Using Roles in Games to Provide an Engaging and Supportive Co-Experience Among Children

A study of how individual accountability in games can engage co-located children in close collaboration

A Master's Thesis by

Asger Stryhn Rasmussen
20104478

Daniel Værnhøj Westergaard
20112398

Mathias Thyssen Kristensen
20115554

AARHUS UNIVERSITET

Advisor:
Marianne Graves Petersen

Date:
15/06-2016

Department of Computer Science at Aarhus University.

Asger Stryhn Rasmussen
20104478
20104478@cs.au.dk

Daniel Værnhøj Westergaard
20112398
20112398@cs.au.dk

Mathias Thyssen Kristensen
20115554
20115554@cs.au.dk

Abstract

The aim of this thesis is to investigate how the use of technological devices can engage children in a co-experience with close collaboration. The investigation is motivated by the recent debate on children's use of technological devices. Some believe that early use of tablets and smartphones has positive effects on the children's social development while others think it can be damaging. This investigation contributes to that debate. Furthermore, children want to play together, but the devices do not support collaboration very well. Therefore, they often end up playing alone or in a group around a single device where one child plays while the others spectate and comment.

Initially, ethnographical studies were conducted at two centers for afterschool care and in a 4^{th} grade class. This was to observe and gain an understanding of children's current use of technology and their social behavior. The collected data from the ethnographical studies were then analyzed using theories from the research field Human-Computer-Interaction.

On the basis of the results, we created prototypes which consisted of three different 3D games where the children had to collaborate by controlling a single object towards a shared goal. Afterwards, we performed three field studies where we examined the children's abilities to collaborate using the prototypes. In general, the children were fond of the collaboration and enjoyed having to coordinate their actions toward a shared goal.

Lastly, a set of guidelines will be presented based on the results of the field studies and the theory. These guidelines describe how roles can be used to create a well-balanced group dynamic and a positive interdependence. Therefore, these guidelines present elements to be considered by designers striving to design games that support collective action.

Resumé

Målet med dette speciale er at undersøge, hvordan brugen af teknologiske enheder kan engagere børn i en fælles oplevelse med tæt samarbejde. Undersøgelsen er motiveret af den seneste debat om børns brug af teknologiske enheder. Nogle mener at tidlig brug af tablets og smartphones har positive effekter på børns sociale udvikling, mens andre mener det kan være skadeligt. Denne undersøgelse bidrager til denne debat. Yderligere, vil børn gerne spille sammen, men enhederne understøtter ikke samarbejde særligt godt. Derfor ender de tit med at spille alene eller at sidde flere rundt om én tablet, hvor et barn spiller mens de andre kigger på og kommenterer.

Til at starte med blev der foretaget etnografiske studier ved to SFO'er og i en fjerde klasse. Målet var at observere og forstå børnenes nuværende brug af teknologi og deres sociale opførsel. Den samlede data fra de etnografiske studier blev analyseret med teorier fra feltet Human-Computer-Interaction. På baggrund af resultaterne blev tre prototyper konstrueret, der hver bestod af et 3D-spil, hvor børnene skulle samarbejde om at styre et enkelt objekt mod et fælles mål. Prototyperne blev brugt i feltstudier, der havde til formål at undersøge børnenes evner til at samarbejde gennem prototyperne. Børnene var generelt meget glade for samarbejdet og havde det sjovt med at koordinere deres handlinger mod et fælles mål.

Specialet afsluttes med at præsentere et sæt retningslinjer, som er baseret på resultaterne fra feltstudierne og den benyttede teori. Disse retningslinjer beskriver, hvordan roller kan bruges til at opnå en afbalanceret gruppedynamik og indbyrdes afhængighed. Disse retningslinjer præsenterer derfor elementer, der kan overvejes af designere, der ønsker at designe mod collective action.

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1 Introduction

The starting point of this thesis is the debate on children's use of technological devices in recent years. The debate focuses on questions like: Do children become socially hampered when they are playing too much or do games help them to form social relationships? Does the brain take any damage from too much screen activity? And what exactly is too much usage of technological devices? [22].

