I-FIVE

A platform to promote social interaction between developmental diverse children in team sport

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Summary

Developmental Diverse Children (DDC) have a higher chance of becoming overweight or obese. One of the reasons for this is the lack of physical activity. Physical activity can have several benefits for DDC, such as sleep improvement and stress reduction. However, DDC can experience different barriers to engage in physical activity than their Typical Developing (TD) peers. One of these barriers is the social behaviour challenges that DDC experience, which is especially challenging in team sports. Interactive technology could be beneficial to help with these social challenges in team sports.

Starting this thesis, the goal of the technology was to promote social interaction between DDC and their TD peers to make regular team sports more inclusive. During the design cycles, the goal of the technology was redefined based on the discovered information. The main objective of this thesis stayed the same, which is investigating the challenges and possible solutions that can be encountered when designing interaction technology for DDC in the context of physical activity. An iterative design approach was used to go through the five phases of the Design Thinking Process. By going through the five phases three times, challenges and possible solutions encountered were documented and compared to challenges found in the preliminary study. To guide the design process, a design space was created and adjusted throughout the design cycles.

The research outcome and contributions include an overview of the challenges encountered and possible solutions, the design space, and a hi-fi prototype of the I-Five. Several challenges that were not found in the preliminary research were encountered during the design of the I-Five, such as the influence of the type of exercise when testing the prototype.

The goal of the I-Five was redefined in every design cycle. This led to the final goal of the I-Five: promoting physical non-verbal compliments and encouragements between DDC in team sports. The I-Five is based on a reward system that gives DDC a reward in the form of a LED light when giving a non-verbal compliment or encouragement to another player using the I-Five.

Initial test results show that the I-Five could promote non-verbal compliments and encouragements between DDC. However, the I-Five was tested on a small sample

size and the type of exercise influenced the results of the final user test. Therefore, more research is needed to investigate the effectiveness of the last iteration of the I-Five, and other applications or designs of the I-Five.

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Chapter 1

Introduction

Approximately 15% of children are described as having Neurodevelopmental Disorders (NDD) [7]. NDD is defined as *'multifaceted conditions characterized by impairments in cognition, communication, behaviour and/or motor skills resulting from abnormal brain development'* [8]. Examples of NDD are Attention Deficit/Hyperactivity Disorder (ADHD), intellectual disability and autism. This thesis will use the term 'Developmental Diverse Children' (DDC) to describe children with NDD to avoid the negative nuance of 'disorder' [9]. Studies [10], [11] show that DDC are at a higher risk of becoming overweight or obese. A lack of physical activity contributes to the higher risk of overweight and obesity in DDC [12].

When comparing DDC to Typical Developing (TD) children, DDC were found to be less fit, less active and more sedentary than TD children [13]. Furthermore, DDC can experience physical activity or team sports differently than TD children: DDC are aware of their differences from their TD peers, can experience sensory issues, can get frustrated due to the competitive nature, and the social aspects of sports are a challenge for DDC. Even though DDC could have these somewhat negative experiences with physical activity, the physical benefits of physical activity are well-known. Furthermore, children with autism who frequently engage in physical activity show an improvement in social behaviour [14], motor skills, daily living activities [15] and sleep quality [16].

The reason for people to engage in physical activity depends on the individual, where age was found to be a factor that influences this reason [17]. Social engagement with peers is what attracts children around the age of ten to participate in sports [14], [18]. As mentioned before, when children participate in physical activity, they learn a variety of social aspects, such as, solving and preventing conflicts, socializing better and communicating [14]. This shows the importance of the social aspect in sports [19].

However, one of the barriers for DDC to participating in physical activity or team sports is their social challenges [13], [18]. Next to that, there are fewer possibilities

for DDC to engage in team sports due to the difficulties of including DDC in regular sports [13]. Therefore, this thesis will focus on the social challenges of DDC in team sports. Interaction technology could be beneficial for making a more inclusive team sports environment for DDC. Designers experience a variety of challenges when designing with and/or for DDC (Chapter 2). This thesis shows what challenges are experienced while designing for this target group in the context of team sports and discusses how to counter these challenges.

1.1 Motivation

Research has already shown that sports can increase social skills and that children participate in physical activity to spend time with their friends. Unfortunately, social challenges are one of the reasons that many DDC do not participate in physical activity. Preliminary research shows that several studies have been conducted on how to increase the social skills of DDC in therapy or education using technology. However, how to increase the prosocial behaviour of DDC in the context of physical activity has not got much attention.

Designing technology for DDC comes with several challenges (Chapter 2). One of the challenges is the diversity of this target group. The umbrella term Developmental Disorders includes a variety of disorders, such as autism, ADHD and Down Syndrome. All these children have unique wants and needs. Designers need to take this into account. Furthermore, the social challenges of these children make it difficult to conduct, for example, interviews with this target group. By promoting prosocial behaviour between DDC and their TD peers, DDC do not only develop their social skills, but could also lead to making team sports more inclusive.

Moreover, these challenges make it difficult and time-consuming to test prototypes on a variety of DDC. Moreover, the diversity, representation and lack of prosocial behaviour of the target group (Chapter 2), make it difficult to draw conclusions on the acceptance and user experience of these prototypes. Therefore, this thesis describes a design process for designing technology for DDC in the context of organized physical activity and evaluates this process by discussing the challenges that were encountered and suggestions on how to counter these challenges. These challenges will also be compared to the already found challenges in the preliminary research (Chapter 2).

1.2 Objective

The method that was used is an iterative design approach (Section 3.1). This means that the objective of the study changed in every (re)define phase. This thesis started with the aim to design technology that promotes prosocial interaction between DDC and their TD peers during organized physical activity. By increasing prosocial interaction, DDC will be one step closer to being included in regular organized physical activity. After the first Define phase (Section 4.2), the objective was changed and extended to that the system should support the coach with a variety of activities to make it easier for DDC to feel included and accepted by their TD peers. Then, in Section 5.2, the social interaction was specified to promote physical non-verbal interactions, such as high-fives. In the last Define phase (Section 6.1.4), the objective was changed to the final version: designing technology that promotes physical non-verbal interactions between DDC.

Although the objective was redefined, the main goal of this thesis stayed the same: design interaction technology for DDC in the context of physical activity to promote prosocial behaviour. The variety of challenges that designers experience when designing with and/or for DDC (Chapter 2) makes it difficult to create a technology that is accepted and contributes to a positive experience by the target group. The main outcome of this thesis is a description of this design process and an evaluation of this process to discover the challenges and possible solutions.

Using the Design Thinking Process, a variety of design activities were conducted to find the solution that most fit the targeted problem. Through the iterative steps of Empathizing, Defining, Ideating, Prototyping and Testing solutions for the problem, a system was designed that promotes social interaction between DDC. To test low-fi prototypes, the use of the Technology Acceptance Model and the 5D rubric (Section 3.2) was used. Furthermore, during the design process, challenges that are encountered and possible solutions were documented and discussed.

1.3 Research question and thesis structure

The goal of this thesis is to uncover challenges that occur when designing interaction technology in the context of physical activity and suggest solutions on how to counter these challenges. To uncover these challenges, this thesis goes through three design cycles of the Design Thinking Process. A schematic overview of the structure of this thesis is shown in Figure 1.1.

As preliminary research, a systematic literature research was conducted to investigate challenges and opportunities found in previous studies. These findings are described in Chapter 2. Because this research uses an iterative design approach,

the objective and the main research question were redefined in every Define phase (Figure 1.1). From the Preliminary Research (Chapter 2), it was learned that DDC experience social barriers when playing sports together with TD children. This inspired the main research question:

Main research question V1: | ***Chapter 2***
How to design a system to promote prosocial behaviour between developmental diverse children and their typically developing peers in team sports?

In the Empathize and Define phase of the Design Cycle 1 (Section 4.1), it was found that the coach plays a key role in promoting pro-social behaviour in (team) sports. Therefore, the main research question was redefined to explicitly include the coach:

Main research question V2: | ***Section 4.1***
How to design a system ***that supports the coach*** *to promote* ***prosocial interaction*** *between developmental diverse children and their typically developing peers in team sports?*

In the Define phase of Design Cycle 2 (Section 5.1), findings showed that physical touch, such as high-fives, during physical activity can have a deeper level of emotional importance. DDC might have difficulty with physical prosocial interaction. Therefore, the main research question was redefined to explicitly include the physical non-verbal aspects of eliciting pro-social behaviour:

Main research question V3: | ***Section 5.1***
How to design a system that supports the coach to promote ***physical non-verbal interaction, such as high-fives,*** *between developmental diverse children and their typically developing peers in team sports?*

In the Empathize phase of Design Cycle 2 (Section 6.1), findings showed that the social dynamics between DDC and TD children are quite complex and that DDC also have difficulties with showing prosocial behaviour amongst themselves in team sports. Therefore, it was decided to first look into how to promote prosocial behaviour between different DDC within a team. The main research question was redefined to focus on prosocial behaviour between DDC:

Main research question V4: | ***Section 6.1***
How to design a system that supports the coach to promote physical non-verbal in-

teractions, such as high-fives, ***between developmentally diverse children*** *in team sports?*

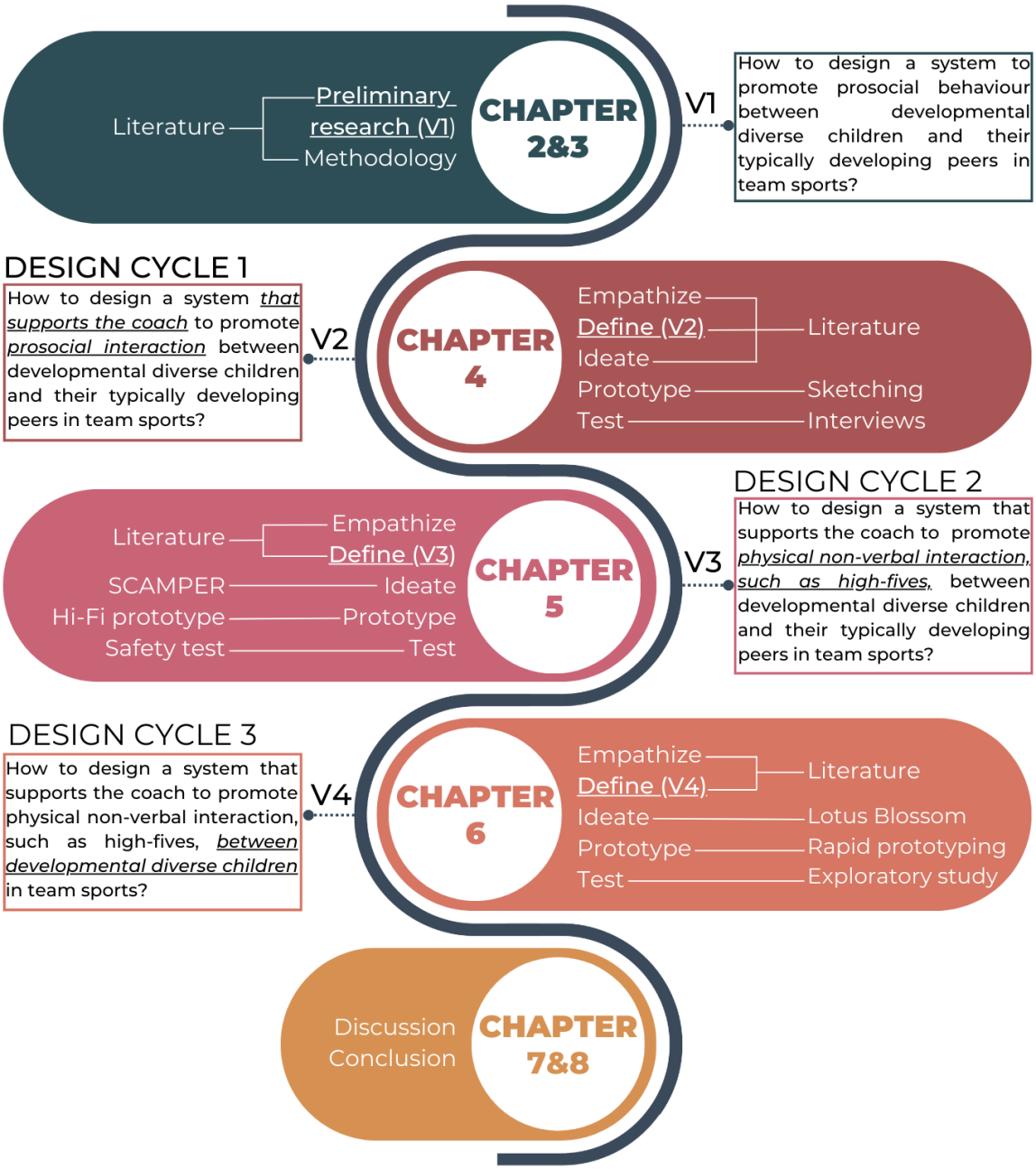


Figure 1.1: Schematic overview of the structure of this thesis and versions of the main research question (V1-V4).

CHAPTER 2&3

PRELIMINARY RESEARCH & METHODOLOGY

Chapter 2

Preliminary research

This research aims to identify challenges that can occur and suggest solutions for these challenges when designing interaction technology for DDC in the context of physical activity. A systematic literature review was conducted to get familiar with the challenges that previous research encountered. The Design Thinking Process was used as a framework (Chapter 3). A summary of these challenges and possible design requirements are explained in this chapter. These challenges will be kept in mind during the design process of this thesis and will later be compared to the challenges encountered in this research. More information on the preliminary research can be found in this PDF: Challenges and opportunities in designing movement interaction technology for Developmental Diverse Children. The challenges and opportunities in the literature were divided into three themes: Representation and generalization, Diversity and Social behaviour of DDC.

2.1 Representation and generalization

Representation refers to who or what is over- or underrepresented in target groups and gender. When one of these categories is over- or underrepresented, the results of the study cannot be generalized over the underrepresented categories.

Generalizing the results over children with other disabilities, such as Down Syndrome, cannot be done when the technology is not yet tested on this target group. In the Preliminary Research, children with autism mainly represent the target groups for which researchers designed movement interaction technology (Figure 2.1). Next to that, when a participatory design approach is used to design the technology or the technology is tested on the target group, gender could influence the design choices or the test results [20]. This can be a challenge since autism is more prevalent in boys [20]. Therefore, when only one gender is used or is overrepresented in the study, the results or design decisions cannot be generalizable over gender. Lastly,

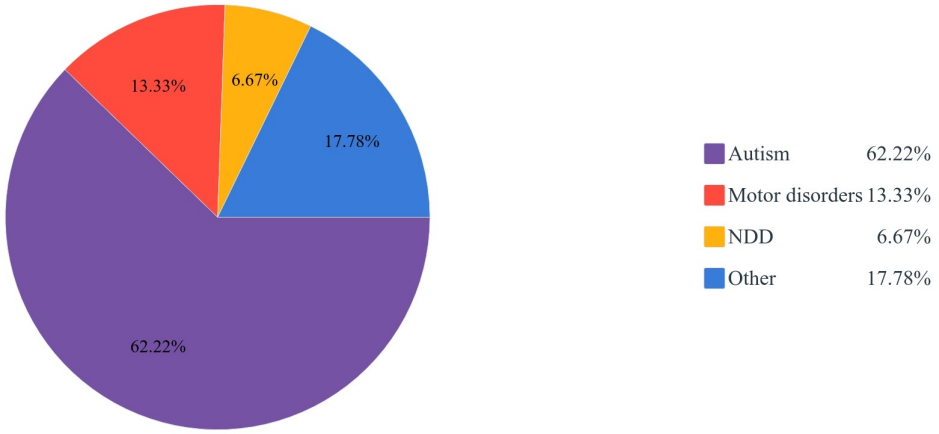


Figure 2.1: Percentages of the target groups of the included literature

most studies could not generalize their results to their target population. The main reason for this was having to research a small sample size.

2.2 Diversity

Diversity, or heterogeneity, refers to the variety of differences in the context of the target group, skills and technology. The main challenge when designing for DDC is the large diversity of DDC as a target group. This is mainly due to that every child has unique wants and needs, meaning that not every method works for every child. Next to that, the diversity of the target group makes it difficult to set up requirements. Furthermore, there could be a variety in the level of motor, social and/or cognitive skills within the chosen target group. This can be taken into account in the design of the technology by making it controllable and adaptable for e.g. teachers, trainers and therapists [21], and by offering a variety of levels and games [22], [23].

2.3 Social Behaviour of DDC

The biggest challenge regarding gaining results from the test phase is determining whether the results were influenced by the introduced technology or by other factors. Studies [22]–[27] discussed they had difficulties defining the cause of the results, for the reason that it was not possible to isolate all variables.

First, DDC vary in levels of being sensory sensitive [21], [25], [28]–[38], which means that too much light or sound can be overwhelming for DDC. This can lead to frustration, which could influence the results.

Second, unfamiliar people and unfamiliar environments, among other factors, can influence the mood of DDC [25], [39]. An unfamiliar environment can especially be challenging when testing technology in a lab or another environment that is not familiar to the participants. Next to that, when for example the researcher is observing or interviewing a participant, the unfamiliarity of the researcher might influence the results.

Third, DDC vary in levels of communication skills or are non-verbal, which makes it challenging to interview them. Studies usually use proxies, such as caregivers [29], [36], [37], [40] or therapists [36], [40], [41], to gain results. Next to that, due to the communication challenges, it is possible that DDC do not understand instructions. Therefore, clear instructions are important to get reliable results.

Lastly, some DDC have difficulties concentrating [24], [25], [28], [32], [34], [40], [42]. This could make it more challenging to provide instructions, because these instructions should be short. Moreover, the duration of the levels of the designed technology should not take too much time [28]. DDC can lose their concentration and attention fast, which could lead to the abandonment of the technology.

2.4 Interpretation

Several challenges, when designing movement interaction technology for DDC, were identified in the preliminary study. However, these technologies were mostly designed in the context of therapy and education. What kind of challenges occur when designing interaction technology in the context of physical activity might differ from these challenges. Therefore, this research wants to expand on the challenges that could occur when designing for DDC in the context of physical activity and to make suggestions on how to solve these challenges. This will contribute to better design practices for DDC.

Chapter 3

Methodology

This thesis aims to design a technology that promotes prosocial behaviour of DDC in the context of organized physical activity. Designing for DDC comes with its challenges (Chapter 2). When using the iterative Design Thinking Process to design technology for DDC several methods are needed to face these challenges, especially when testing low-fi prototypes. This chapter explains the methods and frameworks that were used for this thesis.

3.1 Design thinking process

The design process was guided by the Design Thinking Process [43]. This process is user-driven, iterative and non-linear. The main advantage of the Design Thinking Process is that it is not a step-by-step process [44]. This research went through the design cycle multiple times to investigate which challenges could occur in the different phases of the Design Thinking Process. Furthermore, the Design Thinking Process was used as a framework for the preliminary research (Chapter 2) to identify challenges in previous research. Therefore, using the same method to design the system helps to compare these challenges and make suggestions to solve these.

