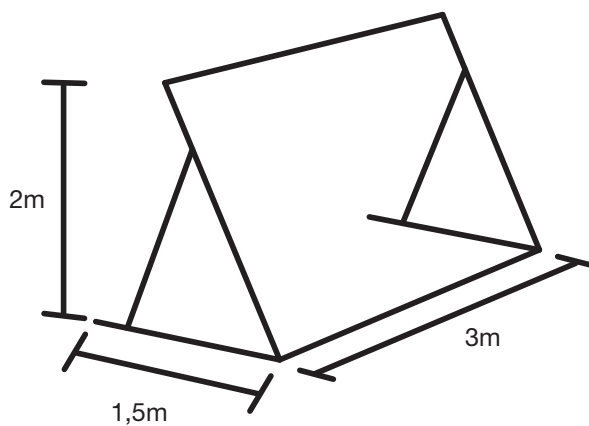


Figure 6.1 Schematic overview of the Futchi Frame

The angle is adjustable is one of the flexible properties of the product. There is of course a recommended setting which is the same as the Futchi Wall when mounted in a 5-a-side goal, but others allow the user to adjust the speed and angle of the rebound, and in extension the difficulty of Futchi. A more vertical setting makes the game quicker and is suitable for higher level players who desire faster paced gameplay. The easier settings allows the user to always find an appropriate setting for their skill level and the product can be kept as they improve their skills and follow their progression throughout.

6.1.1 User assembly

The product is assembled from a package of two units, each representing a half of the frame and mirrored versions of each other. The mounting procedure is to lay out the parts, fold the top bar out (1) and fasten

them to each other (2).

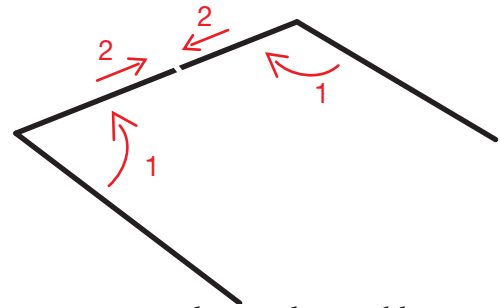


Figure 6.2 First and second assembly step

Next, the bottom bar is attached (3) and the frame can be raised (4) and the rear support legs can be attached and adjusted to the desired angle (5).

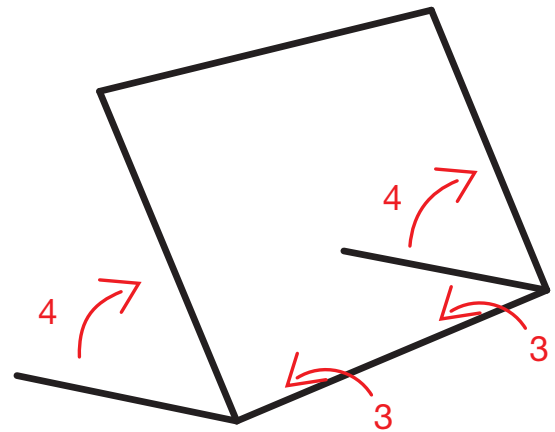


Figure 6.3 Third and fourth assembly step

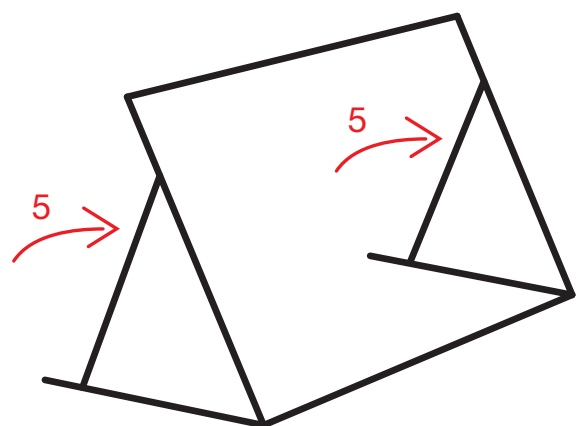


Figure 6.4 Fifth assembly step

Finally, the Futchi Wall is attached by hooking it to the lashing anchors and tightening the straps until the desired tension in the net is achieved.



Figure 6.5 Futchi Frame



Figure 6.6 Packaged Futchi Frame and Futchi Wall

If a playing field is required, the lines which marks it can be attached at one end to the bottom at the frame as depicted in figure 6.7 and the rear corners using the included ground attachments.

6.1.2 Detail Solutions

Many solutions were included in the final concept and a detailed description of the solutions and how they help the product fulfill the requirements can be will be gone through next, beginning with the flexibility of the product.

Flexibility

The Futchi Frame is made foldable to make it more flexible for the user, easier to transport, facilitate distribution for retailers as well as provide different settings to angle the net when playing Futchi. The top bar detaches at the middle and each half is connected to either side of the frame. Hinges are used instead of detachable joints as far as possible since they minimise the number of separate parts. A part attached with a hinge doesn't require the user to find the correct position to place the part, something which is necessary with a detached part. Instead of having to find both the position and ro-



Figure 6.8 Side view of the prototype

The various settings for the angle were made alongside the front sections of the frame in order to not have any protruding parts. By making the end of the support leg attachments move along the frame the support legs never extend outwards from the frame towards the user. If the settings been placed on the support legs, they would have had to move relative to the side section and an posed a hazard when pointing towards the users. Although placing the settings on



Figure 6.7 Attachment of playing field lines

the legs along the ground would have hidden them and created a cleaner expression, they would have been harder to reach and increased their exposure to dirt and gunk entering the frame. The settings were instead placed on the side sections at a height where most users are able to easily reach them.