In the following an overview of children's usage of technology will be described along with different views on the usage – e.g. how researchers believe this technology will affect children. Afterwards, our motivation for the project will be followed by our research question.

1.1 Children's Usage of Technological Devices

The usage of technological devices has increased a lot in recent years. In a report from Børnerådet, this is related to more easily accessible digital media. The Danish families' homes are filled with technology like smartphones, tablets, gaming consoles etc. [22]. This can be seen in DR Medieforskning's report from 2014, which shows that up to 90 % of Danish children have access to a tablet or a smartphone in their home. Additionally, the report shows that 56 % of the 7-12 year olds have their own smartphone while 53 % have their own tablet [24].
The access to the digital world is also available in the children's daily life outside the homes. Tablets and computers are accessible in several institutions and schools [22].

Due to the easier access and increased usage, Jessen and Nielsen argue that children's play culture has changed over the last decades. They refer to recent research reports which show how the media have increasing influence on how children today socialize and play together. The use of tablets amongst children has become a popular tool for entertainment and play. To children, a tablet is easy and intuitive to use, and even children down to one year of age are capable of using it. According to Jessen and Nielsen, the traditional way of playing has changed as children now seek inspiration to play through technology. Media and digital toys are often good tools for play because they contribute to creating companionship and play [18].

When children play on tablets, they either do it alone, together or take turns at being the one who is playing or the one who is spectating the other. Børnerådet found that 75% of children preferred to play alone, but 61% of them also liked to play with others. The children who preferred to play alone explained that too many fingers on the tablet screen ruin the experience. Others did not like taking turns playing on the tablet. To them, sharing the tablet with others is not fun. One of the children also mentioned he does not mind sitting next to others while playing, as long as no one is telling him what to play and how to play it. Those who liked to play with others explained that they enjoy playing with their older siblings, especially when they are good at the games. However, as one of the boys told, they preferred to have a tablet each. Some of the children also saw an advantage in playing together. This way, they are able to help each other. One boy mentioned he liked to play with others if the game supports it, but if it did not, he would rather play alone [22].

1.2 Today's Debate of Children's Usage of Technological Devices

There is no clear consensus on the children's use of technological devices. Many different perspectives exist on what is healthy and developing for the children and what is unhealthy and damaging when using the media. Research reports and news articles in this area point in each direction.

There is a tendency of using worst case scenarios to convince and shape the public debate on children's usage of technological devices [22].The argument of using the devices as a babysitter is one which recur in several articles [12, 15, 31, 40].
Some parents are worried about how the use of technology affects children negatively in their early development [5]. These concerns are shared by numerous psychologists. Sue Palmer [27] published a book ten years ago, warning the public about the dangers of too much screen-time. Today she sees her concerns becoming a reality. Based on her own research, she argues that too much screen-time can lead to obesity, aggression, poor development of social skills and depression. According to her, children have few opportunities to engage in 'real-play' where they can unfold their creativity through play. As a result, they allegedly become more inclined to isolate themselves and develop anti-social traits. This view is supported by Kline and Lindstrom who argue that the media degrade the children's fantasy and ability to create their own plays [18].
Palmer argues that 'real-play' teaches children self-confidence, emotional resilience, creative thinking, social skills and the capacity for focused thought. Her suggestion for a possible solution is to limit screen-time and make sure that children come outside to play. This view is supported by Lee and Pasin [21] who recognize an increasing need for unstructured play.

In contrast, Daphne Bavelier argues that the digital world has the potential to assist in developing children in a positive way. Her research found that computer games affect attention, vision, reaction and spatial cognition in a positive manner. She sees potential in developing games with a specific focus on these skills. However, Bavelier agrees that we should be aware of how much time children spend in front of the screen, and that limiting screen-time is a viable solution [2].
Donohue argues that limitation is not an ideal solution, and we should instead focus on how technology is used:

"*The American Academy of Pediatrics discourages screen time for children under two years old* (…) *It says that technology and media should be limited, but what matters most is how it is used. What is the content? Is it being used in an intentional manner? Is it developmentally appropriate?*" [9].