The Design Thinking Process consists of five phases: Empathize, Define, Ideate, Prototype and Test (Figure 3.1). In the Empathize phase, the needs of the target group are studied. This phase allows for gaining more insight into the user's needs. Next, the users' problems and needs are defined in the Define phase. Further, in the ideate phase, ideas are generated. Then, prototyping these ideas to find the best solution for the defined problem. Next, these prototypes need to be tested. After this, designers return to a phase to refine, iterate or alternate the solution. [44]

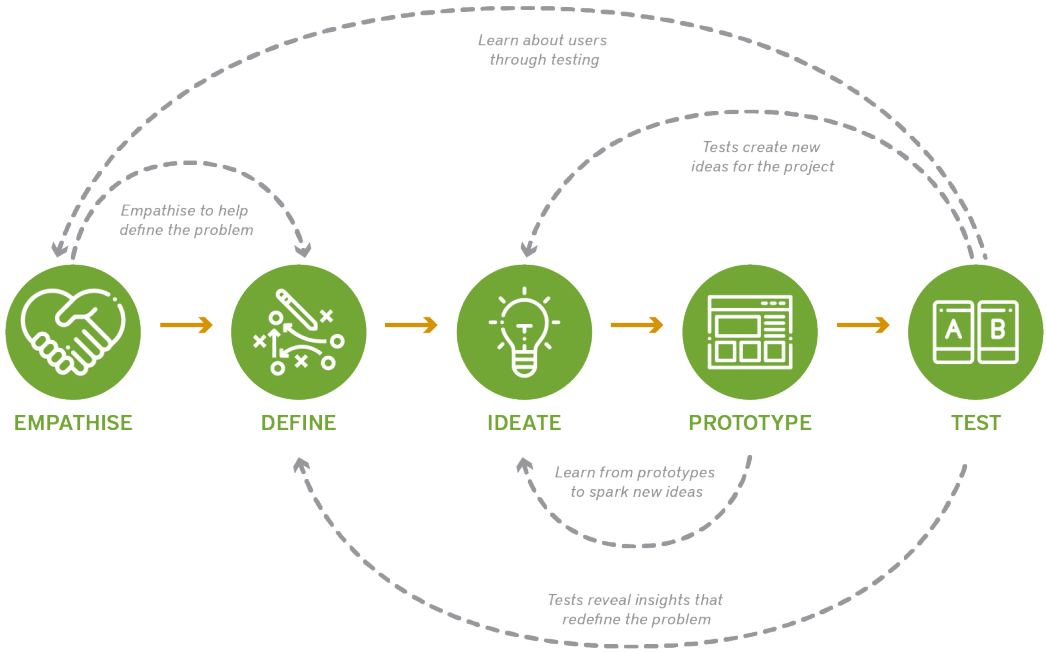


Figure 3.1: Design thinking process [1]

3.2 Technology Acceptance Model and 5D Rubric

During this thesis, several interviews took place to test the prototypes or ask the opinion of participants on the prototype. To structure these interviews, two models were used to define interview questions. To test the perceived acceptance the Technology Acceptance Model (TAM) was used and to test the perceived user experience the 5D Rubric was used. The questions that were defined can be found in Appendix B.0.1. Depending on the kind of interview, the interview questions were adjusted accordingly.

The TAM (Figure 3.2) shows that the usage of a new technology depends on the perceived usefulness and the perceived ease of use. The *perceived usefulness* means whether a potential user views the new technology as useful for the target goal. The *perceived ease of use* means whether a potential user finds the new technology easy to use. [2]

The 5D Rubric, developed by Kreitzberg [45], shows five factors that influence the experience of the user. The five elements are Empowering, Efficient, Easy, Engaging and Trustworthy. *Empowering* is about whether the technology fulfills the need of the user. The *Efficiency* is about the effect that is needed to use the technology. *Easy* is about the accessibility and intuitively of the product. When the technology is *Engaging*, the user is involved with the technology and has positive feelings. Lastly, *Trustworthy* is about the confidence of the user in the technology. [45]

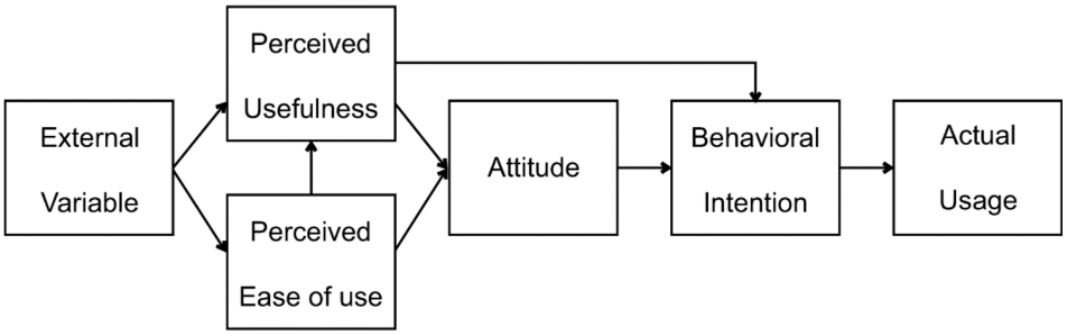


Figure 3.2: Technology Acceptance Model [2]

Due to the challenges of designing for DDC, these models are used to guide interviews to investigate the perceived acceptance and the perceived user experience of the proposed technology when presented with sketches or prototypes, such as in Chapter 4.5.

CHAPTER 4

DESIGN CYCLE 1

Finding methods to promote social interaction in team sports

Chapter 4

Design Cycle 1: Finding methods to promote social interaction in team sports

Several social behaviour challenges that DDC experience were already identified in Preliminary Research (Chapter 2). However, what kind of social behaviour occurs in team sport and which of these behaviours are challenging for DDC needs to be investigated. Furthermore, what type of technology could be used in the context of organized physical activity to guide the social behaviour of DDC needs to be studied.

Therefore, this Design Cycle will focus on finding more information about the topics using literature and interviews. The goal of this chapter is to identify characteristics of social behaviour in team sports settings. Another goal of this chapter is to investigate how such behaviour can be supported through technology and what technology is most suited. The following research questions guided this Design Cycle:

Sub-question 1.1: *What kind of social behaviour occurs in the team sport?*

Sub-question 1.2: *What type of technology would be fitting in the context of physical activity to promote prosocial interaction?*

4.1 Empathize: Diving into social behaviour challenges of DDC in team sport

Social behaviour can be divided into two categories: prosocial and antisocial behaviour [54]. Prosocial behaviour is seen as voluntary behaviour that is intended to benefit or help others [55], such as complimenting someone. Whereas, antisocial behaviour is behaviour that is intended to disadvantage or harm someone [56],

Table 4.1: Prosocial and antisocial behaviour in team sport. * indicates the social behaviour challenges of DDC

Prosocial	**Antisocial**
In-group social behaviour towards others	
1. Positive conflict [46]–[49]	1. Negative conflict* [46], [49], [50]
2. Taking on a role (roles) [46], [50]–[52]	
Individual social behaviour	
1. Taking turns* [53]/Plays fair [46]	1. Shows frustration [47] [47]
2. Stick to group norms* [49]	2. Disrupts* [52]
3. Cooperates* [46], [52]	3. Aggressiveness [47], [48]
4. Group cohesion* [46], [48], [50], [51]	

[57]. An overview of these social behaviours can be found in Table 4.1, where the * indicates social behaviours that DDC deviate from TD children [58], [59].

First, DDC have troubles with social interactions, including having frequent negative conflicts with peers [58]. Negative conflict is seen as antisocial behaviour. This includes, for example, being aggressive towards a peer, verbally abusing someone, fighting or saying negative comments [54].

Next to that, DDC showed to have difficulties with sticking to group norms. Group norms are unwritten and informal rules about how things ought to be done [49]. A group norm is, for example, listening to the coach when he/she is giving instructions. DDC have difficulties concentrating [58], [59] and they could be impulsive [59], which could lead to disrupting the instructions or training exercises physically or verbally [58]. Difficulties with concentrating and impulsiveness could also influence cooperative activities and group cohesiveness. Being able to cooperate means that someone does what is asked or wanted for, or that participants work together on a common goal [46]. Group cohesiveness stands for involving actively in group activities [48].

Furthermore, DDC have trouble with turn-taking [58]. Being able to take turns in organized physical activity means that the individual waits patiently until it is his/her turn, engages in the game when it is his/her turn and returns to the assigned waiting area [53]. Not being able to take turns could disrupt the training.

These social behaviour challenges that DDC could experience in team sport could lead to not getting accepted by their peers and/or their coach [58], [60]. The study of Breitkreuz [58] emphasizes the importance and influence of coaches for including DDC in organized physical activity. The coaches can reduce the conse-

quences of antisocial behaviour and can promote prosocial behaviour [61].

4.2 Redefine

Research shows that the coach has the power to decrease antisocial behaviour and increase the prosocial behaviour of DDC. The Teaching Personal and Social Responsibility (TPSR) model, which can be used by physical activity instructors, was designed to promote lives skills for young people that were at risk of being socially isolated by the means of physical activity [62]. One of the components of this model is "promoting social interaction", which could be achieved by, for example, organizing team-building activities. Promoting social interaction between DDC and their TD peers could lead to an increase in acceptance of including DDC in (team) sports [63]. Therefore, this study will expand on the objective of this thesis described in Chapter 1, by focusing on designing a technology to support the coaches in promoting prosocial interaction in team sports between DDC and their TD peers. This leads to the next version of the main research question, as described in the Introduction (Section 1.3).

4.3 Ideate: Exploring methods and technologies to promote social interactions

In this ideation phase, the methods already used in (team) sports to promote prosocial interaction and existing technologies that promote prosocial interaction were investigated using literature.

Promoting social interaction in the context of physical activity can be done in a variety of ways, such as cooperative activities [64], peer coaching activities [65] and partner drills [66]. The methods promote social interaction by encouraging communication and/or letting the participants work on a common goal [67].

These aspects are also seen in existing technologies that promote social interaction between DDC and TD children [68]–[70], such as Lands of Fog [71]. Most technologies consisted of a game where the participants had to achieve a common goal. To achieve this common goal, a form of communication or social interaction is needed.

These technologies, such as Lands of Fog, are usually large systems where a lot of space is needed. In team sports training or competition, such large systems need time to set up and will probably disrupt the training. Therefore, smaller technologies, such as wearable devices, are seen as more suitable. Two wearable

Figure 4.1: Left: ER [3], Right: CommonTies [4]

technologies, Enhanced Reach (ER) [3] and CommonTies [4] (Figure 4.1), showed that wearable devices could promote social interaction. ER [3] is a wearable device that was designed to promote social interaction in the context of physical activity. These technologies will be used in the Prototype phase as inspiration.

4.4 Prototype: First iteration

From the previous Ideate phase, two types of technology seemed feasible, namely, wearable devices attached to sportswear (ER) and wearable devices like the Smartwatch (CommonTies). Therefore, Two prototype versions were created from the ideate phase. Previous research shows that increasing the interaction between DDC and TD children can increase the acceptance of DDC. Therefore, the goal of the technology is to promote prosocial interaction. The first concept of this technology is to trigger the curiosity of coming closer to each other. This was already the idea from ER [3]. However, after the ideate phase, two versions of these ideas with different use were thought of.

The first version is similar to the CommonTies [4], which is a wristband that lights up when it touches another wristband. This wristband could also be used for collaborative games. In a training context, the wristband might be difficult to implement, because the wristband is less visible for other players. The second version is similar to ER [3]. It is a LED strip connected to a vest that lights up when another vest is close by. The goal of the prototype is to trigger the curiosity of the children to come close to each other and thus to interact with each other. The two versions are slightly different in the way the LEDs will light up and how the technology can be used.

4.4.1 Version 1: Wristband

The wristband works as described in Figure 4.2 and can be used in several ways (Figure 4.5a). When the wristbands touch each other they will vibrate, light up or

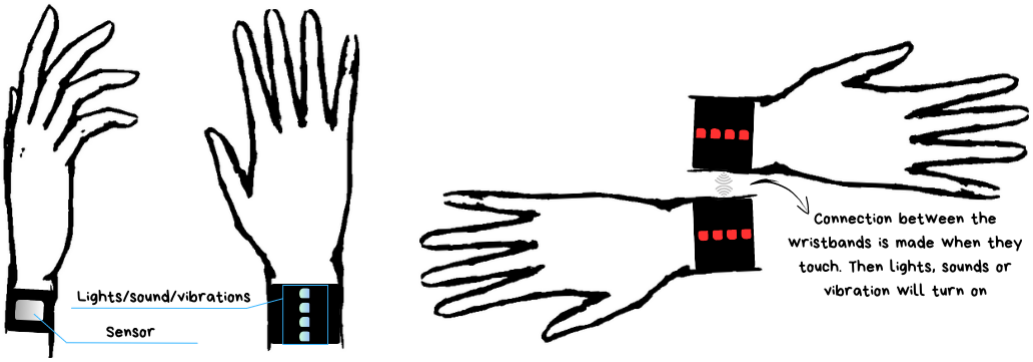


Figure 4.2: Sketch of the concept of the wristbands

make a sound. Several collaborative activities can be implemented to increase the diversity and the customizability of the wearable. Groups can be formed by using the wristbands through vibration, sound or light. When, for example, two groups need to be formed, half of the wristbands are assigned to the red colour and the other half to the blue colour. To find out which colour belongs to which participant, they need their wristband to touch another wristband. Next to that, A game similar to memory can be implemented to make pairs. The participants need to find their matching colour, sound or the wristband needs to vibrate. Other collaborative games can be created, such as letting the players create a rainbow. They first have to find which colour they are and then work together to create a rainbow.

4.4.2 Version 2: Vest

The goal of the vest is also to trigger the curiosity of the children to come close to each and get familiar with each other. Furthermore, the vest can be used to track which players are less active and to organize certain training exercises. The vest will have a string of LEDs attached to it (Figure 4.3). This technology can be used for group forming and forming pairs (Figure 4.5b). This is similar to the group and pair forming of the wristband. For the vest, the children do not have to touch, but only have to come close to each other to light up the LEDs.

Next to that, the LEDs can be used to indicate which child is the least active. When doing a certain training exercise or playing a friendly game, not all players will be active. The vest can be used to show which child is the least active. The LEDs of the vest of this child will light up. The other players will see this and the goal is to pass the ball to the player with the LEDs on.

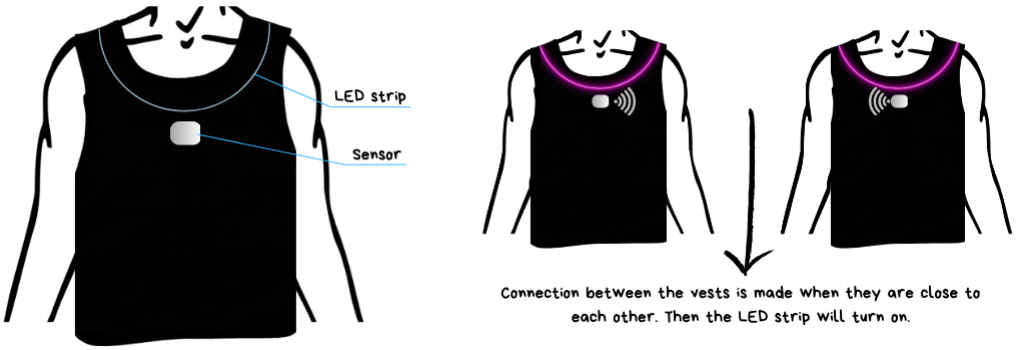


Figure 4.3: Sketch of the concept of the vests

4.4.3 Design space

A design space was created (Figure 4.4) to understand what kind of solutions already exist and how these solutions focus on different elements of the design space. This design space was created using the Preliminary Research (Chapter 2) and the goal of this research. Movement interaction technologies were designed by using movement as a means or as an end, and the technologies all had game-like elements. The movement was redefined to the dimension of physical activity and the term game-like elements was translated to gamefulness. Lastly, the goal of the research is to promote social interaction, which led to the last dimension.

The activities placed in the diagram can be changed to another place in the diagram when elements are added. An example of this would be running. This activity is placed in the dimension of physical activity. However, when people come together to go running, this activity is a combination of social interaction and physical activity. Therefore, this design space shows the variety of possibilities of the concept discussed previously in this section.

Technologies or methods to promote social interactions can be placed in the dimension of social interaction. An example of a technology for this is CommonTies [4]. Next, gamefulness refers to the game- or play-like aspects of activities, methods or technologies, such as Candy Crush. The field where gamefulness and promoting social interaction are combined are methods, such as cooperative activities or Lands of Fog, where social interaction is promoted using activities with game- or play-like aspects. Cooperative activities and Lands of Fog have a game-like character and have the goal to promote social interactions. The wristband is also placed in this field. The wristband uses game-like elements, such as cooperative games, to make these cooperative games more fun. However, this design space shows that other game-like aspects or activities can also be incorporated, such as hide and seek or tag. Next to that, different types of social interactions can be chosen to promote.

Furthermore, the vest is placed in the field of social interaction and physical

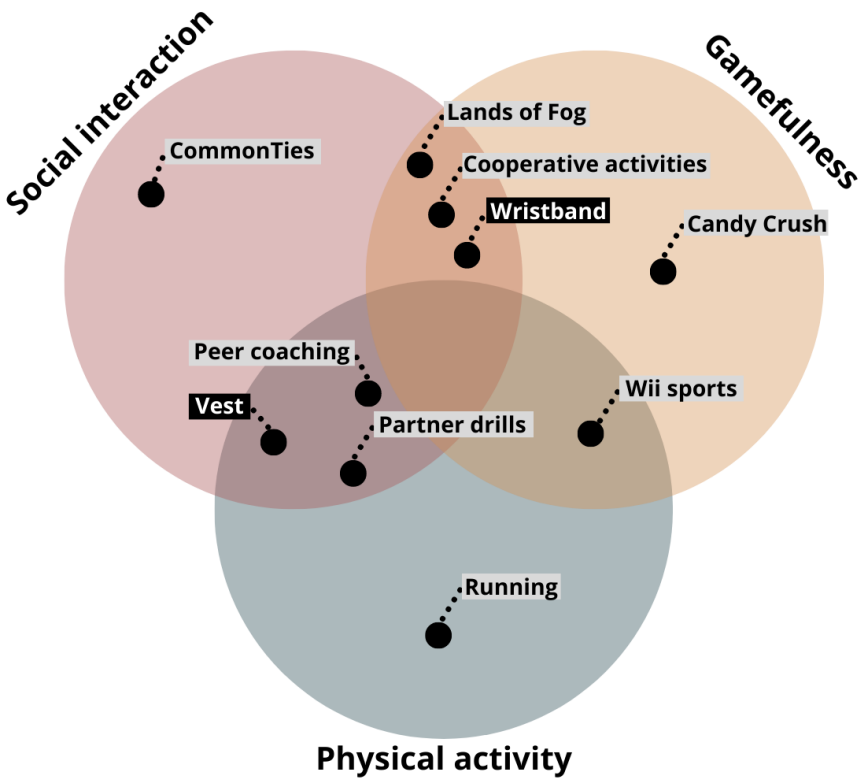


Figure 4.4: Design Space

activity. The vest used in a training context has a physical exercise element and the goal of the vest is to promote social interactions. This is also the case with peer coaching and partner drills. However, these methods do not necessarily use technology. The vest can be used in a variety of physical activities and, like the wristband, can promote different types of social interactions.