Usability

The prototype used very simple axles which the user has to insert pins into to lock in position. Automatic axles with retracting locking features are used in the final concept where the added cost is deemed worth it for the added usability. These are also attached to the frame with wires to not risk the user losing them. Another usability feature which is present throughout the design is to always guide moving parts into one another. If a feature has to fit into a gap and move into it demands are put on the hinge and the tolerances, otherwise it relies on the accuracy of the user. If the part is instead made to never completely exit the gap into which it is placed, it can be continuously guided further in.

Cutting risks when interacting with the product were made unlikely by avoiding exposing sheet metal edges which pass closely to other sharp edges. The frame sections are kept apart by the folding mechanisms to always maintain a distance between them in order to minimise the risk of a user getting their fingers pinched between moving parts.

Support leg attachments

The flexibility described meant that some features became necessary to implement at the points where the support legs are mounted. The support leg attachments allow for the support legs to slide along the side section of the frame where there are a few holes which provide a few settings for the angle of the Futchi Frame. The end caps used to plug the ends of the profiles were

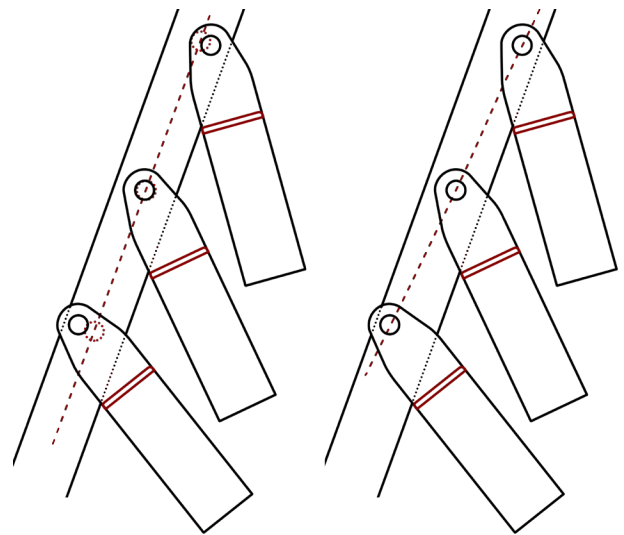


Figure 6.9 Adjustment holes offset from center

made to act as sliders at these positions and maintain the distance between the support leg and side section without damaging either by providing a plastic surface in between the two. As the angle of the frame is adjusted, the angle at the attachments changes which also changes the distance between the support leg and side section. This problem was solved by adjusting the placement of the holes on the side section as seen in figure 6.9. The holes are not placed on the centerline of the side sections but instead along a calculated curve. This feature compensates for the distance between side section and support leg as the angle between the two changes which means that the end cap can slide against the side section and the holes will always line up for the user to facilitate the angle adjustment. The support legs were also made identical at both ends and duplicated at either side so that no error can be made during assembly.

End caps

Although the prototype used one of the available standard blank end caps to plug the profiles, a custom one was designed in this project for a few reasons. Since the product is to be able to stand outside there is a risk of water getting into the profiles. Although aluminium was used partly for this reason and its corrosion resistance, stagnant water can smell, make the product heavier and more difficult to move and

adjust. These end caps are designed have concealed drainage holes to enable the water to escape the profiles. Additionally, the custom made end caps also provide an excellent opportunity to add some branding features and increase the apparent value of the product. Figure 6.10 depicts how adding the Futchi Logo on the ends of the profiles can enhance the product experience and a discreet way in which the user gets to know that the little details have been worked on in the product. The user also interacts with these ends and comes in close contact with this logo which only further strengthens its effects.

Profile cross section

The profile chosen for the final concept is a rectangular one which can be seen in figure 6.11 with the aspect ratio of the Futchi Logo to match the end caps and reflect their brand

identity throughout. The rectangular shape offers different strength in the two directions and are oriented so that they can best withstand their individual load scenarios. The cross section of the top bar is oriented vertically to better withstand vertical loads hanging from it, whereas the cross section of the rear legs is oriented horizontally to enlarge the area where feet can be placed and improve stability. The corners are also rounded which gives the product less dangerous and unfinished expression as well as makes the frame more comfortable to grip during assembly and adjustment.

Upper corners

Large surfaces were added to the upper corners for three reasons, the first of which was to add some rigidity to the frame. It had been decided during the shape evaluation stages that bars should be avoided inside

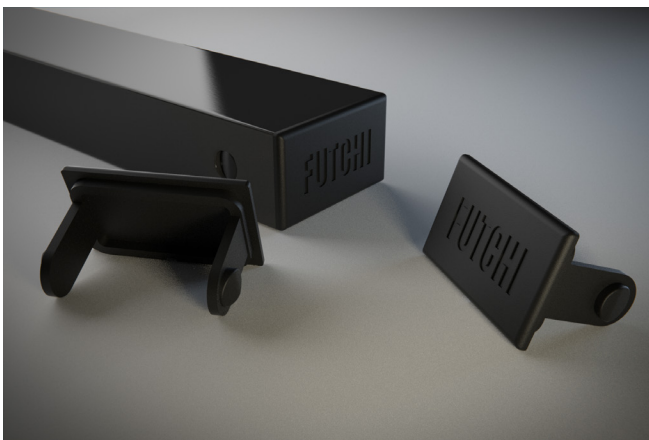


Figure 6.10 End caps branded with Futchi logotype



Figure 6.11 Logotype proportions and profile



Figure 6.12 Upper corner

the frame since they could interfere with the net during gameplay and disturb the company's brand identity. A diagonal bar from one corner to the opposite would have added a great deal of support but was because of this not viable and extra rigidity had to be added in another way. Instead the upper corners were enlarged to increase their resistance to torsion. The reason for enlarging the upper corners and not the lower was because of their strategic positioning. Their high vantage point increases their exposure and allows for branding features added and decrease the likelihood that the features are obscured by obstacles when compared to features added at its base. In addition to structural and branding reasons, enlarging the upper corners also hides the attachment straps which simplifies the expression and removes focus from the mounting.