Therefore, technology should not simply be regarded as dangerous for children. Instead, we should focus on the information mediated by the devices. Jessen and Nielsen argue that computer games are highly social activities, and that children prefer to use them in social contexts. Playing alone is no different from watching TV or reading a book. It does not mean spending time with friends have a lower priority; it is simply a way of passing time. Computer games are actually bringing children together across ages due to their common interests – and this creates opportunities for dialogue. They elaborate further that the use of media is not in opposition to being social with other children, but is an integrated part of the children's socialization and play. It is often used as a tool for play and as an important means to create playful situations [18].

1.3 Our Motivation

The debate serves as the motivation for this thesis. We aim to reduce the many concerns in regards to children's use of technology. Jessen and Nielsen argue that technology is an integrated part of the children's current play culture. We wish to accommodate the children's interests as well as reduce the parent's concerns, by showing how technology can be used in social activities. Tablets and smartphones have many opportunities to engage children in playful activities. Following Donohue's notion of how technology is used, technology could be designed to encourage collaborative behavior. Tablets already support multiplayer games where the children can cooperate. However, these games can be played online which does not require the children to sit together when playing. We see a potential in creating a social game where the children are co-located when playing.

In the report from Børnerådet, it is apparent that the children want to play games together as they can help each other to complete the game. However, tablets do not support the children's desire to be social. Having several fingers on the screen can create unintentional actions or block the shown content. It can also become dull to watch each other play, take turns at controlling the tablet or repeatedly being told what to do by the spectators. We are interested in investigating how a game, which uses only one screen, can support several users. As the game is going to be designed for social use, we wish to design a collaborative game where the children work together towards a shared goal. We seek to explore how the game can engage and motivate the children to collaborate.

We have worked with Huusmann Media which is an organization that develops games for children. They have assisted in determining the scope, ensuring a clear direction in the development process and evaluating ideas. Our first step was to develop a game design which encouraged collaborative behavior, like shared goals, positive interdependence and individual accountability. The design of the game takes into account the different design challenges of multiplayer games and a requirement set out by us to create meaningful interaction. Our approach attempts to live up to the characteristics of the collective interaction model while following the design guidelines for collaborative games found in the literature.

1.4 Research Question

Children wish to engage in co-experiences when using technological devices, but their available tools rarely allow for more than one participant at a time. The purpose of this thesis is to study how the technological devices can be used to create an engaging co-experience where children are able to play together.

Our research question is:

How can individual accountability support children's engagement to collaborate in a social game which aims to achieve collective action?

1.5 Delimitation

We are aware that collaboration is a broad area within both games and Human-Computer Interaction (HCI), and we cannot cover every aspect of it. Therefore, we have chosen the field collective action with a focus on three main aspects: engagement, level of participation and roles. We were interested in how these aspects can be actively and positively used to affect collaboration in a group of children.

Since the current research of collective interaction has mainly used adults, we chose children as the target group. The age group was chosen to be between nine to twelve years.

We acknowledge that different contexts of use have an influence on how the children interact with each other and the game. We see opportunities in both designing for home and institutional use as both of them are places where children are together and playing with each other. We have not distinguished between them as the context itself is not our main focus. The focus of this thesis have thus been on the interaction between the children.

2 Theory

In this section, we will account for how different theories can be combined to create a comprehensive set of tools which can be utilized in the design of a system encouraging collaboration. Each theory has been chosen because it provides information of a specific area, which is important to consider when creating optimal group dynamics and ensuring the best conditions for collaboration. The benefits of each theory will be described along with theory itself.

The section will finish by briefly summarizing all theories and their benefits for this project.

2.1 Single Display Groupware

Research in using technology for Computer-Supported Cooperative Work (CSCW) to support collaboration among co-located people has gotten a lot of attention. Before Single Display Groupware (SDG), most of the CSCW systems mainly focused on people working apart from each other. Stewart et al. therefore developed SDG to explore the potential of using the computer as a collaborative tool [17]. SDG enables co-located users to collaborate through a shared computer with a single shared display and simultaneous use of multiple input devices (Figure 1b).