4.5 Test: Interviewing experts

The previous design phases showed that Vests or Wristbands might promote prosocial interaction between DDC and their TD peers. Although the prototypes were designed with the idea to promote social interaction, it is difficult to test the sketches on their level of acceptance and the experience DDC would have with the proposed prototype versions. Therefore, in this phase, the two versions were presented to three experts to investigate the perceived acceptance and the perceived user experience of the technology.

4.5.1 Aim of the session

This testing session aims to find which version, the vests or the wristbands, would suit the aim of this thesis best. By asking different experts about their opinion on the two versions of the prototype, could result in a deeper understanding of the perceived acceptance and perceived experience of the concept by DDC.

The research question for this testing phase is the following: ***How do the two different prototype versions score on the perceived acceptance and the perceived user experience?*** To examine the perceived acceptance, the TAM was used to evaluate the two versions on the following: Usefulness and Ease of Use. The 5D rubric was used to evaluate the two versions on their perceived experience using the following elements: Empowerment, Efficiency, Engagement and Trustworthy. (Section 3.2)

In this session, the goal is to find what aspects of the prototype would work well in promoting prosocial interaction and which aspects might not work. Furthermore, the experts were used to discover design aspects that were not thought of yet.

4.5.2 Method

To test the two versions of the prototype, an expert review was conducted using interview methodology. The paper of Rowley [72] was used to make the decisions described in this section. The goal of the interviews is to investigate the opinion of the two described versions.

Participants

The participants were selected in this research by convenience sampling. Permission was obtained from the relevant authorities to conduct the interviews. The first participant (P1) has expertise in psychomotor therapy. The second participant (P2) has experience with sports science. The last participant (P3) is familiar with the field of educational sciences. These participants were chosen on their types of expertise to gain a broader view of the described concepts.

Interview structure

The interviews were semi-structured. This was done to prevent bias and this method ensures a more free form of conversation. The topics that were discussed during the interviews were the two prototype versions. The interviewer first explained the concepts using Figure 4.5 and then asked the questions based on the 5D Rubric

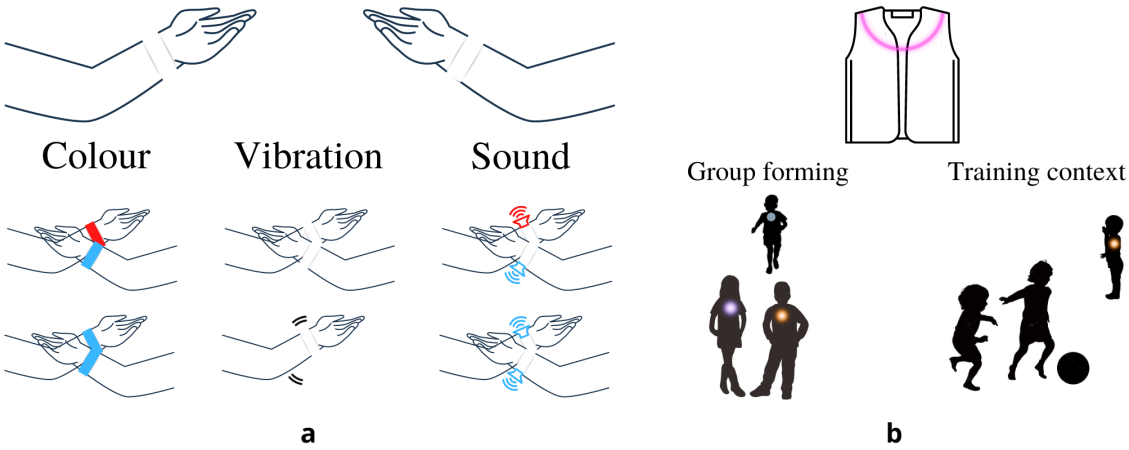


Figure 4.5: a) Sketch of the wristband technology and how it could be used. b) Sketch of the vest technology and how it could be used.

and TAM (Chapter 3). The interviews were conducted in Dutch and the findings were translated accordingly.

Procedure

First, a pilot interview was conducted with a fellow student to investigate whether the questions were understandable and in a logical order. The questions were revisited and adjusted accordingly. The final version of the questions can be found in Appendix B.0.1. Before the interviews, the participants read the information brochure and signed the consent form A. All interviews were recorded with the verbal permission of the participants. First, one version was explained, followed by the questions. Then, the other version was explained followed by the questions. The author explained first the wristband and then the vest to P1 and P3. P2 saw the vest first and then the wristband. Which version was explained first, was randomly assigned per participant. Lastly, the participants were asked which concept they preferred and why. Furthermore, during the interviews, notes were taken. Lastly, the data was extracted and analysed.

Data extraction and analysis

The interviews were needed to investigate the opinion of three different professionals on the two prototype versions (Section 4.4). The data was first organized in an Excel file [72]. The next step was getting familiar with the data to find key themes. This was done by organizing the data into the following categories: usefulness, ease of use, empowerment, efficiency, engagement and trustworthiness. Then, to structure themes and subthemes of the data set, the data was interpreted as positive (+)

Table 4.2: Results of attitude of participants towards the wristband and vest

	Wristband				Vest			
	P1	**P2**	**P3**	**Summary**	**P1**	**P2**	**P3**	**Summary**
Usefulness	-/+	+	+	+	-/+	-/+	-/+	-/+
Ease of use	+	+	+	+	+	-/+	+	+
Empowerment	-/+	+	-/+	-/+	-	-/+	+	-/+
Efficiency	-/+	+	-/+	-/+	-	+	-/+	-/+
Engagement	-/+	+	+	+	-/+	+	+	+
Trustworthiness	+	+	+	+	-/+	+	+	+
Preference	x	x	x	x			x	

attitude, negative (-) attitude or suggestion. A positive attitude was coded when the participant said something positive about the technology. A negative attitude was coded when the participant showed concerns about the technology. Data was coded as a suggestion when the participant made a suggestion about the design of the prototype or the concept. [72]

4.5.3 Results and discussion

Table 4.2, summarizes the attitude of the participants towards the two versions of the prototype. Overall, the wristband scores higher on usefulness. This is mainly due to the way of interacting. The lights of the wristband will light up when the wristbands touch, which will give the participants more time in the interaction.

Furthermore, during the interviews requirements for the technology and testing came to light, which were also found in the Preliminary Research (Chapter 2). These include that the technology should be safe, simple and during testing the instructions should be clear.

Looking at the group forming, collaborative games (wristband) and the training aspects (vests), some interesting elements were discussed. When the technology is used for the goal of forming groups, the technology would probably only be useful when meeting each other for the first time. Collaborative activities and the training aspect are interesting. However, the collaborative activities might steer the focus of the training too much toward the activities and the wristband and less toward the sport itself.

4.5.4 Conclusion

All participants preferred the concept of the wristbands. The wristband scores higher on perceived acceptance (TAM). The attitude of the participants toward the user ex-

perience (5D Rubric) is the same for the wristband and the vest. This was mostly due to the way of interacting: the wristbands have to touch another wristband to interact. However, when continuing this thesis using the concept of the wristband, some suggestions should be taken into account, such as simplicity. The proposed concept would probably only be interesting in the first group phase. Therefore, the second Design Cycle will focus on how the wristband could promote social interaction in team sports in general and what other applications may be designed.

CHAPTER 5

DESIGN CYCLE 2

Approaching a physical representation of the I-Five platform

Chapter 5

Design Cycle 2: Approaching a physical representation of the I-Five platform

Design Cycle 1 showed that different prosocial and antisocial behaviours occur during organized physical activity and that for DDC these behaviours might be challenging, which could lead to not getting accepted by their TD peers. Technology could help increase this acceptance by promoting social interaction between DDC and their TD peers. Two versions of a design concept were elaborated and placed into a design space, which revealed the possibilities of the proposed concept. Experts expressed that the use of the wristband would only be applicable in the familiarization phase. Therefore, this Design Cycle will dive deeper into social interaction, what it is and how it can be steered.

The main goal of this chapter is to dive deeper into the concept of social interaction and how the concept of the wristband could contribute to steering this kind of behaviour. The following research question guided this Design Cycle:

> **Sub-question 2.1:** *How might technology be used to promote prosocial interaction in the context of organized physical activity?*

5.1 Empathize: Diving into the psychology of social interaction

Looking specifically at team sports, prosocial interaction or positive conflict, usually takes the form of peer support. Peer support consists of, among other aspects, feedback or complimenting each other [46], [48], [57]. Studies show that giving compliments and encouragement increases the likability and thus the acceptance

of the person giving the compliment [73], [74]. Two methods to promote and steer these compliments and encouragements were discovered: prompting or providing rewards. Prompting can take the form of, for example, video modelling [75] or a poster displaying the desired behaviour [76]. Both methods were found to be effective.

A study by Stavropoulos [77] found that children with autism do not get the same neurological reward from social interactions as TD children. However, neurological rewards are an important element of being motivated to socially interact [78], [79]. This means that for children with autism, it is less rewarding to socially interact [77]. Therefore, one way of increasing the motivation of DDC to interact is by increasing the reward.

Different kinds of rewards can have different kinds of effects. DDC respond differently to rewards than TD children [80]. DDC are more sensitive to tangible rewards than to social rewards [81]–[83]. Tangible rewards are, for example, money, gifts or stickers [80]. Furthermore, DDC respond better to immediate than postponed rewards [81], [82], [84], [85]. Next to that, Constatin et al. [86] found that rewards need to be customizable on the preference of the child. This was also found during the Preliminary Research (Chapter 2). Lastly, the rewards should change in magnitude and reflect the progress over time of the child [86].

Combining prompts or instructions with rewards to steer social interactions was found by the study of Apple et al. [87] to be more effective than only instructing the desired behaviour. On the other hand, Macpherson et al. [75] found that video modeling on its own already showed an increase in complements given by children with autism. These studies show that prompting and reinforcement (combined or separate) can increase the number of complements initiated by DDC.

5.2 Redefine

It was found that the lack of social skills of DDC could result in not being accepted by their TD peers (Section 4.1) and that initiating positive conflict could increase this acceptance. Rewards and prompting were found to be effective methods to promote complementing and/or encouraging behaviour. These methods and the found requirements will be taken into account in the ideate and prototype phases. Furthermore, studies show that all forms of communication in organized physical activity are important, however physical touch, such as high-fives, during physical activity has a deeper level of emotional importance [88]. DDC might have difficulty with appropriate physical touch behaviour. Therefore, this research will redirect its focus to promoting positive conflict using appropriate physical touch during training or competition. This leads to the third version of the main research question, as

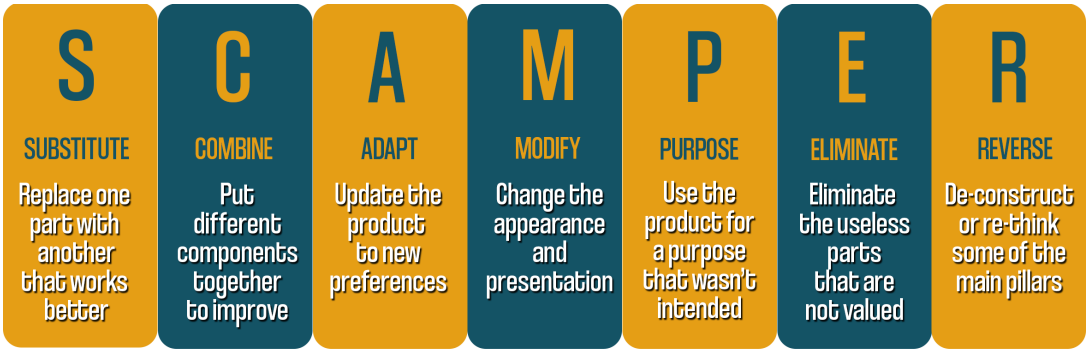


Figure 5.1: The seven perspectives of the SCAMPER method [5]

described in the Introduction (Section 1.3).

5.3 Ideate: Exploring the concept of the interactive wristband

In the previous section, rewards and prompting were found to be effective methods to promote positive conflict. Furthermore, DDC are more sensitive to immediate and tangible rewards. This information is used to improve the concept of the interactive wristband in this ideation phase.

5.3.1 Method

The method that was used to improve the concept of the interactive wristband was the SCAMPER method [89] (Figure 5.1). This method is a well-known ideation method to revisit and improve existing technology or prototypes by looking through different perspectives. These perspectives are Substitute, Combine, Adapt, Modify, Put to another use, Eliminate and Reverse. For every perspective, the Interaction Design Foundation [89] provides guiding questions to guide designers through the process, which were kept in mind when brainstorming for ideas. The ideas were written down using the online tool Miro.

After generating several ideas, the best ideas were selected by using the How, Now, Wow matrix. This matrix helps categorize the ideas on ease of implementation and originality. [90]

5.3.2 Results and discussion

In total, four ideas were placed in the Wow part of the matrix (Figure 5.2), of which two ideas apply to the goal of this thesis: promoting social interaction between DDC

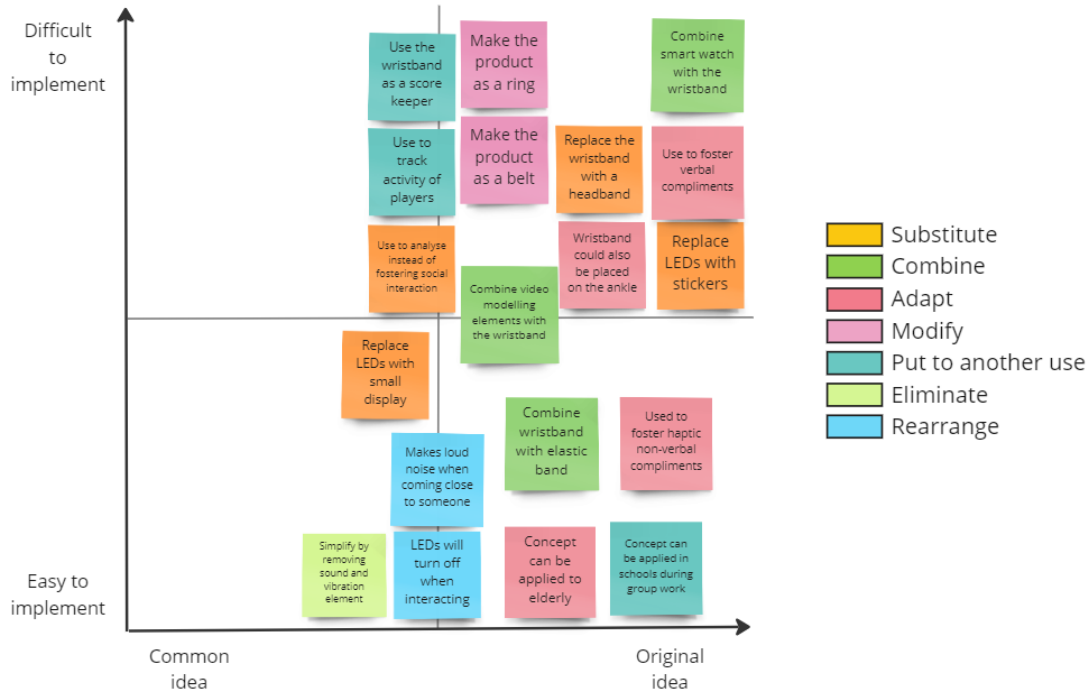


Figure 5.2: Results of the SCAMPER brainstorming session placed in the Now, How, Wow Matrix

in the context of organized physical activity. The first idea concerns the physical part of the wristband, namely combining the wristband with an elastic band. An elastic element could help to make the wristband one-size-fits-all.

Next, the wristband could be used to promote physical non-verbal compliments, such as a high-five or fist bump. Video modeling was already found to be effective to promote non-verbal communication. However, for these kinds of interventions, the children have to watch a video which is time-consuming and steer away from the physical exercises. Furthermore, to the knowledge of the author, no other technologies were found with a similar idea.

5.4 Prototype: Second iteration

The Empathize phase (Section 5.1), showed that rewards and prompts could promote social interaction. In the ideate phase, the concept of the I-Five came to life. The concept was sketched out to illustrate all the aspects of the interactive wristband (Figure 5.3).

An RFID system is placed on the wrist of the children, which can sense the proximity of other players. When the children would place the back of their arms with the wristband close or against each other for the first time, the first LED on the LED strip will light up (Figure 5.3). According to experts (Section 4.5), DDC have

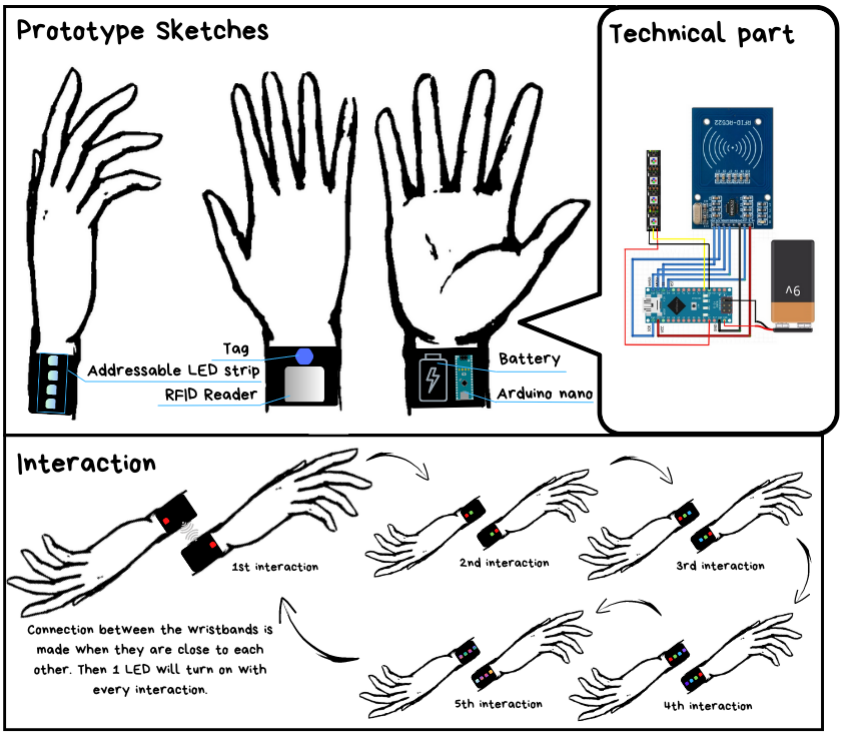


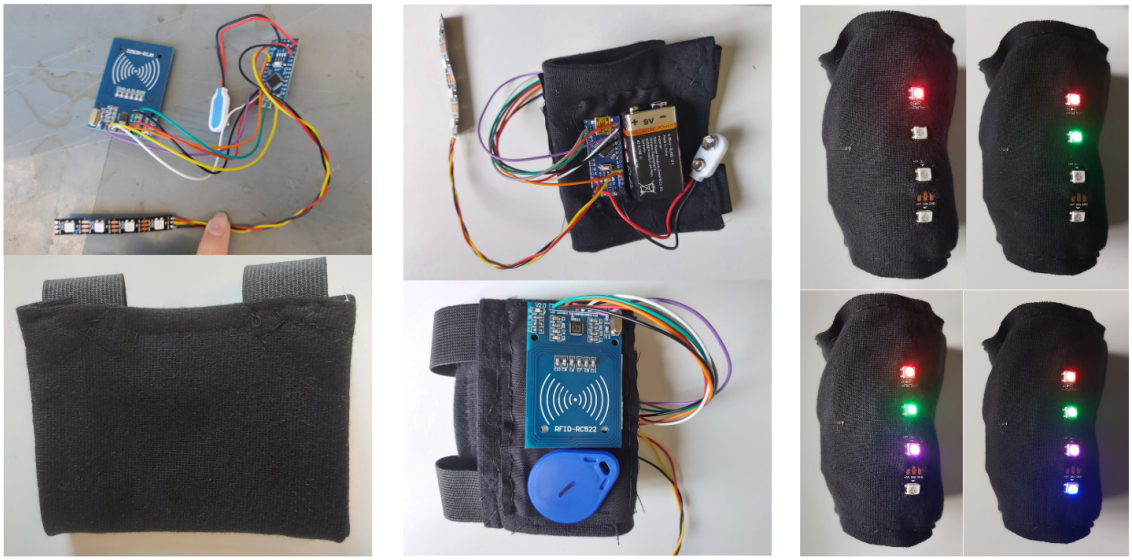
Figure 5.3: Sketch of the second iteration of the I-Five

a high interest in lights. This interaction is seen as a non-verbal compliment to the other player. The LED lighting up is an immediate tangible reward for the giver and for the receiver for this interaction. This kind of reward was found most effective for DDC (Section 5.1). When having the fifth interaction, thus after lighting up the four LEDs, the lights will light up in a disco light sequence for an extra reward. This also takes into account the process the child makes, which was found to be important in Section 5.1. After the fifth interaction, the cycle will start again (Figure 5.3 and 5.4c).