Lower corners

Although the usage has been designed to avoid the user having to interact with the lower corner when it is moving the possibility still exists that someone else might

put their hand there. To make the product safer this was particularly important area since surfaces meet and pose a crushing or cutting hazard. A gap was left between the two profiles to not allow them to fully close upon finger-sized objects and no sheet metal was left protruding from the rest of the construction which could otherwise have sheared against each other and posed a cutting risk.

Attachment points for feet were added to the lower corner sheet metal parts as they provide the most stability if placed at the outmost corners of the base. Lashing anchors were however not placed on the lower corner parts themselves since they had to be as close to the ground as possible to decrease the gap between the net and the ground. They were instead placed on the front face of the bottom bar which lies on the ground which in turn required the bottom bar to be attached close to the front as can be seen in figure 6.13.

Middle of top bar



Figure 6.13 Lashing anchor at lower front corner

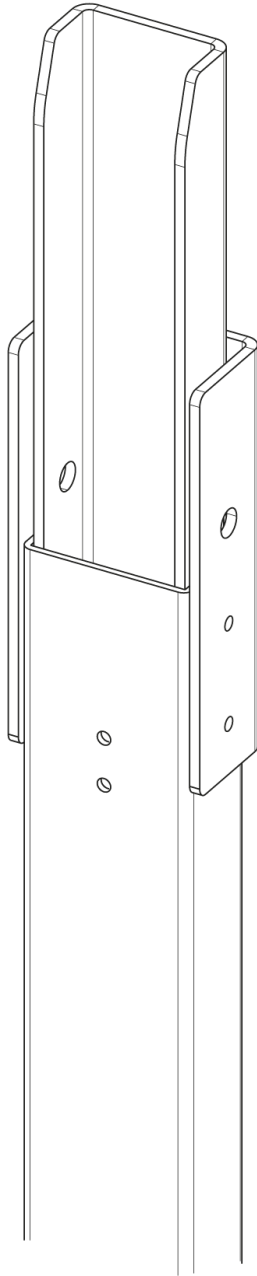


Figure 6.14 Upper middle attachment with outer cover and inner support structure

Because the top bar is easily grabbed and there is a potential for kids to hang their weight from it, it has to be able to withstand a significant force which puts some demands on the attachment which joins the two sections. It was designed with strength in mind where there is an inner and longer part which provides the strength and guides the profile into the second shorter sheet metal parts as seen in [figure 6.14](#). Both a pin and eccentric lock were tested in the prototype but the two sections remained connected even if neither was used. An eccentric lock could possibly help the user pull the two together, but if manufactured correctly, the two should slide into each other with ease, something which wasn't always the case with the low tolerances of the prototype.

Middle of bottom bar

The joint at the bottom bar had less demands than the otherwise very similar joints at the top bar. This meant it could be made cheaper and less robust without the necessity of the inner support. One section is simply lifted and dropped onto the other without any requirements on aligning the angles. This mimics the outer ends of the bottom bar which also just drop into place at the bottom corners as illustrated in [figure 6.15](#).

6.1.3 Branding

There are many possibilities for branding made possible with the final concept. The end caps are of course an excellent example where adding a bit of extra cost can greatly improve the as depicted previously, but there are also plenty of opportunities to use branding to an advantage in other areas of the product. Deals could be made where the hosts of an event could use the Futchi Frame as a marketing tool. It also allows for partnerships to be made with companies who sponsors for instance a football team by subsidizing the product cost in return for having their logo seen on the product. As



Figure 6.15 Lower corner

can be seen in [figure 6.16](#), the frame could be branded with logos, and especially the larger upper corner surfaces prove ample space for screen printing and logos to be placed. The Futchi Frame will in its standard configuration be powder coated a flat black for a professional expression which fits into many environments. Other than protecting the surfaces, the powder coat also provides makes it easier to achieve greater contrast with for instance logos and advertisement printed on top.

6.1.4 Manufacturing

Future development is facilitated by the design which is based on extruded aluminium profiles and sheet metal parts, which also helps to keep the costs down. The length of the extruded profiles can easily be changed and adapted to a new sized Futchi Wall if

need be. Additional angles are simply added by placing additional setting holes along the side bars. More potentials for improvements which this product allows for can be found in the later chapter Future Work.

6.2 Prototype evaluation

The prototype which was manufactured was tested and the results and conclusions of those tests can be found below. Other things of interest noted during the manufacturing and assembly which affect the final prototype and the recommendations made for it are also presented.

6.2.1 Manufacturing

Some parts of the manufacturing process were performed manually by hand to speed up the process in addition to picking the



Figure 6.16 Branded surface at upper corner

parts up on site at the manufacturers to not have to wait for delivery. Rivets were replaced with screws and nuts in the prototype to not have to source a place which could assemble it and the manufacturing time for the prototype could thus be decreased even further. They also provided the possibility to disassemble parts and make changes to the prototype far easier.

All holes in the aluminium profiles were drilled with a small drill press which limited the tolerances. When it came to mounting holes for screws the problem was insignificant and the hole could if needed be enlarged without much negative consequences. The larger holes meant for pins to enable adjustment of the angle of the Futchi Frame were however more crucial. The low tolerances achieved meant the pins couldn't be inserted easily in some cases, and the holes had to be enlarged a bit in certain places to alleviate this problem a bit. Because of this, the experience when inserting pins was made worse and the prototype gave less of a quality impression. During testing, it was also believed to have been one of the causes of rattling, undesired noises and a bit of extra movement of the frame. A test should be performed with CNC machines which would be capable of far tighter tolerances, and if the problem persists the suggested solution would be to add bushings to all joints.