SDG differs from standard systems by how it manages input and output channels. They define the input channel as a device that provides independent input to the computer, and the output channel as how the computer communicates with and gives the users feedback. In current systems, this would mean that each user has their own separate input channel, like a mouse, and independently control their own cursor on the shared display. None of the inputs would influence the other user's actions.

To our knowledge, a system which fully utilizes SDG does not exist outside of the research area. The closest example we could find has been a Groupware application (Figure 1a). Groupware systems are defined by multiple workstations which can communicate with each other through a computer network. Like single user applications, each user has their own input and output channel [41]. In contrast to SDG, the groupware application is not strict when it comes to being co-located and sharing the same display.

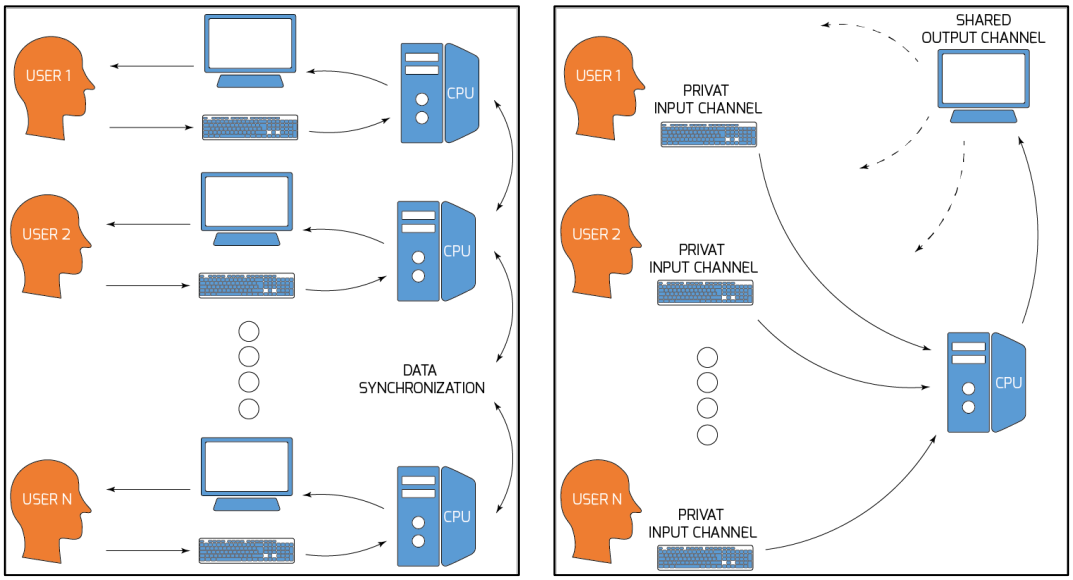

Figure 1 - a) Groupware, b) Single Display Groupware.

The groupware application we know is called Google Docs[1]. This application allows multiple users to edit the same document with text, images, graphs and so on. Each user uses his or her own computer and connects to the document through the website. This also means that the users do not have to be co-located, but can collaborate wherever they are.

Stewart et al. [41] presents tradeoffs of a SDG system (Table 1). These are listed below:

Possible benefits	Potential negative effects
Separate input channel • Allows another person to use the application comfortably without violating the personal space of another.	*Conflicts and frustration* • Working in parallel can be an advantage, but it could also be a disadvantage if users each have separate conflicting agendas.
Multiple users • Enables new types of interaction which utilizes the amount of users.	*Limited screen space* • Functionality may be reduced due to the limited screen space.
Enriching the collaboration among users • With multiple input devices, work can be done in parallel. Can enhance the verbal and nonverbal communication by shoulder-to-shoulder collaboration.	*Can be more time consuming* • Tasks might take longer to complete because of the required cooperation. No one is able to complete everything alone.
Reduce conflicts with simultaneous use • The separate channels can help to push potential conflicts away.	*Risk of less collaboration* • Due to the parallel work, each user can work on their own task, and therefore never have to communicate with the other users.
Encouraging peer-learning and teaching • It is possible to enrich learning and teaching through the multiple communication channels by removing the competition for the access to the input channel.	
Strengthening the communication skills • No one has the full control of the input device. Users will have to communicate with each other to complete a common task.	