The interactive wristband would stimulate non-verbal compliments and social interaction between the players. The reward that TD children receive internally from social interaction and DDC receive less or not will be replaced by the extrinsic reward of the LEDs. The LEDs are a similar idea to the physical stickers as a reward, which has proven to be effective [85].

5.4.1 Hi-fi prototype

The concept of the interactive wristband is transformed into a hi-fi prototype. This prototype can be used to test the wristband on promoting social interaction between DDC in the context of team sports, and to develop and improve the concept further. The wristband should be wearable for DDC on their wrist during physical activity, therefore the wristband should be as small as possible, safe for the children, sensory



a b c

Figure 5.4: Design and components of the prototype. a) Wristband and electronics separate. b) Wristband combined with the electronics. c) Wristband closed and interaction with LED lights is shown

sensitivity should be taken into account (Section 4.5) and no movement should be restricted. Next to that, when the wristbands (almost) touch each other in a certain place, one LED would light up. This should happen at every interaction.

These requirements led to the following prototype concerning the physical part of the wristband. The wristband consists of soft and thick fabric so that the technical components would not hurt the children. The soft fabric will be closed using two elastic bands, this way there is more freedom and it is easier to take the wristband on and off (Figure 5.4a).

Next to that, the technical components will be explained. The Arduino Nano, which is a small Arduino, was used for this prototype. Furthermore, an RFID reader and tag would both be in the wristband, as shown in Figure 5.4b. Every time the reader registers a tag, one LED of the addressable LED strip will turn on. The Arduino nano, LED strip and RFID reader will be powered by a 9V battery. This circuit is shown in Figure 5.3.

5.4.2 Design space

The design space, developed in Section 4.4.3, showed the possibilities that could be explored concerning the concept of the wristband and vest. The I-Five is placed in the middle of the diagram, covering all three dimensions (Figure 5.5). The I-Five has game-like elements, which is the goal of getting all the LEDs displayed on the

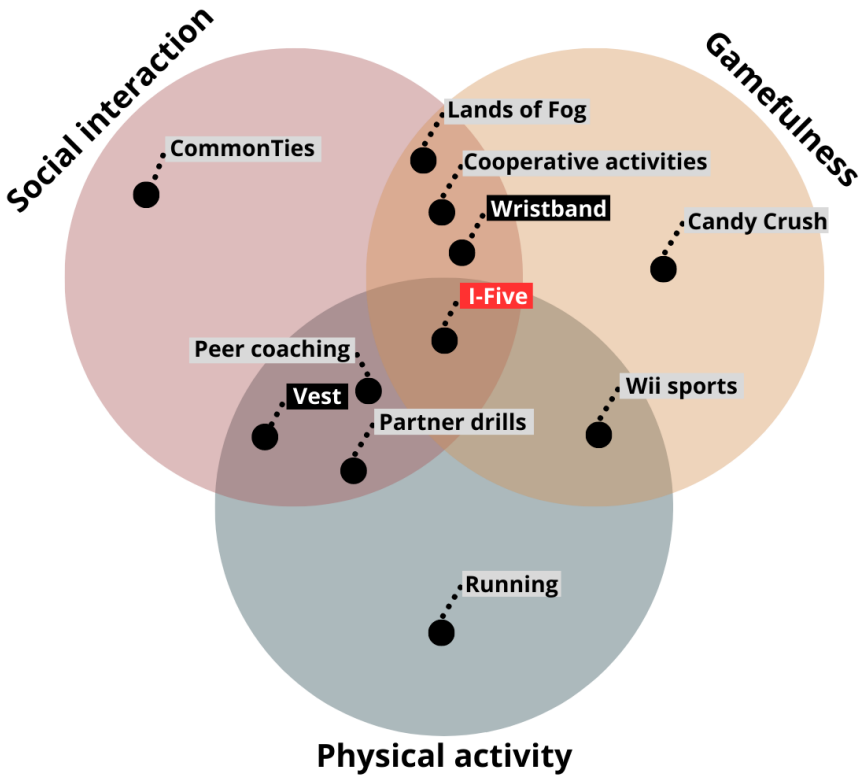


Figure 5.5: Design space updated

wristband to turn on. These LEDs can be turned on by touching the wristband with another wristband, which promotes social interaction. Lastly, when using the I-Five to give a compliment after a good pass or when someone scores during team sport, the wristband is used during physical activity. The different kinds of interactions or applications of the I-Five will be further explored in the next design phase.

5.5 Test: Assessing the safety, performance and usability of the I-Five

The previous section describes the development of the I-Five. Before testing this prototype, the prototype was first tested on safety and whether the prototype has any deficiencies or flaws. How this test was conducted and the results are discussed in this section, followed by the conclusion.

5.5.1 Aim of the session

The Preliminary Research (Chapter 2 and the first Test phase (Section 4.5), showed that the technology should be simple and take into account the sensitivity of DDC.

The objective of this session is to evaluate the prototype on its simplicity, find any bugs in the system and on the comfortability of the wristband. Furthermore, it is evaluated if the technology is safe to use for DDC. The following research questions will be answered in this session: 1) ***What are the major product deficiencies?***. 2) ***What are major usability flaws that prevent the user from being able to use the prototype?***. Product deficiencies were discovered by observing the prototype on its functionalities. Next to that, the usability was tested on its ease of use by observing and interviewing the participants, and on its comfortability by interviewing the participants.

Four prototypes have been developed to be tested with DDC as participants. However, since DDC are a sensitive target group, it is important to first test the prototype on its safety and identify any bugs that the system still has that could lead to the system not working properly. The preliminary study (Chapter 2) showed that a system that does not work properly could lead to frustrations by DDC, which could influence the results of the study.

5.5.2 Method

To answer the research questions, an environmental study was conducted. Meaning that the prototype was tested on a field and with a hockey stick, because certain deficiencies might not be detected in a test environment.

Participants and setting

Four students were recruited using convenience sampling. Some participants have not played hockey before and others have previous experience with hockey. This way, the variety in skill levels of DDC can be taken into account during this test. This session was held at a grass field in the city center.

Data extraction and analysis

Data was collected about the usability and functionality of the prototype. This was done by observing the prototype while the participants were wearing it and interviewing the participants. It was observed if any product deficiencies showed, such as LEDs not turning on when they are supposed to. Next to that, the participants were observed how they used the prototype, to find any usability flaws, such as not knowing how to interact with the wristband. These observations were written down.

Furthermore, the opinions of the participants about the ease of use, and their feeling of safety and comfortability while wearing the prototype were collected by conducting semi-structured interviews with the participants after using the prototype

using modified TAM and 5D rubric interview questions (Appendix B.0.1). Questions such as the following were asked: how comfortable the wristband felt during interacting and hockey exercises, how easy it was to use and whether they think any issues could arise. The data from the observations and the interviews were organized in an Excel file. The data was analysed by identifying similarities between the deficiencies and flaws found in the observations and/or between the interviews of the participants. Furthermore, suggestions about the prototype were identified.

Activities

First, how the wristband feels on the wrist when performing hockey movements using a hockey stick was tested. Participants practised different movements, such as passing and stopping the ball and dribbling with the ball. This way, the participants could experience how the wristband feels around their wrist during hockey movements.

Secondly, the interaction of the wristband was tested by giving the participants the assignment to turn on their four LEDs on the wristband. They had to do this without any explanation about how the interaction of the wristband works. This way, the ease of use was tested.

Procedure

Before this research, all four participants read the information brochure and signed the informed consent form (Appendix A). The test session took approximately 30 minutes. The first 10 minutes were used to give pre-test introductions, explaining the goal of the test and the task the participants had to perform. After this, the participants received their interactive wristbands and placed them on their wrists. Then, the participants conducted the hockey exercises to test the movement freedom for 10 minutes. The author would observe from the sidelines during the exercise and take notes. Then, the participants were asked to turn on all the LEDs on their wristbands. This would also take 10 minutes. During this task, notes were taken and the interaction between the participants was observed. After the two tasks, the participants were interviewed separately about their experience with the prototype.

5.5.3 Results and discussion

During the hockey exercises and the interaction task, the participants did not show any concerns about the physical representation of the wristband. When observing the interaction task, the LED strip of one of the wristbands moved and caused the LEDs were not visible. Furthermore, it was not clear for the participants which parts

of the wristband should touch to light up the LEDs. Even after explaining, it was difficult for the participants to recognize this. Several participants suggested integrating an identification, such as a sticker, on the wristband on where the wristbands should touch. Moreover, the wristband was programmed in such a way that every time another wristband was touched, a LED turns on. However, this could lead to two participants lighting all the LEDs in a few seconds, which was also observed during the interactions.

5.5.4 Conclusion

Some deficiencies were found when observing the interactions during the second task. The LEDs on one wristband were not visible all the time. Next to that, it was not easy for the participants to interact with the wristband. This should be more clear and needs to be taken into account in the next iteration of the prototype. Lastly, a delay should be implemented such that it is not possible to light up all LEDs in just a few seconds.

CHAPTER 6

DESIGN PROCESS 3

Tailoring the design of I-Five to promote social interactions between DDC in team sports

Chapter 6

Design Cycle 3: Tailoring the design of I-Five to promote social interaction between DDC in team sports

During the second Design Cycle, it became clear that rewards and prompts could steer social interactions. The focus of this thesis changed to promoting physical non-verbal compliments and encouragements. This led to the development of the I-Five prototype. However, the test phase showed that it was not easy to understand which parts of the wristband should touch. Therefore, this Design Cycle will explore a variety of applications with the wristband and thus explore the design space. Next to that, the I-Five will be tested with DDC in a team sport environment.

This Design cycle will focus on observing social interaction between DDC in team sports and improving the prototype developed in Design Cycle 2. The main goal of this chapter is to test the final version of the I-Five on DDC in team sports on its level of acceptance, user experience and effectiveness. The following research question guided this Design Cycle:

> **Sub-question 3.1:** *What is the experience, the level of acceptance and the effectiveness of the I-Five when the system is used by DDC playing hockey?*

6.1 Empathize and Define: Observing DDC in team sport

In the previous Design Cycles, social interactions in sports and social challenges for DDC were discovered using literature and experts. However, the target group was not yet observed during a team sport to confirm these findings. Therefore, in this Empathize and Define phase, DDC during team sport training were observed to

enrich the previous findings.

6.1.1 Aim of the session

This observation session aims to gain more practical insight into the social behaviour and interaction of DDC during training. Before this session, much information about this target group was gained through literature. Therefore, the goal of this observation session is to link the information that was found from the interviews in Section 4.5 and literature in Design Cycle 1 (Chapter 4) and 2 (Chapter 5).

The following research question will be investigated in this session: ***What social interaction and behaviour can be observed between DDC team players during training?*** This research question will be answered by observing the social behaviour of DDC during G-hockey training. G-sports in the Netherlands are sports that are meant for people with a disability and in this case players with NDD. Furthermore, the author talked with the coach and the parents to gain more insight into the observations.

6.1.2 Method

This phase aims to gain a deeper understanding of social behaviour and interaction in the context of team sport from an external point of view. Therefore, direct non-participant observation methodology was used during the G-hockey training [91]. This way, the behaviour that was observed occurred naturally [91].

Setting and participants

Eight DDC hockey players between the age of 12 to approximately 35 from the G-hockey team G2 participated in this observation. In the G-hockey team, the team members have different NDDs, mostly including autism and Down syndrome. All participants play hockey together. Furthermore, the players also know each other outside the hockey, such as from school.

The observations were held at a hockey club during training times on March 16, 2023. This was their first training after the winter break. Furthermore, the observations were conducted during training exercises that were given by their coach. This was done to intervene as little as possible with their normal training.

Data extraction and analysis

Data was collected by observing the players on their social behaviour. The information found in the literature research of Design Cycle 1 (Chapter 4) and 2 (Chapter

5) was kept in mind during the observations. The distance between the players was observed and what non-verbal and verbal behaviour was seen. Furthermore, their attention and skill level during the exercises was observed. Other data was collected by talking to the parents and the coach during and after the training. Every social behaviour that stood out or was not observed during the training was written down. The data was analysed by comparing the observed social behaviour to the information found in literature.

Procedure

Before this research, all participants and their caregivers read the information brochure and signed the informed consent form (Appendix A). The training and the observations took 1 hour. The training for G2 was set up as follows: a dribbling exercise as warming-up, followed by three different exercises and ended with a small competition. During the training exercises, the observer was standing next to the field or close to where the training exercises took place. This was all discussed with the coach. Furthermore, during the training, the author talked to three parents and the coach for gaining more insight into the observations.

6.1.3 Results and discussion

The following findings were observed. Most players seemed to interact verbally and physically with the coach more than with each other. The coach explained that the players had a lot of questions since it was their first training after the winter break. This could have led to the players having more interaction with the coach than with each other.

Next, during exercises, some players did not understand where to pass the ball or at which pawn to stand. This happened at the beginning of the exercise, but also sometimes during. Furthermore, some players got distracted during the exercise and did not pay attention when it was their turn. When this happened, the coach encourages the players to pay attention by saying, for instance, '[name player], it is your turn'. The coach also demonstrated that when she did not encourage the players to continue the exercise, the players would quit the exercise. Having difficulties understanding instructions and concentrating was in line with the found literature in Section 4.1.

Moreover, the diversity of DDC was found as a challenge when designing for this target group (Chapter 2) and also why it is difficult to train coaches on the unique wants and needs of DDC (Section 4.1). One player with Down syndrome only wanted to play with the orange balls and when they played a small competition

exercise, she only wanted to play while wearing a vest. Furthermore, the diversity in motor and social skill levels was observed. During the warming-up, one player did the exercise distanced from the other players. Later, during practice, this player also distanced himself while waiting to do the other exercises. Other players stood closer to each other and this player stood a little further apart. The diversity in skill level, motor and social, between the players was found in the Preliminary research as a challenge when designing for DDC.

During the training, compliments or encouragements initiated by the players were not observed. The coach did give the players multiple compliments. However, during exercises and during the small competition at the end, no compliments were observed from player to player. This adds to the prosocial challenges of DDC in the first Empathize phase: positive conflict (Table 4.1).

Furthermore, the players did not show frustration on the field, although this kind of behaviour was found in the Preliminary Research (Chapter 2) and in the Empathize phase of Design Cycle 1 (Section 4.1). This could be due to the goal of the training, which is mostly enjoying playing hockey together. One of the parents emphasized this and explained that the goal of performing is one of the reasons that it might not be good for DDC to get included in regular hockey. Having to perform was also one of the barriers for DDC to not participate in physical activity (Chapter 1).

6.1.4 Conclusion and redefine

To empathize with the target group, an observational study [91] was conducted. These observations confirmed the findings found in the Preliminary Research (Chapter 2) and in the Empathize phase of Design Cycle 1 (Section 4.1) and 2 (Section 5.1). These are that DDC have unique wants and needs, have difficulties keeping concentration, have difficulties understanding instructions, not given each other compliments (verbal or non-verbal) and engage in physical activity for fun. What was not observed, but was found in literature, is that DDC could show frustration. These findings show that a Developmental Diverse team might also benefit from technology that promotes social interaction. Therefore, this research will redirect its focus on promoting physical non-verbal positive conflict during training or competition of team sports between DDC. This leads to the fourth and final version of the main research question, as described in the Introduction (Section 1.3).

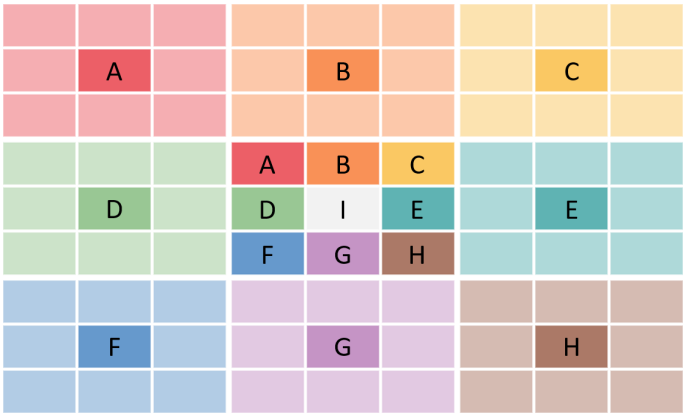


Figure 6.1: Example of a Lotus Blossom template [6]

6.2 Ideate: Exploring a variety of interactions of the I-Five

In the second Design Cycle (Chapter 5), it became clear that the rewards and prompts could promote non-verbal physical compliments, such as a high five. This led to the development of the I-Five. Testing the I-Five with students showed that how the wristband should interact to turn on the LED, was not clear. However, only one application was developed and tested. Therefore, using the observations, a variety of applications will be explored in this ideation phase. Later in the prototype phase, these applications are displayed in the design space to show the variety of applications of the I-Five (Section 6.5).

6.2.1 Method

The method that was used to explore a variety of interactions with the I-Five was the Lotus Blossom method [92]. This method is a well-known ideation method to generate as many ideas as possible [92]. As shown in Figure 6.1, the method starts with nine building blocks within the middle of the problem statement. In this thesis, the following statement was used: Different interactions (or applications) with the I-Five. Then, on the eight blocks around the problem statement, eight different ideas are generated. These ideas are then placed in their building block in the middle. For each of the eight starting ideas, again eight ideas can be generated. The ideas were written down using the online tool Miro.