To avoid having to buy a tool to make custom aluminium profiles for the prototype, it was decided early on to instead use a standard profile already available and grind the edges down as needed at the ends. It was known beforehand that grinding might become necessary and it was confirmed to be absolutely required because of the limited inner radii of the bends in the sheet metal parts. This is however easily resolved by making an aluminium extrusion tool which aren't that expensive when this fixed cost is distributed on the the lengths required in

this product.

6.2.2 Durability

The assembly and modification took a few days to get right, after which the prototype could be taken outside and tested. In the beginning, there were no signs of rust, but a few days in, it suddenly became visible overnight. The sheet metal parts were made of steel and initially intended to be powdercoated, but since the paintshop were fully occupied until the soon to begin vacation, they were left untreated until later. There was only surface rust on them which was easy to sand and remove, but more important this information was of great use to give an idea of its sensitivity. To prevent rust from reappearing, the sheet metal parts were painted using common hobby spray paint after having been sanded. Testing the resistance to scratches of powdercoating and evaluating how well it could prevent rust was deemed important because of this event. Stainless steel could also be used but a cheaper stainless variety such as magnelis would be recommended because of the high cost of stainless steel.

Something else which was noted was the durability of the paint used in the prototype. Since common hobby spray paint was used it is not a cause of concern in the final concept other than a reminder that the wear resistance of the powder coat should be carefully examined.

6.2.3 Assembly

Tests regarding the speed and ease of assembly were made with positive results. There were some issues in terms of pins being difficult to insert into their sockets, which can be attributed to the poor tolerances achieved when manually drilling these holes. They were confirmed to be a fair bit off when measured. The conclusions drawn from this is to of course use CNC drilled holes, but also to make the holes for axles

and pins which are inserted during manufacturing tight and the ones where the user are to insert a pin a bit larger to facilitate the action for the user. Conical add ons which makes the holes easier to target with the pin can be used for an additional cost of course.

The flexibility of the side sections enables them to touch at certain points which was noticed since the hollow aluminium profiles emitted sounds when it occurred. It was however not a common occurrence and since the points of potential contact were easily defined and restricted to a few places, solutions such as rubber bumpers or other protective measures can easily be applied at the affected locations.

The assembly steps required are largely determined by the number joints the user has to interact with. This in turn depends on the maximum length allowed when disassembled and the total lengths of the side, which can't be changed as they depend on the Futchi Wall. This means there is a direct correlation between maximum length of a single part and the number of assembly steps. One can prove that the final concept is close to the ideal solution in the following manner. The total length of all the bars amount to 15 meters. The maximum length allowed is just about two meters, which means that there will have to be at least 8 sections of about two meters each and 7 places which join them together. The Futchi Frame is divided into 8 side sections and has 7 joints with the longest part being slightly above 2 meters, which is close to optimal under these circumstances.

Additionally, the assembly does not require any extra tools or accessories, making it even more flexible and easier to assemble, disassemble, and move to different locations.

6.2.4 Usage

The prototype was tested through sever-

al sessions of Futchi. The three main areas where users noticed potential for improvements were the wobbliness of the product, the various noises made, and the necessity of a steel bottom bar.

Stability was of importance and a fair bit of testing went into it using the mockup. The prototype is indeed stable in that it doesn't move, tip over or even lift much on the feet when shot at, which should be considered a success. A bit of wobbliness was however noted by some of the test subjects when playing Futchi and interacting with the Futchi Frame. This occurred when a force was applied sideways to the frame where the corners could give a bit which allows the rectangular frame to become a bit rhombic and flex back.

There were also some undesired sounds emitted both during mounting but also during use. When mounting the product the user is able to make contact between the aluminium profiles, and noises best described as clonking or slamming can happen. This can easily be alleviated by using small rubber bumpers in strategic positions. There are two other types of noises which are emitted during use and which are undesired. The first is a rattling noise emitted from all joints when the Futchi frame is hit. The vibrations causes small slacks and loose tolerances to hit each other and and mentioned previously, increased tolerances should be tried as a first measure to get rid of it. There is also a little squealing noise caused by the lashing anchor and the attachment points of the net.

The stability of the product when it comes to movement and lifting from the ground was great, which asks the question whether the steel bottom bar is necessary or whether it can be an aluminium profile like the rest of the frame. There are cost advantages of having all sides in the same profile, and the total weight of the product would also be



Figure 6.17 Front feet and rotation mechanism



Figure 6.18 Comparison between the prototype and the original Futchi Wall



Figure 6.19 Prototype testing



Figure 6.20 Prototype testing

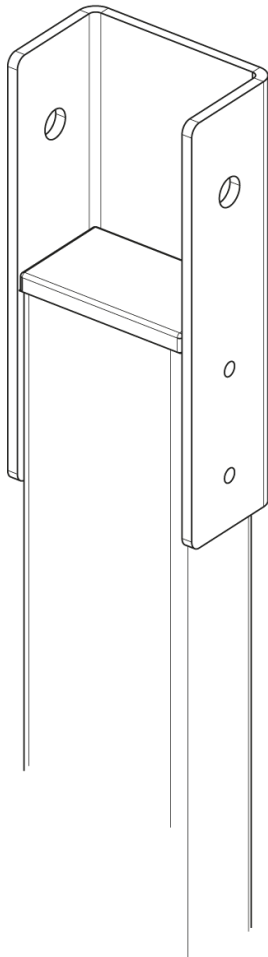


Figure 6.21 Lower middle attachment with aluminium profile instead of steel U-profile

decreased. Some quick additional estimations were also made by replacing the steel bar with some spare aluminium profiles left over from the assembly. Although they were not cut to fit some improvised attachments were added and the tests seemed to indicate that the weight was sufficient on grass and soft ground. On asphalt and concrete, the stability was compromised by the lower weight but it was by no means unplayable. It was still likely to fulfill the criteria set on stability in the requirements specification.