Table 1 - Pros and cons of Single Display Groupware.

We see the theory behind SDG as a positive way to support collaborative work. Even though there is a risk of less collaboration, it offers many advantages. Especially how it can potentially strengthen the

[1] Link to wiki explaining Google Docs: https://en.wikipedia.org/wiki/Google_Docs,_Sheets,_and_Slides (visited on March 2 - 2016)

communication skills between the users as it is necessary to communicate in order to complete a common task.

2.2 Interaction in Social Spaces

Where SDG focuses on the interaction with the system, Ludvigsen developed a framework that focuses on the social interaction between people. The framework describes four levels of engagement. Each level describes how actively engaged the participants are in the social activity. The levels range from the lowest social engagement called "Distributed attention" to the highest "Collective action" (Figure 2). In the schema (Table 2), borrowed from his paper, the four categories are listed [23]:

Social interaction	Examples from a workplace	Examples for a playful situation
Distributed attention	Awareness of colleagues before the presentation starts or in breaks during the work.	In e.g. a daycare where lots of children are playing different games to themselves in small groups.
Shared focus	Presentation. One person in front of the rest of the colleagues.	Bystanders to a game might be observing in order to join the game later or just looking at a friend playing Game Boy.
Dialogue	Discussion on e.g. how to frame a design problem or understand a specific parameter.	When children play, a large part of the efforts goes into deciding what the rules are for the game, and they often return to this dialogue level during play.
Collective action	Collaboration in a team of colleagues brainstorming/working towards a solution to a design problem.	In the game itself children will quickly lose track of time and e.g. take on new roles in the interaction.

Table 2 - Levels of social engagement.

Figure 2 - Illustration of Ludvigsen's levels of social engagement.

In "Distributed attention" the only thing that is shared is the presence in the space. This means that the level of interaction among people is low since each person has their own focus. The next level is "Shared focus", where the situation develops a single focus shared among its participants, e.g. in a presentation. The third level is "Dialogue" where participants engage in a shared activity in which they are investing themselves and their opinions. The final level is "Collective action", which is the most engaging social activity. Here the participants collaboratively work towards a shared goal. Ludvigsen defines this level as: "*The focus of attention is beyond the interaction and situation itself, directed towards a shared third subject matter*" [23].

Collective action can be compared to a good brainstorm where the participants can lay aside their disagreements to immerse themselves in the creative process [23].

Especially the notion of collective action is interesting to us because a shared goal encourages collaboration. In relation to SDG, there should not be any risk of distributed attention if all the users work towards the same goal. We can use the framework to consider which aspects of our prototype encourage collective action. Furthermore, we can use the framework to classify social interactions found in our empirical observations and field studies.

2.3 Collective Interaction

Petersen and Krogh used Ludvigsen's notion of collective action in combination with SDG and Forlizzi and Battarbee's co-experience [13] which resulted in the Collective Interaction (CI) model [29]. Their work focused on how you can design co-experiences among co-located people who share resources for controlling interfaces.

CI is inspired from SDG in terms of how it focuses on co-located people and how it sends content to applications by using individual input channels to a single shared output channel.