After coming up with as many ideas as possible, the best ideas were identified with the Now, How, Wow method, explained in Section 5.3.1, was used. However, the ideas were not placed in a matrix, but were given a certain coloured sticker. Ideas in the Now field were given a blue coloured sticker, ideas in the How field were

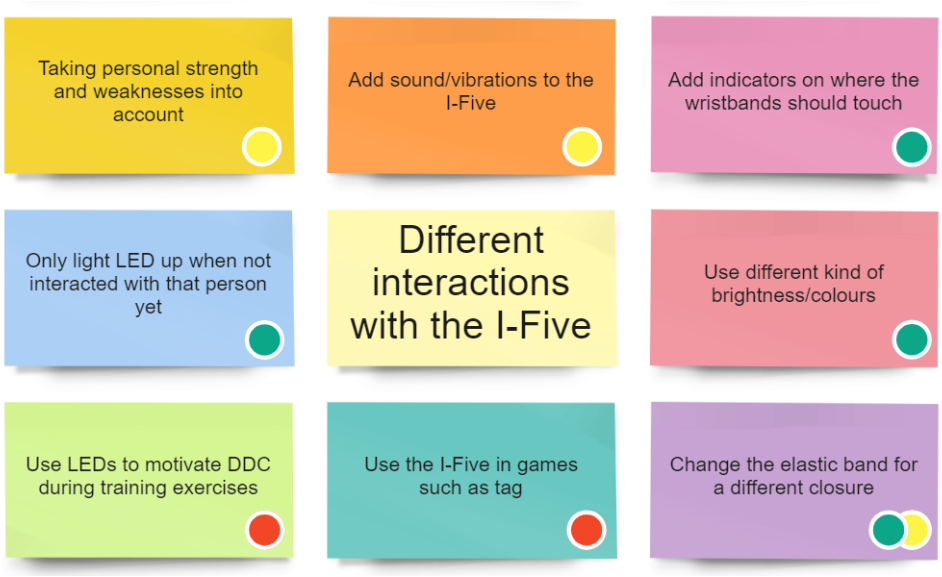


Figure 6.2: Middle part of the Lotus Blossom showing the eight core ideas around I-Five interactions and the design.

given a yellow sticker and ideas in the Wow field were given a green sticker. While placing these stickers, the goal of the thesis was kept in mind. Meaning that some ideas were Wow ideas, but did not fit the goal of this thesis. Therefore, these ideas were given a red sticker.

6.2.2 Results and discussion

The complete Lotus Blossom can be found in Appendix C. Due to a large number of ideas, only the relevant Wow ideas are discussed in this section, of which the main ideas in the middle of the Lotus Blossom can be seen in Figure 6.2.

Starting with 'Add indications on where the wristbands should touch', a variety of ideas were thought of how this could be integrated (Figure C.4). Three of these ideas were seen as Wow ideas. The indicators could be half of a figure, such as a heart, placed on one part of the wristband and the other half on the other wristband. When the wristbands touch in the correct place, the heart will be whole again. Next to that, a circle of a certain colour could be placed between the tag and the reader as an indication. These ideas can be made from a fabric of certain colours and figures. This solution should make it easier for DDC to know where the wristbands should touch to light up the LEDs.

Next to that, different kinds of brightness or colours could be used (Figure C.5. One idea is that each wristband, and thus each player, has its own identical colour. This means that one player can, for example, light up a red LED on the wristband of other players, whereas another player can light up a green LED on the wristband of

other players. Next to that, since the sensitivity of DDC should be taken into account, it is important to be able to make the wristband customizable. Some DDC might find the LEDs too bright, therefore, a tag card could be used to change the brightness of the LEDs without having to upload a different code to the wristband.

6.3 Prototype: Third and fourth iteration

During the test phase (Section 5.5, it became clear that it was difficult to understand where the wristbands should touch to turn on a LED. Therefore, markers were added to the outside of the wristband (Figure 6.3). This is also seen as a prompt on how to give a physical non-verbal compliment, which was found to be an effective method to promote social interactions (Section 5.1). Furthermore, another deficiency was found, because not with every correct interaction, a LED would turn on. After some research, it was found that the signals of the RFID readers disrupted each other's signal when they came too close. Since the interaction is based on getting the wristband close to each other, the tag was replaced in the wristband to the other side of the wristband. This means that the interaction will change as well. One player can compliment another player without receiving a compliment at the same time. When one player connects to the wristband of another player, only the LED of one player can be turned on. This is the wristband where the reader is used in the interaction (Figure 6.3). All these changes led to the third iteration.

This third iteration was tested with team G2 of the G-hockey. The participants and the setting are described in Section 6.1.2. During the pilot study, the participants were observed on how they interacted with the wristband. When four participants were wearing the wristband, most of the time groups of two were made. Furthermore, the coach explained when certain players would have the wristband, they would only interact with each other. Next to that, players asked what the meaning of the colour of the LEDs is. Therefore, in the fourth iteration of the I-Five, one player can turn on one certain colour LED of the wristband of another player. This colour is displayed on the outside of the wristband (Figure 6.4). The only way to turn on all LEDs is to interact with every player wearing the I-Five. Since there are four LEDs and three players who can give another player a LED, this will leave one LED on the wristband. During the observations, the coach also wanted to motivate the players to do the exercises by giving them one compliment. Therefore, one LED on the wristband can be turned on by the coach.

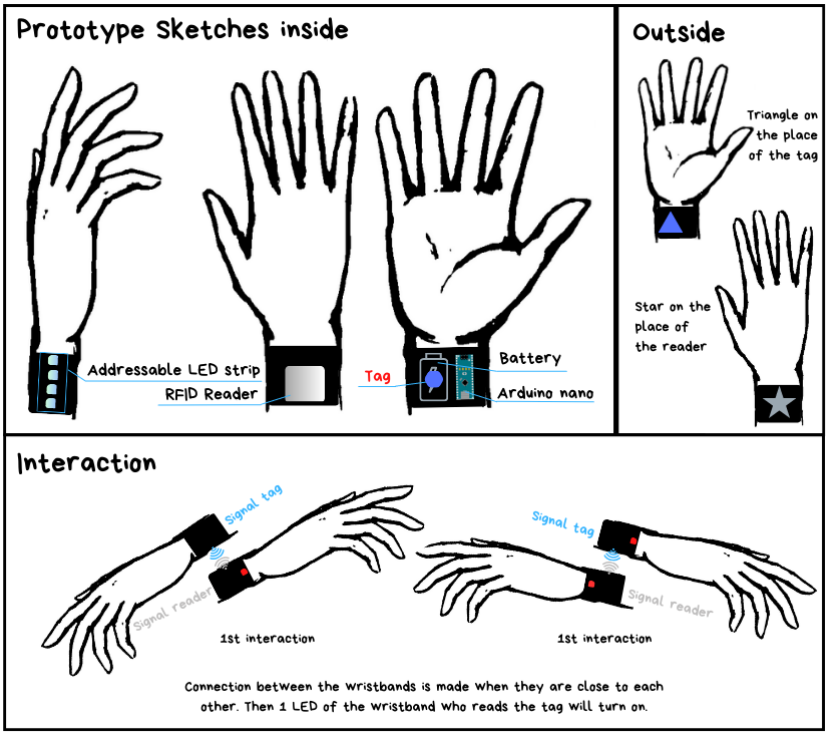


Figure 6.3: Sketch of the third and fourth iteration of the I-Five

Figure 6.4: Final iteration of the I-Five showing the two markers on the reader (seal) and tag (penguin), and the colour of the LED that this wristband can give (purple).

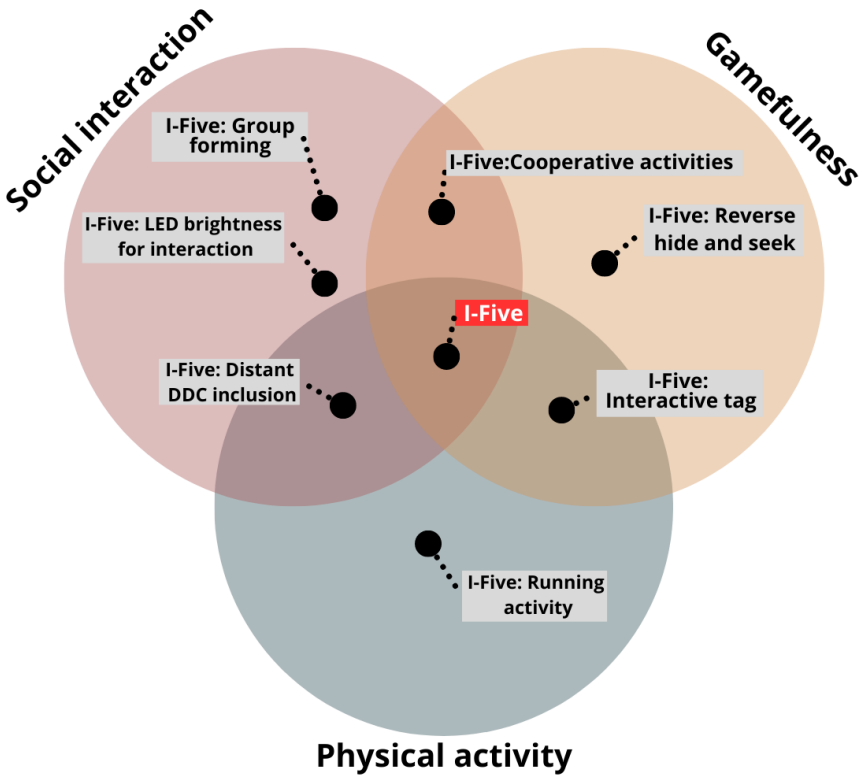


Figure 6.5: Design space of the I-Five

6.3.1 Design space of the I-Five

The final iteration of the I-Five is placed in the middle of the design space. Other applications found in the previous Ideate phase have not been implemented. Using the design space, these applications show the variety of possibilities the I-Five can offer (Figure 6.5).

Starting with the dimension of promoting social interaction, the I-Five can be used for group forming. This can be done in a variety of ways, of which one is explained in the first iteration of the prototype (Section 4.4). Furthermore, the brightness of the LEDs can increase when close to someone, which could also promote social interaction.

In the dimension of social interaction and gamefulness, the I-Five can be used for interactive cooperative games (Section 4.4). Other games that do not necessarily promote social interaction where the I-Five could be used are interactive reversed hide and seek or interactive tag. Where interactive tag could promote physical activity as well.

Next, a running activity can be implemented where the wristband makes a sound when the player needs to run to the other side. To promote social interaction during physical activity, the I-Five can be used by producing a sound when a distant person has not interacted for a while with others.

6.4 Test: Exploratory study

The previous section describes the final iteration of the I-Five. To investigate the initial acceptance, user experience and effectiveness of the I-Five, an exploratory study was conducted through observations and interviews. How this test was conducted and the results are discussed in this section, followed by the conclusion.

6.4.1 Aim of the session

The objective of this session is to test the I-Five on its initial acceptance, user experience and effectiveness. The following research question will be answered in this session: ***What is the perceived acceptance, user experience and effectiveness of the I-Five?***. The acceptance and user experience were investigated by conducting structured interviews with the G-hockey players using the adjusted interview questions of the TAM and 5D Rubric (Section 3.2). The effectiveness was studied through quantitative observations in a naturalistic context.

6.4.2 Method

To answer the research question, a semi-controlled study was conducted at the hockey association of the G-hockey team. The I-Five was compared to a baseline and a poster intervention. The players used the interventions during training exercises.

Setting and participants

Eight DDC of team G2 were selected by the coach to participate in this exploratory study. A more elaborate description of the participants can be found in Section 6.1.2. The test was held on April 13, 2023. The coach developed exercises where free social interactions can take place. Free social interaction is where all players can interact with each other. These exercises usually have competition-like elements. The participants would perform these exercises while testing the interventions.

Data extraction and analysis

Qualitative and quantitative data was obtained during the training. Qualitative data was extracted by interviewing the participants about the acceptance and user experience of the I-Five. The interview questions of TAM and 5D Rubric were changed to Likert-scale questions (Appendix B.0.2) that the children can answer using a smiley scale. The questions were checked by the coach and a DDC expert, and tested

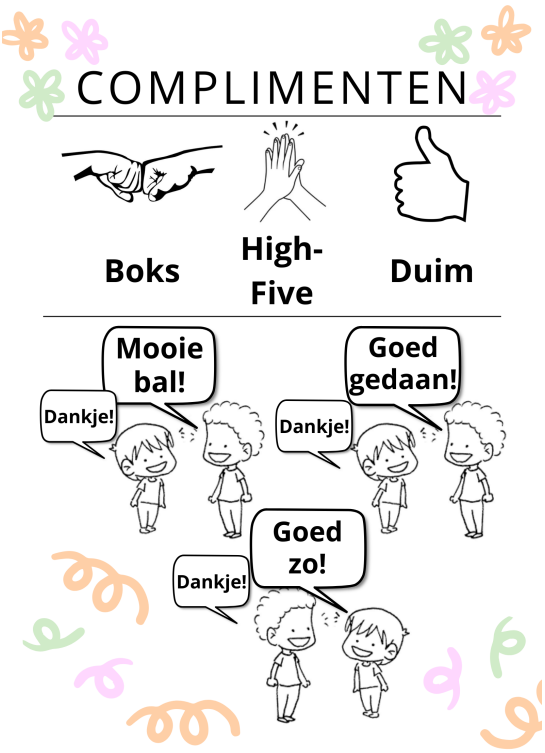


Figure 6.6: Poster showing prompts on verbal- and non-verbal compliments and encouragements

during the pilot study with the target group to investigate whether the players understood the questions. The questions were adjusted accordingly. The mean of the answers to the questions was calculated to find the average score on acceptance and user experience. Furthermore, the observations were discussed with the coach to find out her opinion on the behaviour of the players during the intervention.

Quantitative data of the verbal- and non-verbal compliments and encouragements (further called desired behaviour) was obtained by counting and comparing the results of the I-Five intervention to no intervention and a poster intervention (Figure 6.6). The training was divided into three sessions of 10 minutes, with each session having a unique exercise. The eight players were divided into two groups of four. In the first session, both groups were observed on the desired behaviour when no intervention was tested. In the second session, group one received the poster intervention and group two the I-Five intervention. In the third session, group one received the I-Five intervention and group two received the poster intervention. This was done to counter the effect of the order of the interventions.

The eight players were observed by eight observers, with each observer observing one player through the three sessions to prevent confusion. Three observation coding schemes were made (Appendix D), one for each intervention session. This scheme was similar to the scheme used by the study of Lauterbach [76]. There were

two main categories in the scheme: player-player interactions and player-coach interactions. Furthermore, a difference was made between initiating or responding to a compliment or encouragement, and verbal- and non-verbal compliments. Next to that, there was room to leave a comment on any interesting observations. The observers were informed when to count which interaction through a document. The data of the players initiating compliments and encouragements were counted and divided by the number of players the interaction could take place. This was done to counter the influence of having four I-Fives prototypes. In total, nine players participated in the training. This means that an observed player could initiate a high-five to 8 other players. However, an interaction with the I-Five can only be initiated with three other players. Therefore, the total amount of (non-)verbal compliments in 10 minutes was divided by 8 and interactions with the I-Five were divided by 3. These results were visualized in a bar chart and discussed.

Procedure

All participants and their caregivers already read and signed the consent form for the observations done in the Empathize and Define phase (Section 6.1). The two groups were made by the coach at the beginning of the training and every observer was assigned a player. Both groups did not have an intervention during the first exercise. The observations started when the exercise started and a timer was set to keep track of the 10 minutes. During the exercise, the observers observed their assigned players. After 10 minutes, the observations and the exercise were stopped. The coach set up the new exercise, the researcher gave and explained the I-Five to group two, and an expert on DDC explained the poster to group one. Then, the players participated in exercise two for 10 minutes while the observers observed their behaviour. Next, the coach set up the last exercise, the researcher gave and explained the I-Five to group one and the expert explained the poster to group two. The players were again observed for 10 minutes during the last exercise. Lastly, six of the eight participants were interviewed. All data that was extracted was organized and analysed as described in the previous section.

6.4.3 Results and discussion

Qualitative results

The qualitative data shows a score of 4.75 on the acceptance and a score of 4.79 on the user experience on a scale of 1 to 5. Furthermore, the players seemed to be enthusiastic about the lights on their wrists and expressed this. One player said: *"Very fun to give a compliment"*. It should be noted that due to the limited amount of

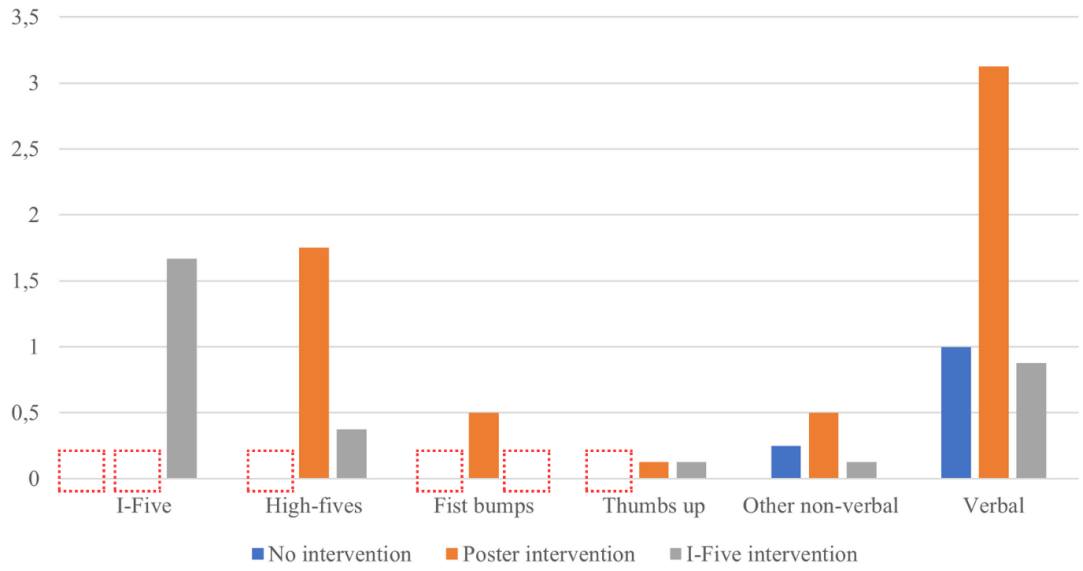


Figure 6.7: Total amount of player-initiated (non-)verbal compliments and encouragements in each intervention category divided by the number of players the interaction could take place. The red dotted squares highlight the type of interactions that were not observed during the intervention.

time in the training to ask the questions, the participants had a limited time to answer. This is more challenging for this target group. Next to that, the expert on DDC that checked the formulated questions, explained that DDC tent to give a desired answer, thus in this case the green smiley.

During the poster session, one of the observers noticed that the observed player was more talkative after the poster was introduced. Next to that, multiple observers noticed that their players did not participate in the exercises. They stated on the observation form: 'player stands still a lot and does not participate in the exercise'. Furthermore, the coach explained that she would use the I-Five in organized exercises to motivate the players to do the exercise and in return, they would receive a compliment. Other qualitative observations were not conducted due to the limited amount of observers for the quantitative results.

Quantitative results

The quantitative results (Figure 6.7) show that the poster and the I-Five intervention could promote compliments and encouragements that are initiated by the players. Especially, the poster intervention seems to increase verbal and high-five compliments. During the last exercise, the coach was surprised that the participants in group 2 of the poster intervention, spontaneously gave each other high-fives and fist bumps, which they usually do not do during a practice competition. During the pilot

study, more and longer interactions with the I-Five were observed. This could be due to two main reasons: the type of exercise and the skill level of the players.