The hooks used to attach the lines which define the playing field worked well on grass and artificial grass. A question was however raised on whether they would work as well on gravel or other material. On grass, they even appear to hold the Futchi Frame in place and they render it impossible for the Futchi Frame to move backwards during a

game.

When handling the prototype, it became apparent that an aluminium profile would indeed be favorable for other reasons than simply to comply with the inner radii of the bent sheet metal parts. The edges had only been rounded at the ends of the aluminium profiles in the prototype to enable the sheet metal parts to lie flush against the surfaces. The majority of the edges had been left sharp and it was apparent that the expression and handling suffered by this compromise. Rounded edges all along the sides of the Futchi Frame would make it look safer and more user friendly, as well as make the sides easier to grip. The sharp edges on the sides were a bit uncomfortable to grip because of the compromise made in the prototype.

6.2.5 Cost breakdown

The cost can be divided into three main categories that are about equal in terms of cost, the profile sections, the sheet metal parts, and the standard components. Possibilities exist to bring the cost down in the two latter groups, whereas the side sections reach the material cost once a volume is ordered and can't be decreased any further. The costs surrounding press braked components are mostly due to the work labour and can therefore be brought down by moving the manufacturing to another country. The standard components get large discounts when larger quantities are ordered and cheaper resellers should be looked into.

6.2.6 Requirements fulfillment

Summarised results corresponding to each category found in the requirements list can be found below. The requirements specification can be found in appendix V.

Mobility

It is possible for a person to move the assembled frame if they are tall enough (even

with net attached). Two people can move it with ease. Since it is possible to disassemble the frame into an unobtrusive package, it can also be stored during winter and moved by car if desired.

Safety

Further testing is necessary to assure that the product is perfectly safe, but design measures have been taken to minimise possibility for safety issues including (but not limited to): no protruding parts, no risk of cutting etc.

Functionality

The rebound is considered to be equal, or better, with the frame compared to its current mounting solution (in a five-a-side goal) and it can also provide rebound at a variety of angles.

Functionality has been tested on grass, artificial grass and asphalt and are considered to work according to requirements, although when the prototype is used on asphalt it rattles more due to the hard surface. It is believed that the rattling will decrease in the final prototype because of tighter tolerances. The prototype is believed to work well on the other surfaces as well, although they are not as important considering that the testing has covered the most probable usage scenarios.

Assembly

First time assembly has been estimated to slightly below 10 minutes with all test subjects stating a possibility to improve if they were to do it again. In the tests where the test subject had previously seen the frame (mounted or in pictures) the time it took to assemble was slightly shorter. The assembly process does not require additional tools, large forces or excessive reaching. It is however not entirely unambiguous as some of the test subjects mounted some of the things wrong, though the error quickly became apparent and error recovery was quick and easy. All test subjects also managed to as-

semble the prototype without instructions prior to or during the test. The area which can be improved is a more obvious order in which to assemble the parts.

Expression

According to the majority of people, the product's expression is in line with the intended expression. It was placed as expected with regard to quality, stability, professionalism and price, considering the wished place on the market. An expressed wish from Aracne was that the frame should bring out the net, but be discreet in itself. This was something that people interviewed expressed, when asked to compare the expression of the two.

Durability

Design measures has been taken towards this problem (powder coating to avoid corrosion, plastic washers to avoid schafe), though longer testing outside will be required to verify this requirement. Destructive testing has not been done to measure capability of handling forces applied to the structure because this could possibly halt other tests. Some surface rust was noted before surface treatment was done, but no rust has been observed after lacquering. Better paint will also be used for the actual product.

Main function

The requirement of attaching the futchi wall to the frame is fulfilled and the cost requirements have been met.

6.3 Future work

This chapter defines the tasks left to perform until a final product can be released to the market. Other than a more substantial long term test to ensure that the product maintains its features properties over time, some additional tests are suggested based on the results from the evaluations. Some tasks left out of the project based on the initial agree-

ments but which remain very useful are also listed along with recommended choices of what solutions and features which are worth their added cost.

validity of the product to ensure its success.

6.3.1 Current state

The handover of the prototype and CAD to Aracne marks the end of the project. The drawings have not been adjusted to include riveting which is suggested for the final product, nor have any other notable changes been made to it after ordering and testing the prototype, only the results thereof are included in the handover. The CAD includes 3D files of individual parts and the assembly but without detail specified construction drawings. Customizing the drawings to better fit a local manufacturer would not add anything to the thesis or the results thereof and is something which is left for future work once a manufacturing and logistics have been arranged. The handover fulfills the goals agreed upon at the start of the project and should allow the company to perform tests based on the results of this project and hopefully launch a product similar to the final concept in the near future.

6.3.2 Tasks left to perform

The most important tasks left to do before a product can be launched is to make the product production ready. This includes developing a tool for aluminium extrusion, making adjustments towards the selected manufacturers and undoing some compromises made with the prototype. The benefits of improved tolerances should also be evaluated compared to their cost and there are still a few alternate solutions which remains untested. A list of additional concepts and ideas which could improve the concept was included in the information which was handed over to Aracne at the end of the project. These options could be worthwhile to pursue and investigate further. Before the product launch, a final study should also be made to confirm the

Discussion

This chapter aims to discuss the project in its entirety and evaluate the events therein and any thoughts which might have arisen and haven't been presented elsewhere. The process, the result and what remains are discussed as well as what went better or worse than expected and what

In very many ways, this has been both a very interesting and in many ways also different project from what we are used to working with. The fact that we worked on our project while Aracne developed their prototype meant that the solutions developed had to be very universal and adaptable. It also meant that some decisions had to be postponed until that part was finalised on their prototype. The process also had to be adapted some, in order to fit with this development of an extension to a product, in lieu of creating an entirely new product. We don't think that the end product would be very different if Aracne would have had their prototype finalised before the project started, but the process would likely have been very different. We would probably have been able to except a lot of ideas earlier on that we did now, as well as having a better understanding of the exact target group. Studies could also have been done on users with different amount of experience with the product, as almost all of the users in our studies were first time users. Interviewing experienced users could also have given us more information, in terms of what the current product lacks. This could possibly have resulted in some additional requirements, although we don't believe that it would have affected the result much.