First, the type of exercises most likely influenced the number of interactions with the I-Five. The type of exercise during the pilot study was more regulated and left more time for the participants to interact. Moreover, with the competition-like exercises, the players were usually standing at a distance from each other, thus a verbal compliment or encouragement is then more easily made.

Next to that, the coach explained that in team G2, the players are more concentrated and sometimes also less active during this kind of exercise. The players need to be encouraged to engage in the exercise. This was also observed during this exploratory study. Most of the players stood still and did only participate in the exercise if the ball was close to them. These participants also gave fewer compliments and encouragements. More structured exercises allow the coach to individually encourage the players to engage in the exercise. Furthermore, when players are less active or need to concentrate more on the exercise, there is less time for interactions. In a team where the players have a higher skill level, the results could be different according to the coach.

Other variables that might have influenced the results are that some players did not participate in the pilot study and therefore had a lesser understanding of the wristband. Next, the time to give instructions was limited due to the duration of the training. Therefore, the instructions on how to interact with the I-Five might not have been clear to some players. This could have influenced the interactions with the I-Five. Lastly, there were eight observers and it was not allowed to record the sessions, thus the inter-rater reliability might be low due to the bias of each observer.

6.4.4 Conclusion

In this exploratory study, the effects of I-Five in a naturalistic context were investigated. The players show a positive attitude towards the user experience and acceptance. Furthermore, results show interesting changes in DDC when it comes to initiating compliments and encouragements when the I-Five is used. This shows that technologies, such as the I-Five, could be promising to promote pro-social behaviour like compliments and encouragements.

CHAPTER 7&8

DISCUSSION & CONCLUSION

Chapter 7

Discussion

The objective and main research question was changed throughout this thesis, starting with: **How to design a system to promote prosocial behaviour between developmental diverse children and their typically developing peers in team sports?** The objective and main research question have been redefined in every Define phase based on previous findings leading up to that certain phase. Prosocial behaviour was made more specific to promoting physical non-verbal compliments. Next to that, the target goal of promoting this behaviour between DDC and their TD peers was changed to promoting this behaviour between DDC. This led to the final version of the main research question: **How to design a system that supports the coach to promote physical non-verbal interactions, such as high-fives, between developmentally diverse children in team sports?** This chapter discusses the outcomes of this research and the findings that contribute to answering the main research question. The answer to the main research question can be found in the Conclusion (Chapter 8). Furthermore, the strengths and limitations of this thesis are discussed.

7.1 Research outcomes and contributions

This thesis has four research outcomes and contributions. First, this thesis showed how the iterative design process was used to design the I-Five. Second, the challenges found in the preliminary research were combined and expanded upon, whereafter some possible solutions were validated in practice. Third, a design space was created using the knowledge obtained through this research, containing the variety of possibilities of the I-Five. Fourth, the designed tangible prototype platform of the I-Five was created and tested.

7.1.1 Design process

During the three iterations of the design thinking process, several methods were used to Empathize, Define, Ideate, Prototype and Test. First, social challenges for DDC in sport, and the kind of methods and technologies that exists to promote social interactions were investigated. The most important finding was that the social challenges of DDC could lead to not getting accepted by their TD peers and/or the coach. The coach was found to be an important aspect in promoting prosocial interactions, which could lead to a higher acceptance. Therefore, the objective was changed to designing a system to help the coach promote social interaction. In the Ideate phase, it was found that social interaction in physical activity is promoted by activities with a common goal. This led to the first iteration of the I-Five with two versions. The TAM and 5D rubric were used to define interview questions and experts answering these questions gave insight into the possibilities and concerns of the wristband. One important finding was that the wristbands having to touch each other would probably increase social interactions. Furthermore, the experts expressed that the wristband would probably only be useful in the familiarization phase.

The findings of the previous test phase were the input of the empathize phase of the second Design Cycle. In this phase, the different how to steer prosocial interactions were explored using books and models. The main findings showed that rewards and prompts could steer prosocial interactions in the form of (non)-verbal compliments and encouragements. The objective was changed to promoting non-verbal compliments and encouragements. In the Ideate phase, the possibilities of the wristband were explored with the changed objective as input. This led to a hi-fi prototype of the I-Five platform, where a user would receive a reward in the form of a LED when interacting with another user. Throughout the following design phases, the platform was coded in a variety of ways, which shows the possibilities of the platform. The testing phase showed that it was not clear where the wristbands should touch and the LEDs did not turn on when they were supposed to. These findings gave input to the next Ideate and Prototype phase in Design Cycle 3.

First, in Design Cycle 3, DDC in team sports were observed to compare the findings in previous design cycles to observations. This revealed that what was found in the literature also applied to the observed team. The main finding was that DDC did not compliment or encourage each other. Therefore, the objective was changed to focus on prosocial interaction between DDC. In the Ideate phase, different applications of the I-Five were explored, leading to adding indication on the wristband on where they should touch. Furthermore, to make sure that the RFID readers did not disrupt each other's signal, the tag was replaced in the wristband. This iteration was tested on the target group in an informal pilot study. The main

findings were that DDC were enthusiastic about the wristband and that the coach used the wristband to encourage DDC to engage in the exercise. Next to that, most of the time the same two players would interact with each other. This led to the fourth iteration of the I-Five, where one wristband could turn on one specific coloured LED on the other wristband to prevent group forming. An exploratory study was conducted on the target group to investigate the effectiveness of the wristband. The results were promising on promoting prosocial interaction between DDC.

These design cycles show how different methods can be used to design and develop a prototype from an idea to a hi-fi prototype for DDC in the context of physical activity. Interesting findings were used as input for the next design phase or design cycle(s). Using an iterative design approach also led to redefining the objective of the study in every Define phase. This gave the possibility to change the objective according to information that was not found previously and to explore multiple possibilities, such as different prosocial behaviour.

7.1.2 Challenges and possible solutions

Throughout the design process, several challenges were encountered and documented. In this section, the most interesting challenges encountered leading to research contributions are discussed. Next to that, solutions that were used in this thesis and other possible solutions are discussed.

Representation

The G-hockey team consisted of children with autism and Down Syndrome. Children with autism were overrepresented in the preliminary research, however no research was found on designing movement interaction technology for children with Down Syndrome. Furthermore, in the G-hockey team, the group was balanced when looking at gender. Thus, the challenges of the over-representation of boys was not encountered in this research. Therefore, this thesis fills these gaps by including a more diverse research population, as this group specifically has this diversity in gender and NDD. Thus, the challenge of representation could be tackled by searching for participants in specific environments for DDC, such as special schools or sports teams.

Diversity

The diversity of social challenges that DDC experience made it difficult to decide what to focus on in the context of physical activity, because almost no studies were found in this context during the preliminary research. This thesis decided to focus

on prosocial interaction. However, other social difficulties, such as attention deficits, are also important aspects when it comes to including DDC in regular team sports. To tackle this challenge, an iterative design approach leaves the freedom to redefine the objective and thus the main research question based on information that is found during the design process.

Furthermore, the diversity in motor and social skills was observed, especially in the G2 team. This diversity might have influenced the results of the exploratory study. Testing the I-Five using exercises where free social interaction can take place, did not seem to fit well with the G2 players. This could be due to their hockey skill level, which led to that they had to focus more on the game. The coach explained that this kind of exercise might have worked better with a more skilled team. Therefore, future research should test the intervention on different skill groups and type of exercises.

Lastly, the difference in understanding the technology was observed. One player helped others understand where the wristband should touch to light up the LEDs. This shows the importance of making the technology as simple as possible so all DDC can understand. After testing the second iteration of the I-Five, it was not clear where the wristbands should touch. Next to that, some DDC did not seem to understand the last iteration of the prototype. Therefore, making the prototype as simple as possible, and testing the prototype with the target group before testing its effectiveness and user experience, is important.

Social behaviour

The frustration challenge that was found in the preliminary research was not observed with these participants. However, this could be a snapshot of behaviour that could be observed, because while informally talking to the coach, she explained this could be a challenge. For example, when one of the prototypes stopped working, the player who wore this prototype did not show any frustration. This lack of frustration could indicate that testing prototypes in a familiar environment prevents frustration. Next to that, longitudinal observations should be conducted to tackle the snapshot limitation.

Moreover, communicating with DDC was a challenge observed during this thesis in two main ways: interviewing DDC and giving clear instructions. DDC in interviews tent to give a desirable answer, which could lead to unreliable results. This study showed that likert-scale questions and the use of a smiley scale for answering the questions gave more insight than yes or no questions. Furthermore, a pilot test with the target group shows whether the instructions and interview questions are clear. This also decreases the novelty effect and gives the DDC time to get familiar with

the prototype.

Physical activity

One challenge that was not found in the preliminary research is the challenge of designing in the context of physical activity. First, the technology should not influence the movement of the physical activity. To tackle this challenge, this thesis first tested the prototype using proxies in an environmental study. This could reveal any flaws that may prevent the user from sufficiently testing the prototype during physical activity.

Another challenge when testing the prototype during training is that the type of exercise might influence the results. More regulated exercises give the players more time to interact and give the coach more time to motivate specific players to engage in the exercise. On the other hand, competition-like exercises give the possibility for free social interaction. To tackle this problem, the intervention should be tested on different types of exercises to investigate where the intervention adds the most value.

7.1.3 Design space

The second contribution is the design space that was constructed in the first Design Cycle using the preliminary research and the first Empathize, Define and Ideate phases. Three dimensions were discovered and placed as a venn-like diagram (Figure 4.4). At first, this design space was used to understand what kind of solutions are out there and how these different solutions focus on different elements of the design space. Furthermore, placing the existing solutions in the design space, revealed possible design solutions that were not discovered yet, such as having elements of all three dimensions in the concept. The design space guided this way, for example, the Ideate phase in Design Cycle 2. Later, when designing and ideating applications, the design space was used as a tool to navigate the space of possibilities and design targeted interactions.

This led to the final design space in Design Cycle 3, which shows the variety of applications the I-Five could be used for. However, only one application was tested in Design Cycle 3 on its acceptance, user experience and effectiveness on eight participants. Due to the limited time of this thesis, other applications of the I-Five were left unexplored. For example, taking into account the strengths and weaknesses of the participants in the I-Five itself by further customizing the wristbands, using the I-Five more in a training context or more as a playful application. Next to the dimensions of this design space, other areas, such as improving other prosocial behaviour, could benefit from getting more attention.

7.1.4 Tangible prototype platform

Another outcome of this research is the I-Five platform, which was designed by going through the five phases of the design thinking process using a variety of methods. The first iteration of the I-Five was in the first Design Cycle evaluated using experts. In the second Design Cycle, a hi-fi prototype was developed and tested using proxies. The main improvement that was made from the second iteration, was adding indications on the outside of where the wristband should (almost) touch. After an informal pilot study with DDC during team sport, another change was made: one user could light up one LED of another wristband. With this last change, all users have to interact ones with each other to light up all four LEDs.

The fourth and last iteration was tested with DDC during team sport. The I-Five was tested on the acceptance, user experience and effectiveness. The effectiveness was tested by comparing no intervention, a poster intervention and the I-Five on the amount of interactions DDC had with each other. Initial results show that when no intervention was tested, almost no compliments and encouragements were observed. When introducing the poster and the I-Five, more interactions were observed. However, due to several limitations, such as the type of exercise, no clear conclusions can be drawn about the effectiveness of either intervention. Looking at the acceptance and user experience, the players seemed enthusiastic about the wristband, especially during more structured exercises. Furthermore, the coach explained that she would use such technology to engage the players in the structured exercises.

7.2 Strengths and limitations

First, understanding social interactions and behaviour without a background on this topic was a bigger challenge than expected. This could have led to missed important observations during the Empathize and Test phases. Furthermore, the observations to empathize with the target group were conducted in Design Cycle 3, which was due to the winter break of the hockey. Having these observations at an earlier stage of the overall design process could have steered the research another way. However, this also one of the strengths of this research, because it gave the author more time to get a better understanding of social interactions and behaviour of DDC. This knowledge was used during the observations.

Next to that, the author noticed late that the RFID readers disrupted each other signal. Therefore, other sensors might have worked better. However, with RFID technology it was possible to identify with which player the interaction was made which led to the final design of the I-Five. Moreover, the interaction with the wristband might still be too difficult for DDC. With the last iteration to turn on the LEDs

of both wristbands, two interactions have to take place in different places on the wristband. Furthermore, other applications or designs of the I-Five might have had a more positive influence on the prosocial interactions between DDC. DDC used mostly high-fives as non-verbal compliments or encouragement. Therefore, future research could focus on investigating other applications of the I-Five or other designs, such as an interactive high-five.

Looking at the participants of this study, most players of the hockey team were older than 18 and thus are not seen as children according to their chronological age. Moreover, only one team was observed formally to empathize with the target group and only one team was used for testing the prototype. This particular group already knew each other for a longer time, which might have influenced the observations, the test results and the (not) encountered challenges. Next to that, a small number of participants tested the I-Five on the acceptance, user experience and effectiveness. This was not necessarily due to not reaching enough participants, but more due to the number of prototypes developed. Lastly, in this thesis, gender was not taken into account. Although boys and girls were included in the study, gender might have influenced the results. Future research could test the I-Five on a bigger sample size by, for example, recruiting children at education or sports facilitations for DDC.

Lastly, the perceived acceptance and user experience were tested using the TAM and 5D Rubric. However, the interview questions presenting these models were not validated or verified. This was also the case in the exploratory study when the interview questions were adjusted to Likert-scale questions that DDC were able to understand. Therefore, the high scores on perceived usefulness and perceived acceptance might be due to the method that was used. Since it was an exploratory study, the results are seen as an indication of the scores. More research is needed to test and validate these methods.

Chapter 8

Conclusion

The main objective of this thesis was to document challenges and possible solutions when designing for DDC in the context of physical activity. In the preliminary research, challenges that were found in previous studies were investigated. However, these challenges were mostly based on designing movement interaction technology in the context of therapy and education. During the design process, additional challenges were found, such as the technology should not intervene with movements and the type of exercise can influence test results. Furthermore, this thesis proposes solutions for several challenges and used a few of these solutions.

The different methods used during the design cycles led to the design of the I-Five and the design space of the I-Five. The final iteration of the I-Five was established by researching social interactions in team sports, using different methods to ideate this information into prototypes and using the design space as a tool. Literature showed that rewards, such as stickers, could promote verbal and/or non-verbal compliments and encouragements. The last iteration of the I-Five gives the participants a LED reward when interacting with another participant wearing the I-Five. This is only one application for which the I-Five could be used for. The final design space shows the variety of applications that could be implemented in the I-Five.

This research has shown that an iterative design approach and the use of a design space can result in an intuitive and creative design of the I-Five. The I-five shows promising effects on promoting prosocial interaction, in the form of non-verbal physical compliments and encouragements, between DDC in team sports. The pilot test and the exploratory study show that the G-hockey players are enthusiastic about the I-Five and like the rewards of the LEDs. Initial test results show that the I-Five could promote prosocial interaction between DDC. However, the I-Five was tested on a small sample size and the type of exercise influenced the results of the exploratory study. Therefore, more research is needed to investigate the effectiveness of the last iteration of the I-Five. Furthermore, future research could investigate other applications or designs of the I-Five in team sports.

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Appendix A

Information brochure and consent form

Wij maken technologie om sporten en bewegen leuker te maken. Doe je mee?

Beste sporter,
Wij willen sporten en bewegen leuker maken voor iedereen. Dus ook voor jou! Wij willen nieuwe technologie maken voor jouw sport. Daarvoor hebben we jouw hulp nodig. In deze brief lees je hoe dat gaat. Zou je mee willen doen aan ons onderzoek? Je mag zelf beslissen of je mee wil doen. Voordat je beslist vertellen we je graag meer over het onderzoek. Denk er rustig over na. Je mag er ook met familie, vrienden, of begeleiders over praten. Als je vragen hebt, zal Dees proberen ze te beantwoorden. Hij is de onderzoeker en weet er dus veel van.

Wat gaan we doen?
Dees gaat samen met studenten van de Universiteit Twente technologie maken om sporten nóg leuker te maken. Daarom willen we graag weten wat jij van je sport vindt. Wat vind je leuk? Wat vind je niet zo leuk? We willen je niet alleen vragen stellen. We willen ook graag kijken naar jouw training. Vragen stellen en kijken helpt ons om nieuwe technologie uit te vinden.

Als we een uitvinding hebben gedaan, willen we graag weten wat jij ervan vindt. Vind je het een mooie uitvinding? Zou je de uitvinding willen gebruiken? Helpt de uitvinding jou met sporten? We willen je niet alleen vragen stellen over de uitvinding. We willen ook graag kijken hoe je de uitvinding gebruikt. Vragen stellen en kijken helpt ons om de uitvinding beter te maken.

In deze brief leggen we precies uit hoe het onderzoek gaat. Als je mee wil doen is dat fijn. Als je niet mee wil doen is dat ook goed. Je kan gewoon naar training gaan ook als je niet mee wil doen aan het onderzoek.

Met vriendelijke groet,

Namens de onderzoekers:

Dees Postma, onderzoeker
Armağan Karahanoğlu, universitair docent
Maaike Heethaar, Projectdirecteur Special Olympics Nationale Spelen Twente 2022
De studenten van Creative Technology

1. **Algemene informatie**
   De Universiteit Twente en Special Olympics Nationale Spelen Twente 2022 doen onderzoek naar technologie voor sport. Voor dit onderzoek zijn 20-40 deelnemers nodig. Het onderzoek loopt van 01 februari 2022 tot 01 september 2023.

2. **Doel van het onderzoek**
   Het doel van het onderzoek is om sporten leuker, beter en toegankelijker te maken voor g-sporters. Het onderzoek wordt uitgevoerd door onderzoekers en studenten van de Universiteit Twente.

3. **Wat gebeurt er als ik mee doe?**
   Wil je meedoen aan het onderzoek? Leuk! Door mee te doen help je om sporten leuker te maken voor iedereen. Ook help je onze studenten, zij moeten nog leren hoe ze onderzoek moeten doen.

   Activiteiten
   Als je meedoet aan het onderzoek, willen we een aantal activiteiten met je doen. De activiteiten gebeuren allemaal tijdens de training. Je kan dus gewoon naar training komen. Op training zullen we uitleggen wat we gaan doen. Ook als je niet meedoet aan het onderzoek, kan je gewoon naar training komen. We zullen je dan niet storen. Voor ons onderzoek doen we 3 verschillende activiteiten:
   1. Interviews. We stellen je vragen over jouw sport: Wat vind je leuk? Wat vind je minder leuk? Wat vind je moeilijk? Wat vind je makkelijk? Wat zou je anders willen? Als we een uitvinding hebben gedaan willen we je daar ook vragen over stellen: Vind je de uitvinding mooi? Vind je de uitvinding handig? Helpt de uitvinding jou?
   2. Observaties. We kijken naar jouw training om te leren wat je leuk vindt aan je sport en waar je goed in bent.
   3. Testen. Als we een uitvinding hebben gedaan willen we onderzoeken hoe je ermee omgaat. Daarom moeten we misschien wat meten.

4. **Zijn er ook risico's bij dit onderzoek?**
   De risico's van dit onderzoek zijn zeer klein. Soms vinden mensen het spannend om mee te doen aan een onderzoek. Als je het te spannend vindt mag je altijd stoppen. We hebben je begeleiders gevraagd om ook op te letten. Als je begeleider denkt dat je het te spannend vindt, dan stoppen we het onderzoek ook. Je trainer, coach of begeleider is altijd bij het onderzoek. Als je vragen hebt mag je die altijd stellen aan de onderzoeker, de studenten of aan je begeleider, coach of trainer.

5. **Als je niet mee wil doen of wil stoppen met het onderzoek**
   Je mag zelf weten of je meedoet aan het onderzoek. Als je meedoet en je wil stoppen dan kan dat altijd. Stoppen met het onderzoek is niet erg. Je hoeft niet te zeggen waarom je stopt. Als je wil stoppen, zeg dat dan tegen de onderzoeker of tegen de studenten, dan stoppen we meteen.

6. **Einde van het onderzoek**
   Het onderzoek stopt als:

- Je zelf kiest om te stoppen
- De onderzoekers klaar zijn met hun onderzoek
- De onderzoeksgroep, de overheid of de ethische toetsingscommissie van de Universiteit Twente besluit om het onderzoek te stoppen.

Gebruik en bewaren van jouw gegevens
Voor dit onderzoek worden gegevens over jou verzameld, gebruikt en bewaard. Het gaat om gegevens zoals jouw leeftijd, de sport die je speelt en het niveau waarop je de sport speelt. Ook schrijven we de antwoorden op die je geeft op vragen en maken we aantekeningen als we naar je training kijken. Deze notities worden opgeslagen zodat we niet alles hoeven te onthouden. We zullen geen video opnames maken en ook geen audio opnames. We luisteren en kijken gewoon goed zodat dat niet nodig is. Soms hebben onze uitvindingen, zoals een robot, wel een camera. De videobeelden van die camera zullen we dan ook niet bekijken.

Vertrouwelijkheid van jouw gegevens
Om je privacy te beschermen krijgen jouw gegevens een code. Jouw naam en andere gegevens die jou direct kunnen identificeren worden daarbij weggelaten. Alleen met de sleutel van de code zijn gegevens tot jou te herleiden. De sleutel van de code blijft veilig opgeborgen in de lokale onderzoeksinstelling. De gegevens die voor het onderzoek gebruikt worden bevatten de code, maar niet jouw naam of andere gegevens waarmee jij kunt worden geïdentificeerd. Ook in rapporten en publicaties over het onderzoek zijn de gegevens niet tot jou te herleiden.

Toegang tot jouw gegevens voor controle
Sommige personen kunnen op de onderzoekslocatie toegang krijgen tot al jouw gegevens. Ook tot de gegevens zonder code. Dit is nodig om te kunnen controleren of het onderzoek goed en betrouwbaar is uitgevoerd. Personen die ter controle inzage krijgen in jouw gegevens zijn leden van het onderzoeksteam, nationale en internationale toezichthoudende autoriteiten, bijvoorbeeld, de Inspectie Gezondheidszorg en Jeugd. Zij houden jouw gegevens ook geheim.

Bewaartermijn gegevens
Jouw onderzoeksgegevens worden 10 jaar bewaard. De Universiteit Twente kan dus je anonieme data gebruiken om het gebied van sport en technologie verder te onderzoeken.

Intrekken toestemming
Je kunt jouw toestemming voor gebruik van jouw persoonsgegevens altijd weer intrekken. Dit geldt voor dit onderzoek en ook voor het bewaren en het gebruik voor het toekomstig onderzoek. De onderzoeksgegevens die zijn verzameld tot het moment dat je jouw toestemming intrekt, worden nog wel gebruikt in het onderzoek. Als je dat niet wilt, mag je tot 24 uur na het onderzoek contact opnemen met de bovengenoemde onderzoeker.

Vragen of klachten

Mocht je vragen hebben over dit onderzoek, dan kan je contact opnemen met Dees Postma (d.b.w.postma@utwente.nl), één van de studenten of je begeleider, trainer of coach. Zij kunnen je er alles over vertellen. Als je een klacht hebt of wil stoppen dan kan je dat zeggen tegen Dees Postma, een van de studenten of je begeleider, trainer, of coach. Vragen of klachten kan je ook vertellen aan de 'ethische commissie' (ethicscommittee-cis@utwente.nl) van de Universiteit Twente. Zij doen niet mee aan dit onderzoek en helpen je graag als je een klacht hebt.

Onderzoekers	dr. Dees Postma, onderzoeker – Universiteit Twente dr. Armağan Karahanoğlu, universitair docent – Universiteit Twente Studenten Creative Technology – Universiteit Twente
Begeleiders	Maaike Heethaar, projectleider – Special Olympics Nationale Spelen Twente 2020 Je eigen begeleider, trainer of coach

7. Vergoeding voor meedoen

Je krijgt geen vergoeding voor deelname aan het onderzoek.

8. Ondertekening toestemmingsformulier

Wanneer je voldoende bedenktijd hebt gehad, word je gevraagd te beslissen over deelname aan dit onderzoek. Als je toestemming geeft, zullen wij je vragen deze op de bijhorende toestemmingsverklaring schriftelijk te bevestigen (bijlage B). Door jouw schriftelijke toestemming geef je aan dat je de informatie hebt begrepen en instemt met deelname aan het onderzoek. Zowel jezelf als de onderzoeker ontvangen een getekende versie van deze toestemmingsverklaring.

Dank voor je aandacht.

Bijlagen bij deze informatie

A: Contactgegevens: Universiteit Twente
B: Toestemmingsformulier

Bijlage A: Contactgegevens voor Universiteit Twente
Onderzoekers: dr. Dees Postma, bewegingswetenschapper en onderzoeker aan de Universiteit Twente (d.b.w.postma@utwente.nl)

Wil je graag onafhankelijk advies over meedoen aan dit onderzoek, of een klacht indienen? Dan kan je terecht bij de Ethische Commissie van EWI van de Universiteit Twente. Deze bestaat uit onafhankelijke deskundigen van de universiteit en is beschikbaar voor vragen en klachten rondom het onderzoek.

Secretariaat: Ethische Commissie (EWI):
Drs. Petri de Willingen
+31 534892085
ethicscommittee-cis@utwente.nl
Building: Zilverling 1051

Voor meer informatie over jouw rechten:
https://www.utwente.nl/en/eemcs/research/ethics/

Bijlage B: Toestemmingsformulier proefpersoon

Beter bewegen voor iedereen! Sport en technologie.

- □ Ik heb de informatiebrief gelezen. Ik heb al mijn vragen kunnen stellen. Mijn vragen zijn voldoende beantwoord. Ik had genoeg tijd om te beslissen of ik meedoe.
- □ Ik weet dat meedoen vrijwillig is. Ook weet ik dat ik op ieder moment kan beslissen om toch niet mee te doen of te stoppen met het onderzoek tot 24 uur na deelname. Daarvoor hoef ik geen reden te geven.
- □ Ik weet dat voor de controle van het onderzoek sommige mensen toegang tot al mijn gegevens kunnen krijgen. Die mensen staan vermeld in deze informatiebrief. Ik geef toestemming voor die inzage door deze personen.
- □ Ik wil meedoen aan dit onderzoek.
- □ Ik geef toestemming voor het verzamelen en gebruiken van mijn gegevens voor de beantwoording van de onderzoeksvraag in dit onderzoek.

Naam proefpersoon:

Handtekening:

Datum:____/____/____

<Indien van toepassing> Wettelijke vertegenwoordiger / curator / mentor:
Naam:

Functie:

Handtekening:

Datum:____/____/____

Ik verklaar dat ik deze proefpersoon volledig heb geïnformeerd over het genoemde onderzoek. Als er tijdens het onderzoek informatie bekend wordt die de toestemming van de proefpersoon zou kunnen beïnvloeden, dan breng ik hem/haar daarvan tijdig op de hoogte.

Naam onderzoeker (of diens vertegenwoordiger):

Handtekening:

Datum:____/____/____

De proefpersonen krijgt een volledige informatiebrief mee, samen met een getekende versie van het toestemmingsformulier.

Appendix B

Interview questions

B.0.1 TAM and 5D rubric interview questions

1. What do you think is the perceived usefulness of the proposed technology?
    1.1 How can we make it more useful in your opinion?
2. What do you think is the ease of use of the prosed technology?
    2.1 What do you find confusing?
3. Would the proposed technology in your opinion increase the social interaction between DDC and TD children?
    3.1 What do you think is missing or might not work?
4. What do you think about the efficiency of the proposed technology?
    4.1 What could be made simpler or more straightforward, in your opinion?
5. What do you think about the engagement of the technology? Will be children be engaged?
    5.1 How could we make it more engaging?
6. Do you have any concerns about this product?
    6.1 What are the concerns?
    6.2 Do you have any suggestions to fix these concerns?

B.0.2 TAM and 5D rubric interview questions for DDC

1. Would you wear the wristband more often?

1.1 1: I do not want to use the wristband any more. 5: I would like to use the wristband very often.

2. How easy was it to use the wristband?

   2.1 1: very difficult. 5: very easy.

3. How was your experience playing with the other players when wearing the wristband?

   3.1 1: not fun. 5: very fun.

4. How was your experience with the wristband?

   4.1 1: not fun. 5: very fun.