In a project such as this there is always the decision of when to make selections and choose paths and how hard those choices should be kept. Since Aracne expressed wishes to have a realizable product soon and in order for us to experience a larger part of the product development process, the intent was to reach as far as possible in the process. Because of this the project was narrowed down fairly early and it was agreed with Aracne that the development should focus on a standalone product which suited a lot of environments. In contrast, focus can instead be on a wider set of project paths, but on the other hand it is not possible to evaluate them in as much detail,

or reach as far in the end given limited resources. By selecting a project path early the project can reach further along that path towards the ideal solution than possible had more paths been evaluated. That path may however stop short of the ideal solution, and one of the paths not evaluated might have the potential to get closer to the ideal solution in the end. Selecting to work with a standalone product which is to suit multiple environments is an example of such a choice taken during the course of this project. It can be regarded as a one-size fits all kind of solution for multiple environments and conditions. Making multiple products for different demands can in certain cases fulfill the individual demands better and be cheaper in the end. Making this choice early and narrow down the project did however allow us to fully explore this path and reach a functional end prototype, something which may not have been possible had we chosen to explore more options in the earlier stages. We don't think either way can be determined right or wrong in general, but the differences and advantages should be kept in mind in respect to the end goals and the intended outcome.

A rather low price point was set by Aracne initially during the project which led to focus on cost cutting during the concept development. The large focus on maintaining a low manufacturing cost might have led us to overlook more expensive options, some of which could have increased the value of the product for the customer by a larger amount than the added manufacturing cost. The perceived value of an additional feature might also be large enough compared to its added cost to include it at the expense of another feature which had a worse value/cost quotient.

One aspect of this which we worked with significantly during the course of this project was to merge features and complications into function areas which were allowed to become more expensive, but in turn al-

lowed several other parts to be simplified and cheaper. An increase in cost in an area where the features were concentrated allowed for the total cost to be kept down, instead of having the features and their associated cost spread across the product.

To take a project this far while also working with a very constrained budget in order to make the product reach the end price requirements has been a very good experience for us. Working this way forced us to think of not only plausible manufacturing techniques for our solutions, but rather plausible manufacturing techniques for the set price and then generate solutions based on the chosen manufacturing technique. The choice of manufacturing technique of some parts could also cause other parts to have to be more complex and affect their cost as well, so the cheapest manufacturing technique for one part might not be the cheapest in terms of total product cost. It forced us to take a step back and constantly think of the bigger picture which provided us with valuable experience, though it was admittedly hard especially at first. At a bigger company, solutions are likely to be bounced between designer and constructor to get an expert view on both, letting the designer focus more on the solutions and then having the constructor optimise against a suitable manufacturing technique. In retrospect, it would have provided us with some more interesting viewpoints if we would've had some additional workshops during the later stages of the concept phase. During this stage mostly practical test/mock-ups and just idea-spurring between us was used, and since the problem at that time was well defined having workshops with classmates would probably have given us some good perspective on the problem. Additionally, having workshops and discussions with people closer to production and manufacturing could have resulted in us realising that other manufacturing techniques could be beneficial or that similar parts already

exist. With a workshop like this we would also have had the possibility to better evaluate the problem from different stakeholder perspectives. It would also have given us a better balance in the discussions since the stakeholders in the discussion would have been more comfortable in their positions (i.e. we would drive the functionality, design and price perspective and the attendees would take production and manufacturability more into account). In the project now, we had to act as many different stakeholders which gave a more balanced discussion since we were both arguing for the same things. However, splitting the stakeholder positions between us having one person in charge of some stakeholder perspectives and the other in charge of the rest, could have resulted in a more focused and goal oriented discussion.

It was discovered during the project that kids that like to play football are easy to find. By going to the closest football field, it was easy to get in touch with them and let them try the prototype and ask them questions. This did however lead to a focus on short term impressions and shallower information since the interviewed users got limited experience with the products compared to that which would have been received from a preexisting user had we been able to find one. Since Aracne had yet to break through or attain any notable user base, the possibilities to find users with longer experience of their products were limited. The product category is in itself also not very widespread. Attempts at getting hold of users of competitors' products were considered during the early stages and during the competitor analysis. A competing product, the spot rebounder, was provided by Aracne which allowed some user input to be gathered on competing products by letting users try it out. One way in which more long term user information could have been gathered would have been to lend out the spot rebounder or our prototype. Hesitant to lend

the spot rebounder which we had borrowed to begin with, and realising that lending them out would heavily limit our possibilities to gather a larger amount of input from a larger user base, a choice was made. Both the spot rebounder and our prototype were kept and brought along during the user studies. Lending one of them out at a time was another option which was considered, but that would have rendered comparative tests more difficult to make. Additionally, it would only have provided a very limited amount of extra input seen as the time frame for a user to get a long term impression was unfavourable compared to the time frame of the project at large. This meant the focus remained on short term experiences and first impressions. As is the case with most startups, there is a degree of uncertainty on when and where you will break through and what will trigger the success. It is understandable that a startup company would want to avoid narrowing down their possibilities, but a consequence of this is that there is a risk that too much emphasis is put on ensuring a great first impression to break through when presenting the product. Focusing on long term satisfaction is risky since a good short term impression is required to reach the point where long term satisfactions begins to play a role.