5. What did you not like about the wristband?

6. If you could change anything of the wristband, what would you change?

Appendix C

Lotus Blossom results

Figure C.1: Total overview of the Lotus Blossom

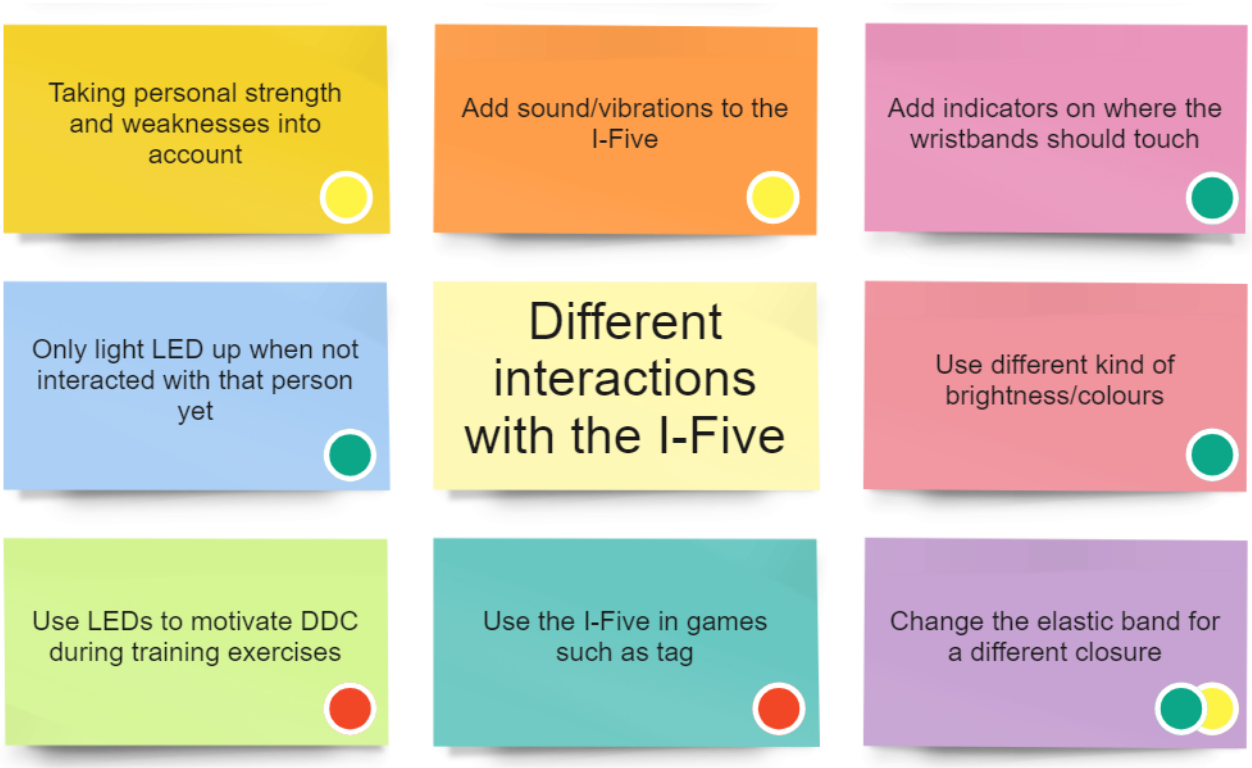

Figure C.2: Middle part of the Lotus Blossom

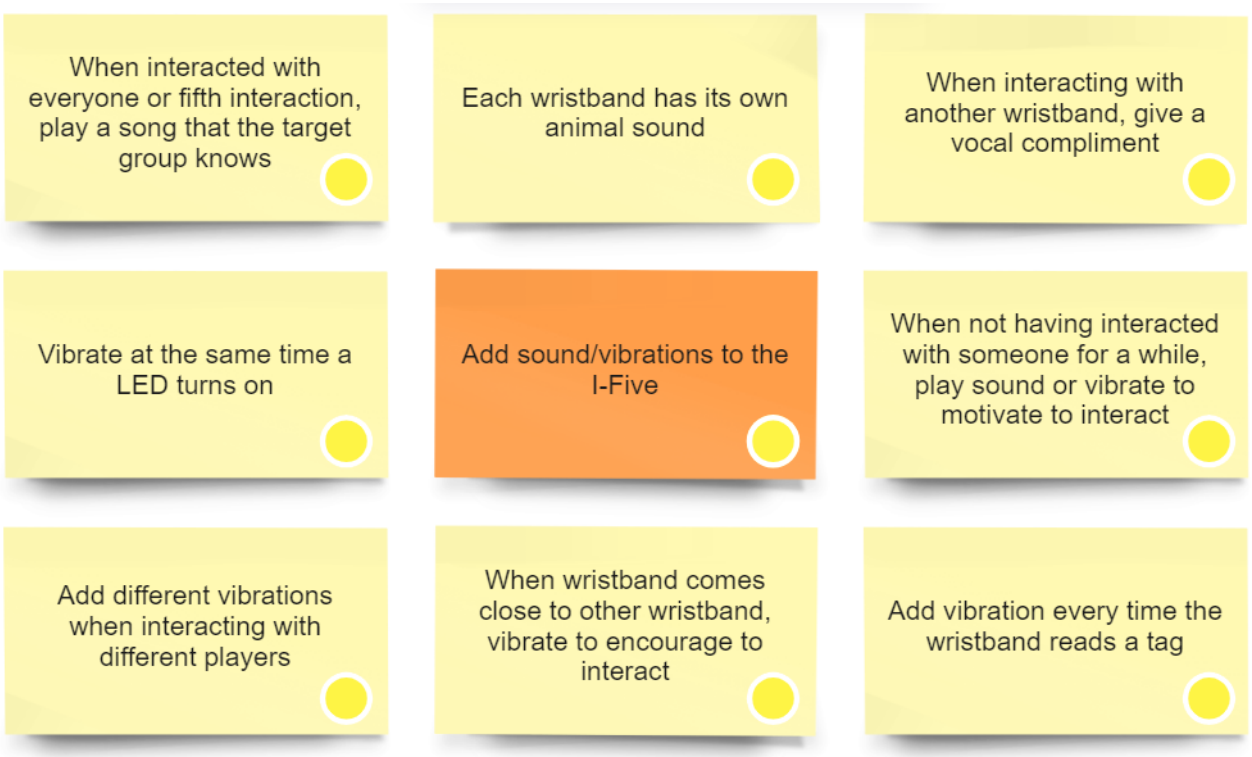

Figure C.3: Orange: Add sound/vibration to the I-Five

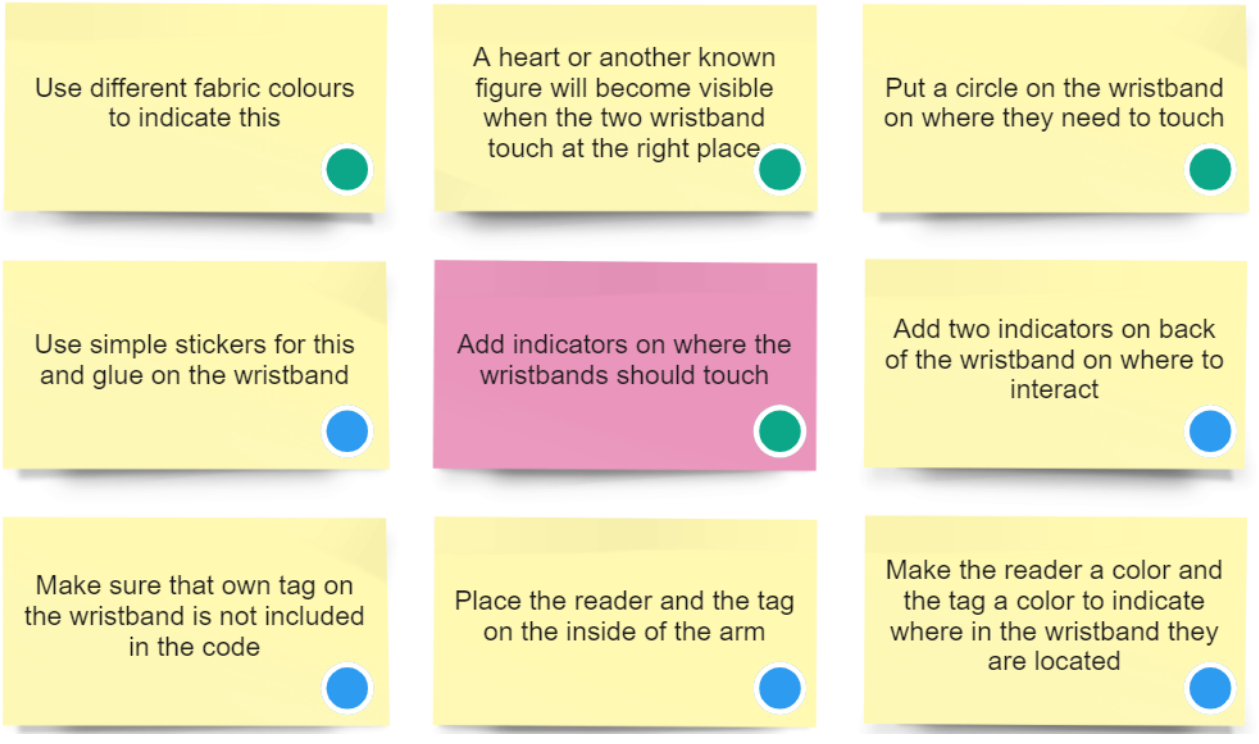

Figure C.4: Pink: Add indicators on where the wristbands should touch

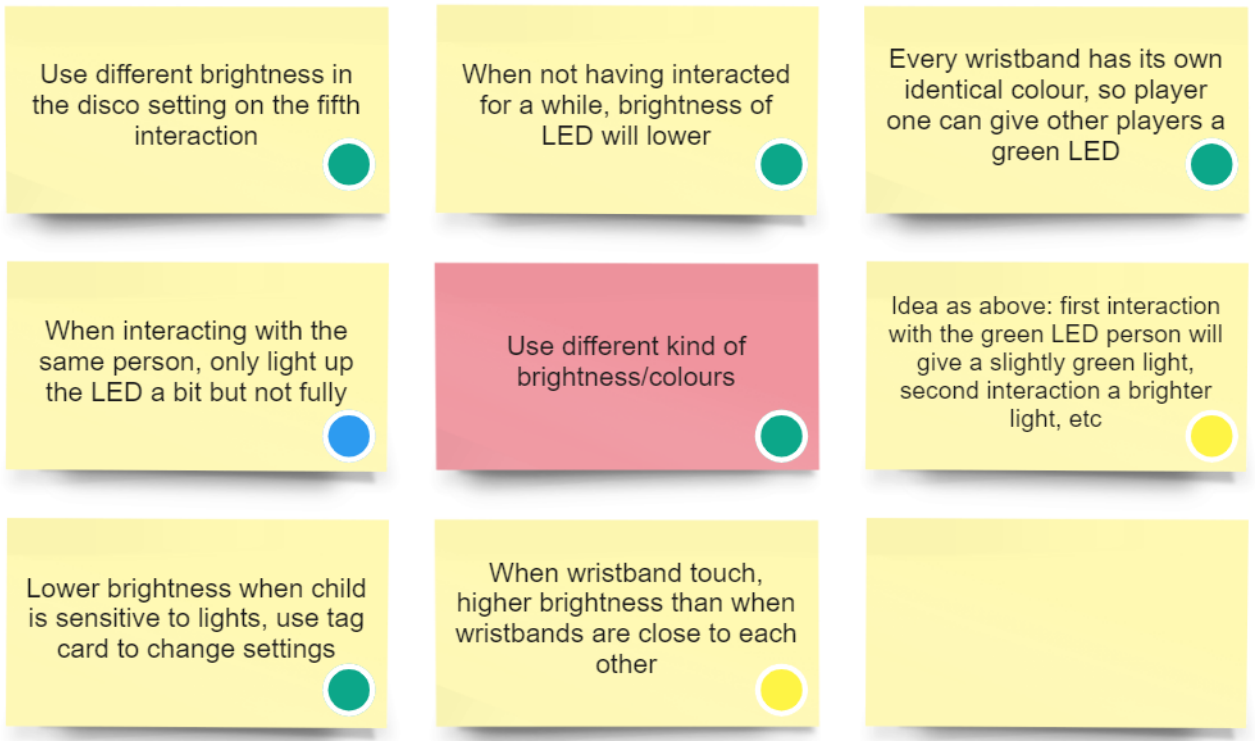

Figure C.5: Dark Pink: Use different kind of brightness/colours

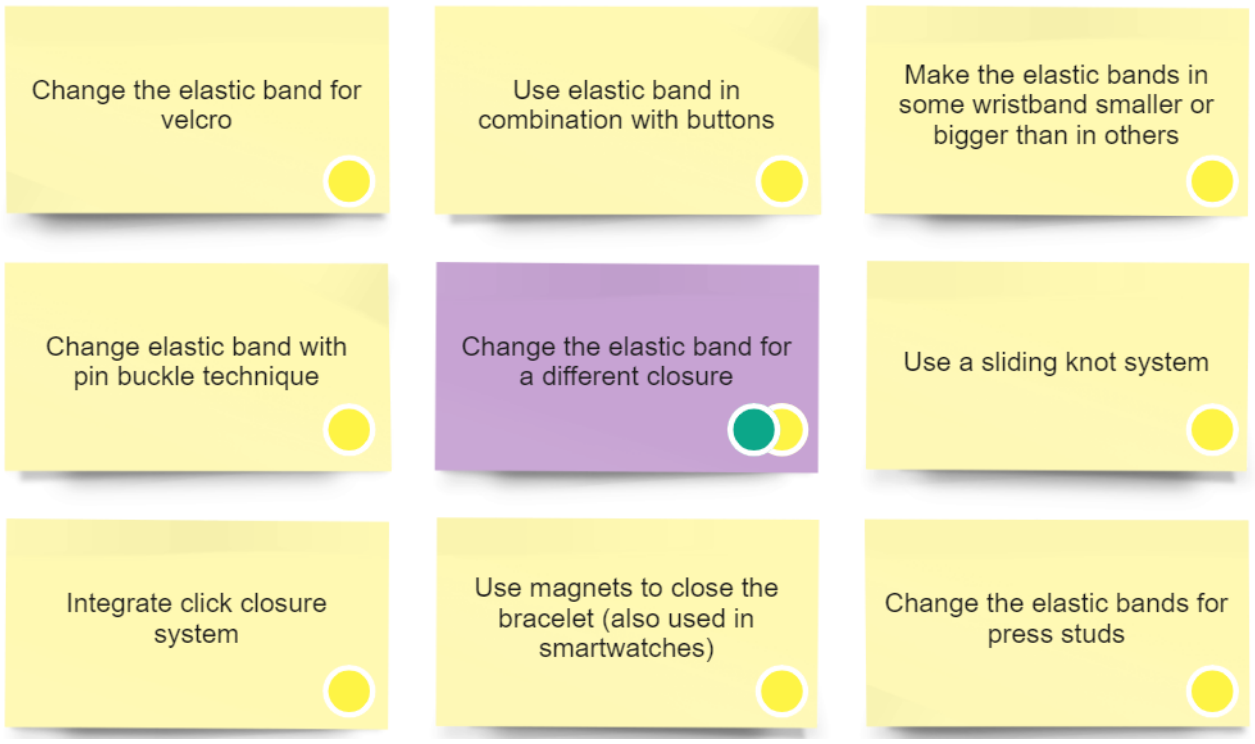

Figure C.6: Purple: Change the elastic band for a different closure

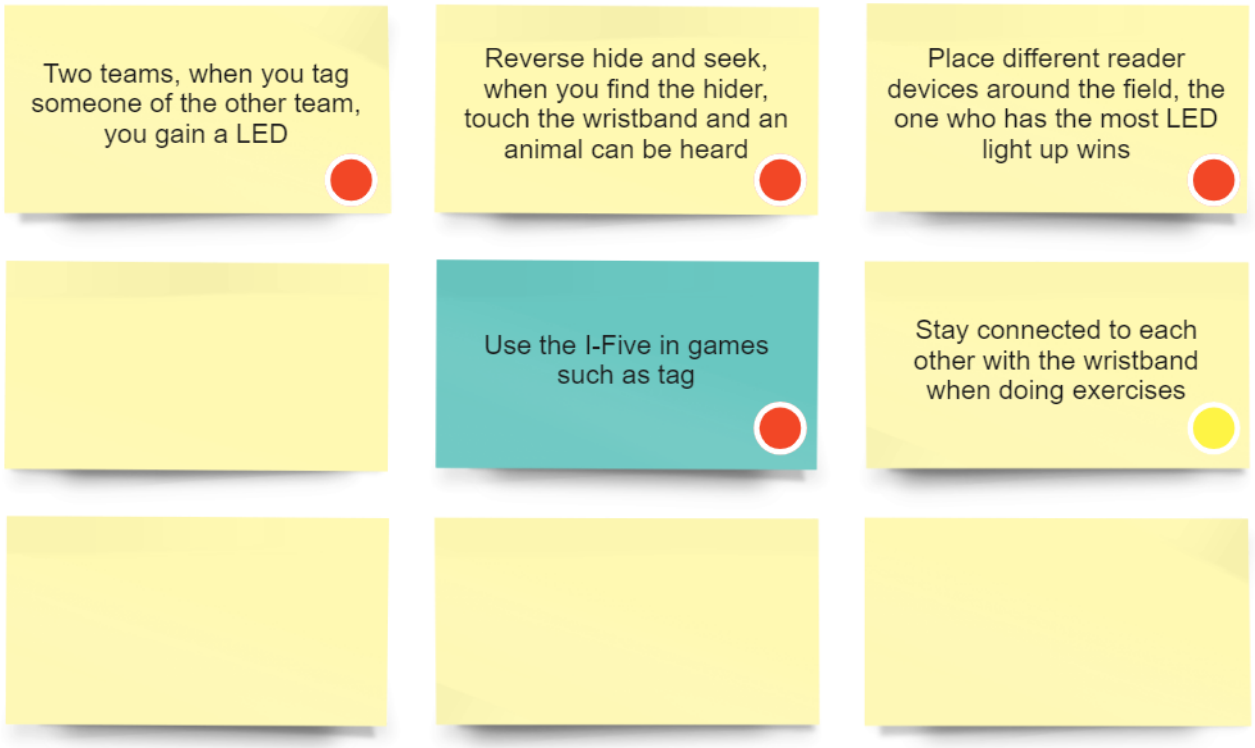

Figure C.7: Dark Green: Use the I-Five in games such as tag

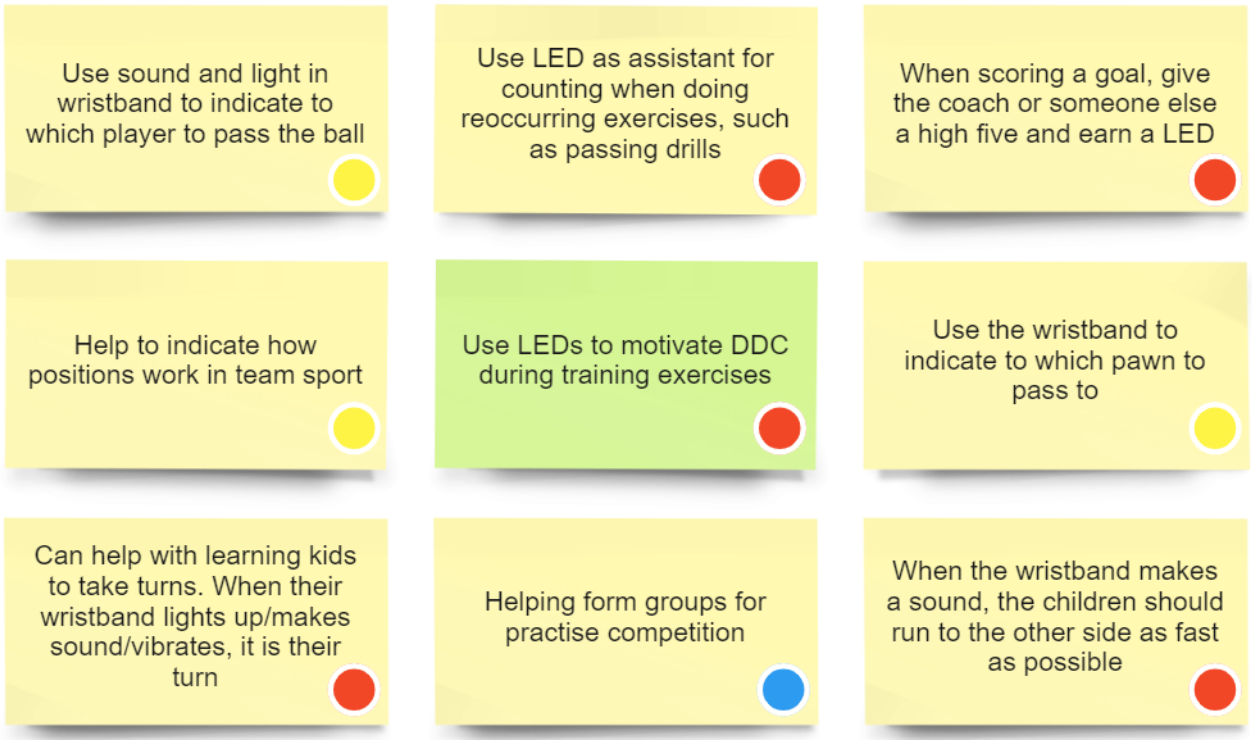

Figure C.8: Green: Use LEDs to motivate DDC during training exercises

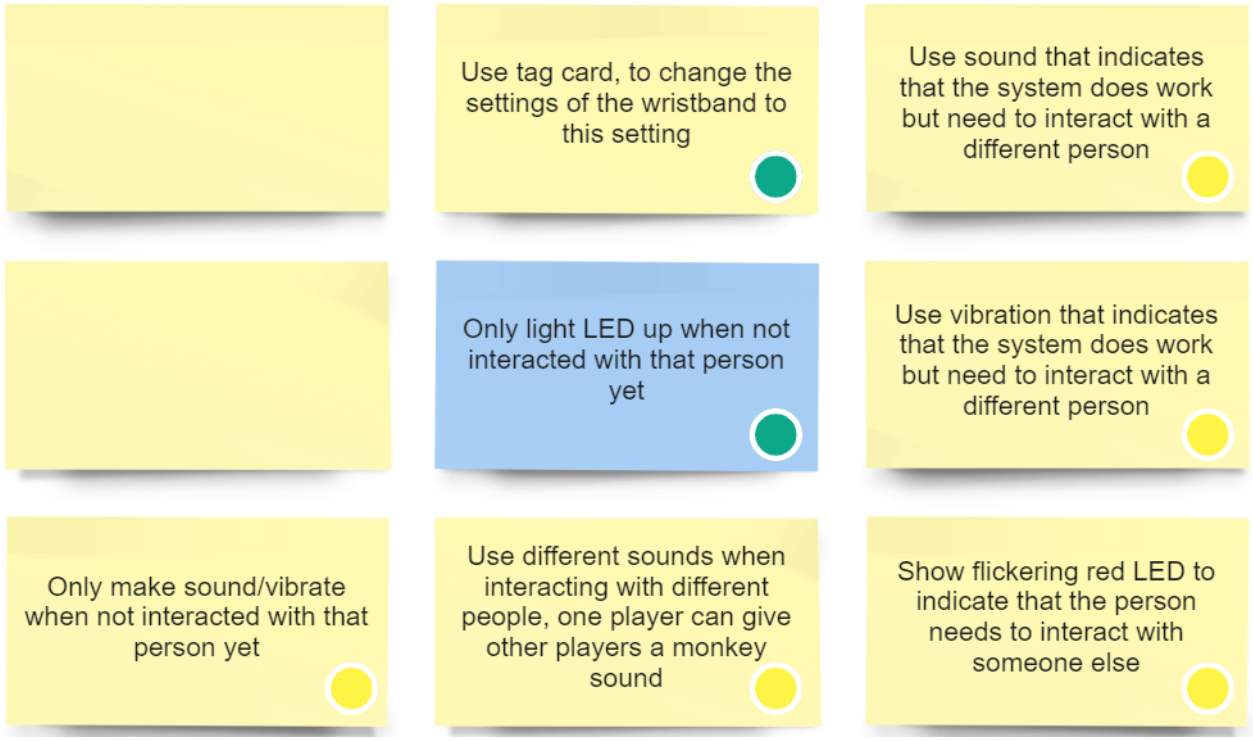

Figure C.9: Blue: Only light LED up when not interacted with that person yet

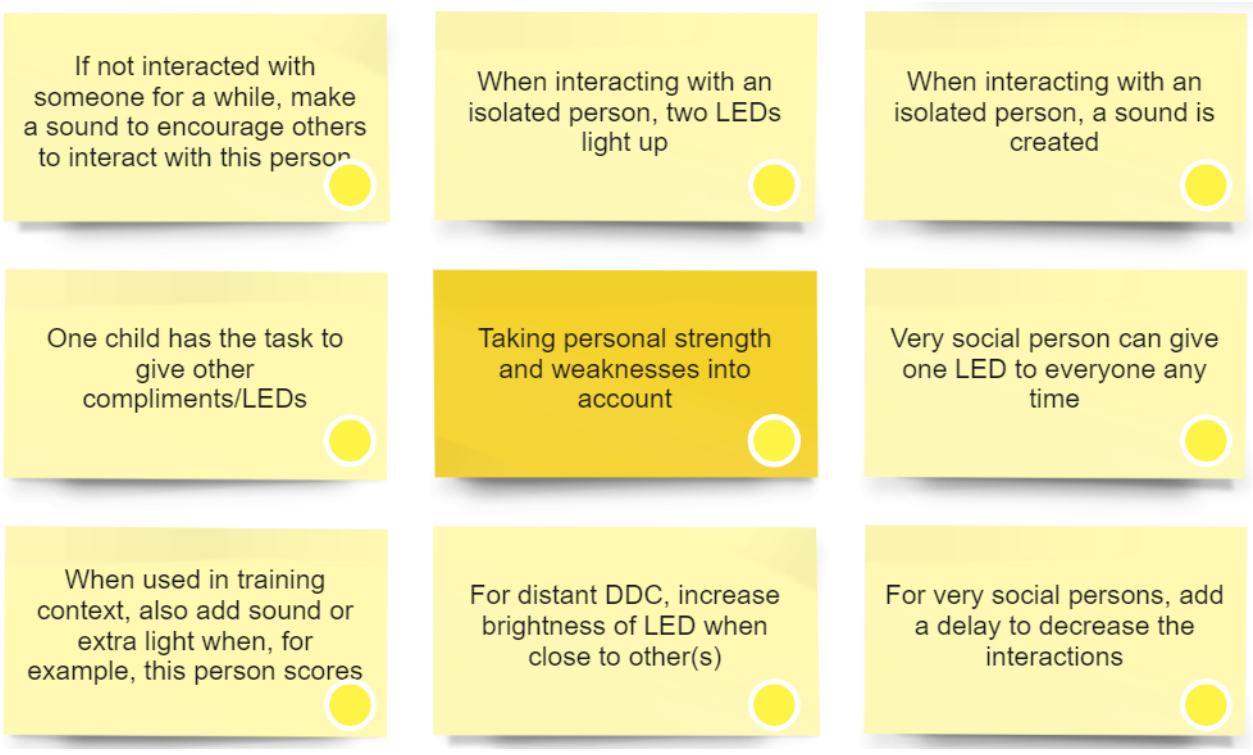

Figure C.10: Yellow: Taking personal strength and weaknesses into account

Appendix D

Observation scheme for the observers

Tabel geen interventie

	Speler-speler interactie		**Speler-coach interactie**	
Non-verbaal	***Initieert***	***Reageert***	***Initieert***	***Reageert***
High-five				
Boks				
Duim				
Andere non-verbale complimenten/aanmoedigingen				
Verbaal	***Initieert***	***Reageert***	***Initieert***	***Reageert***
'Goed gedaan!'				
'Goed zo!'				
'Mooie bal!'				
Andere verbale complimenten/aanmoedigingen				
Andere interessante observaties:				

Tabel poster interventie

	Speler-speler interactie		**Speler-coach interactie**	
Non-verbaal	***Initieert***	***Reageert***	***Initieert***	***Reageert***
High-five				
Boks				
Duim				
Andere non-verbale complimenten/aanmoedigingen				
Verbaal	***Initieert***	***Reageert***	***Initieert***	***Reageert***
'Goed gedaan!'				
'Goed zo!'				
'Mooie bal!'				
Andere verbale complimenten/aanmoedigingen				
Andere interessante observaties:				

Tabel I-Five interventie

	Speler-speler interactie		**Speler-coach interactie**	
Non-verbaal	***Initieert***	***Reageert***	***Initieert***	***Reageert***
Interactie met I-Five				
High-five				
Boks				
Duim				
Andere non-verbale complimenten/aanmoedigingen				
Verbaal	***Initieert***	***Reageert***	***Initieert***	***Reageert***
‘Goed gedaan!’				
‘Goed zo!’				
‘Mooie bal!’				
Andere verbale complimenten/aanmoedigingen				
Andere interessante observaties:				