Getting longer and deeper interviews with parents similarly proved to be a lot harder than initially thought. This has likely to do with the fact that not all parents are heavily interested in their kid's football life, and their main involvement is dropping off and picking them up from practice. It could have been advantageous to have more and deeper discussions with parents, although we don't believe that the end result would have differed. Possible gains from this could however be a better understanding of the possible market which could improve marketing possibilities. After the project, we have been reflecting on however more interviews with different stakeholders would

have affected the outcome of our project. Our goal was to reach depth with deep interviews with all of the stakeholders, which proved difficult with parents. Trainers however proved to have similar demands (mainly because they also were parents) regarding the shallow information received which led us to believe that the demands reached at a deeper level would be similar. Though one major difference was that trainers often described the kids from a practice session point of view. The parents often mentioned that they wanted to activate their kids and get them to play outside. No one mentioned the possibility of using it as a tool to bond and do something together with their kids. As the final product is designed it is entirely possible for parents to play with their kids, but it is also very possible that additional requirements could have risen in regards to this demand had the topic been discussed.

Considering the delimitations put on the project, mostly in terms of price and that the product had to be created alongside an almost finished product, we are very satisfied with the outcome of the project. We think that we have managed to create a product that carries the wished expression, while being discreet enough to focus attention on the net while attached. The prototype carries all of the main functions necessary to be a working product, but as stated earlier it is also recognised that there are some future work necessary in order to reach the high quality which we believe is needed to gain market shares in the intended position. Further evaluation is however needed in order to see if a machined and riveted prototype produced as intended (and not with a pillar drill in a workshop) might be enough improvement in quality.

Conclusion

This master thesis project has resulted in a prototype that works well together with the Futchi Wall and is suitable for use in a home environment. Assembling the product is a straightforward process and is likely to be done once a year by most users (during spring). Because the assembly is done in under 10 minutes it is also possible to bring it to a summer house for a couple of weeks during the summer. Mounting and dismounting the net is also a simple process and is quickly done in under a minute if the frame is pre set-up. Because of this, the net is can easily be brought to a football field during practice or similar and the re set-up without any hassle which increase the usage and value of the product. Additionally, the product will not need any extra tools or accessories to assemble and disassemble which leads to a more flexible product.

Due to the fact that the product is created from only a few different materials, all of which are separable, we consider the sustainability of the concept to be very good. Because of this and the fact that powder coating does not degrade the metals, pretty much all of the materials used can be recycled and re-used in other products. Almost the entire product is made in aluminium, which is very environmental friendly due to it's recyclability.

The intended expressions for the frame were chosen to be sporty, professional, quality, safe and stable, while still being discreet and accent the net when attached. The product is deemed to express these expressions due to its black, metal frame and clean minimalist design.

The main thing we learnt and will take with us from this project is how it is working with a small company. During the project we have had a lot of freedom, but also responsibility, with ideas, solutions, and the holistic view that is needed when being the expert on product development.

"In what context/environments where there are no goals available would there be a desire to use the Futchi Wall?"

During the research it was found that the users could be characterised into two groups determined by their living situation and whether they had a garden and lawn outside their house or an apartment in an urban setting. It was also discovered that few families have goals in their gardens at home. There was also a desire to use the Futchi Wall in gardens and home environments for the former group, as well as in nearby open fields in the case of the latter group and at vacation homes for the ones who had them.

"How can the Futchi Wall be made compatible with environments where there are no goal frames available?"

With the prototype, it is possible to assemble the Futchi Wall together with the Futchi Frame at almost any given location as long as it is relatively flat. A somewhat flat area is a prerequisite in order to play the game Futchi so it doesn't exclude any possible areas. Whether it be outdoor or indoor (with the help of the rubber feet). It is therefore safe to consider that the prototype has made the Futchi Wall compatible with environments where there are no goal frames available and Futchi can be played.

"In what contexts, if any, does the old product remain superior?"

The user group without access to goal frames and storage or a place to assemble the product long term will still benefit from the more mobile solution (i.e. the regular Futchi Wall). As found in the study, this user group is also more likely to have access to football fields and the company's existing product fits better to this group whereas the addition created in this project better fulfills

the demands of the other group. This new product therefore does not compete for the same market share, as they are both superior in their individual markets, a conscious decision which was made during the project.

The increased functionality that this product gives the Futchi Wall is assumed to bring value to Aracne and strengthen their position on the market as well as help to spread their newly founded sport Futchi even more.

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Interviews

Klint, Kenneth (Managing director, Plastinjekt) interviewed by the author 26th may 2014.

Tobiasson, Ted (Head of customer centre, SAPA) interviewed by the author 12th may 2014.

Niklas Allbäck (Tränare, Örgryte IS) interviewed by the author 16th april 2014

Figures

Figure 1.1 Futchi logotype

Figure 2.1 Futchi Wall prototype mounted in goal

Figure 2.2 Lower mounting devices

Figure 2.3 Attachment of lower mounting device

Figure 2.4 Upper mounting device

Figure 2.5 Rebound characteristics

Figure 2.6 Two players playing Futchi on artificial grass

Figure 4.1 Process stages

Figure 4.2 User study phases

Figure 4.3 Concept generation and sketching

Figure 4.4 Workshop with preprinted nets

Figure 5.1 Expression board

Figure 5.2 Shape concepts

Figure 5.3 Problem areas

Figure 5.4 Function areas and mocup

Figure 5.5 Profile shapes

Figure 5.6 Inner and outer surface at edge

Figure 5.7 Preventing contact close to hinge

Figure 6.1 Schematic overview of the Futchi Frame

Figure 6.2 First and second assembly step

Figure 6.3 Third and fourth assembly step

Figure 6.4 Fifth assembly step

Figure 6.5 Futchi Frame

Figure 6.6 Packaged Futchi Frame and Futchi Wall

Figure 6.7 Attachment of playing field lines

Figure 6.8 Side view of the prototype

Figure 6.9 Adjustment holes offset from center

Figure 6.10 End caps branded with Futchi logotype

Figure 6.11 Logotype proportions and profile

Figure 6.12 Upper corner

Figure 6.13 Lashing anchor at lower front corner

Figure 6.14 Upper middle attachment with outer cover and inner support structure

Figure 6.15 Lower corner

Figure 6.16 Branded surface at upper corner

Figure 6.17 Front feet and rotation mechanism

Figure 6.18 Comparison between the prototype and the original Futchi Wall

Figure 6.19 Prototype testing

Figure 6.20 Prototype testing

Figure 6.21 Lower middle attachment with aluminium profile instead of steel U-profile

Appendix

Appendix I - Requirements list

#	Requirement	Explanation	Stakeholder	Type	Validation
1 Mobility					
1.1	Must be able to be moved across the lawn fast and easy	Product should not wear down the grass or prevent mowing the grass	Parent, Player, Coach	Requirement, Demand, Value adder	
1.2	Should be possible to make untrusive in garden	Garden needs to look presentable	Parent	Requirement	User test
1.3	Must be possible to put in storage	Products should not have to be stored in garden (eg. during winter)	Parent	Demand	Y/N
1.4	Must be moveable by car	Brought to summer house or on vacation	Parent, Coach	Requirement	Y/N
2 Safety					
2.1	Must be safe when assembling	User should not be injured by dropping or handling the product while assembling it	Parent, Player, Coach	Requirement	Test
2.2	Must be safe when using	User should not be injured by falling/running into the product	Player	Requirement	Test
2.3	Must be safe when transporting	User should not be injured by dropping or handling the product while transporting it	Parent, Player, Coach	Requirement	Test
2.4	Must not require parental supervision when used	Product should be self-sufficient and activate user without parental guidance	Player	Requirement	User study
3 Functionality					
3.1	Must be able to provide rebound at different angles	Enables more settings and uses for the product	Player	Demand	Y/N
3.2	Product should stand stable during normal use	Product should be stable during use to provide a consistent experience	Player	Requirement	Y/N
3.2.1	Must not move during use in a garden/lawn environment	Product should be stable during use to provide a consistent experience	Player	Requirement	Y/N
3.2.2	Must not move during use in a artificial grass soccer field environment	Product should be stable during use to provide a consistent experience	Player	Demand	Y/N
3.2.3	Must not move during use in a hard ground soccer field environment	Product should be stable during use to provide a consistent experience	Player	Demand	Y/N
3.2.4	Must not move during use in an indoor soccer arena	Product should be stable during use to provide a consistent experience	Player	Value adder	Y/N
3.3	Must provide good rebound	Product should match Futch Wall in rebound performance (Homogeneity, Strength)	Player	Requirement	User study
3.4	Targets on the net	Provides additional possible uses and gameplays for the players	Player	Demand	Y/N
4 Assembly					
4.1	Should allow for quick assembly	The faster the assembly, the more usages can be found	Player, Parent, Coach	Demand	User study
4.2	Must not require large forces to assemble	Children should be able to assemble the product by themselves	Player	Requirement	User study
4.3	Must not require excessive reaching	Shorter users should be able to assemble/mount the product by themselves	Player	Requirement	User study
4.4	Must not require additional tools for assembly	No additional tools should be required to assemble the product	Player, Parent, Coach	Demand	Y/N
4.5	Must be possible for children aged 13y to assemble (after first assembly)	Player should be able to mount him/her-self without parental guidance	Player	Requirement	User study
4.6	Unambiguous assembly	Product should not be possible to mount the wrong way	Player, Parent, Coach	Requirement	User study
4.7	Intuitive assembly	Product should be obvious enough that the manual doesn't have to be used	Player, Parent, Coach	Demand	User study
5 Legal					
5.1	Must not conflict with patents of competing solutions		Aracne	Requirement	Y/N
6 Design					
6.1	Professional design	Professional design strengthens the brand and distinguishes it from undesired associations	Everyone	Requirement	User study
6.2	Congruency between expression and properties	The product should express the inherited properties through its design	Everyone	Requirement	User study
6.3	Express quality	The product should be perceived as a high quality product	Everyone	Requirement	User study
7 Durability					
7.1	Weather resistance	Will possibly be left outside during harsh weather (or forgotten outside)	Player	Requirement	Material selection
7.2	Mechanical resistance	Grass, rubber granules and similar foreign objects should not jam the mechanisms	Player	Requirement	Test
7.3	Should withstand external impacts	Product should not be damaged if an adult falls onto it	Parent, Player, Coach	Requirement	User study
8 Main function					
8.1	Must be compatible with net from Futch Wall	Product is pointless if not compatible with Futch Wall	Aracne, Player	Requirement	Y/N

Appendix II

Shots were made at different parts of the net mounted in the mock-up to test its stability. Weights were added to give an estimation of how weight and the placement of it would affect the stability of the end prototype.

	Left hit (20st)	Center hit (20st)
No weight		
Displacement left side (cm)	83	60
Displacement right side (cm)	50	47
Weight middle of support leg		
Displacement left side (cm)	23	13,5
Displacement right side (cm)	12	8
Weight front middle	20	19
Displacement left side (cm)	8	17,5
Displacement right side (cm)		
Weight back of support leg		
Displacement left side (cm)	20	12
Displacement right side (cm)	22	12
Weights at top corner		
Displacement left side (cm)	22	12
Displacement right side (cm)	9	19,5

Appendix III - User study guides

Questions

How often do you practice:

	Hemma	Träning
Fys		
Teknik		
Spel		
Ensam		

Would you like to practice any of these disciplines more/less?

At what age do you think this kind of product would be of most use for you?

Do you think you would have any use for this kind of product at home?

How much money do you spend on football on average each year?

How much money do you think you would mind to pay for this kind of product?

Pros/cons with aracne's net and the spot rebounder, how can they be improved/changed