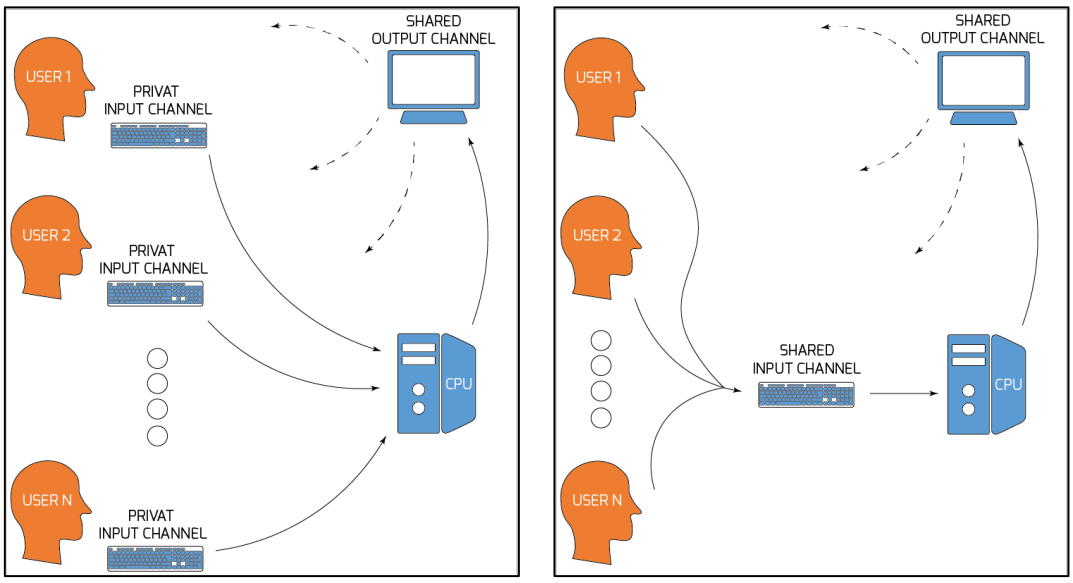

Figure 3 - a) Single Display Groupware, b) Collective Interaction.

As explained earlier, one of the pitfalls in SDG is the possibility to work independently on one's own task. Petersen and Krogh created basis for a more sharable experience where participants are working collaboratively towards a shared goal. This was done by having each person's signal combined with others' to create one shared input which is then send to the application. This way, they are compelling people to negotiate their actions, as none of them are able to complete any tasks alone. The difference between SDG and CI have been illustrated in (Figure 3).

Petersen and Krogh define the CI model as follows:

> *"Collective Interaction is when multiple and collocated users share both one logical input channel and one logical output channel. The input channel may consist of a number of interaction instruments, which are logically coupled in the interaction.*
> *Thus Collective Interaction requires more than one user for controlling and taking full advantage of the system. Through their interaction, the users must actively coordinate their actions towards a shared goal."*
> [29]

Furthermore, they created a number of characteristics for the CI model [30]. These are:

1. Collective interaction involves users actively collaborating and negotiating their concrete interaction.
2. Collaboration is instrumentalized, meaning that collaboration and negotiation is a part of the concrete interaction.
3. The interaction itself invites for human-human interaction beyond what is in the interface.
4. The spatial organization of people induces expectations of use and contributes to the active collaboration.
5. A shared goal is established on the basis of sharing responsibility and negotiating of control.
6. Establishing a shared goal through negotiation is essential both in order to achieve it and in order to challenge and thereby tease other participants.
7. The interaction may be asymmetrical, in the sense people take on different roles, but the efforts of all participating are accounted for and valued in the use of the system.

The design goal in the CI model is to support the human-to-human interaction instead of the human-computer interaction. This is done both in the form of coordinating actions, but also when negotiating a shared goal. It is important to note that depending on the changing interest of the users the shared goal can also change during a session.

2.4 Collective Interaction Projects

The following section will focus on three projects within Collective Interaction. These projects are also regarded as Related Work, but since they are needed in order to explain the CI model, they will be presented here.

The research within CI have been conducted by the researchers who coined term CI, Petersen and Krogh, who discuss three projects that revolve around Collective Interaction: iFloor, Squeeze and a set of controllers for shared navigating through digital photos (referred to as *Collective Controllers* from now on) [28–30]. All projects explore how shared controls can affect the interaction on a human-to-human level.

2.4.1 iFloor

Installed in the entrance hall of a library, the intention of iFloor was to make patrons of the library aware that, apart from the librarians, they could use each other as knowledge resources too [20, 29]. Using a camera and a projector, iFloor (Figure 4) exploits spatial proximity of the users to navigate a cursor through an interface on the floor. The interface displayed various Q/A's received from the users. To read an answer,

the users had to move the cursor on top of the question. When standing next to the interface, each user functioned as a gravitational point that would drag the cursor towards themselves. Users must therefore collaborate by strategically placing themselves around the interface to drag the cursor to the desired Q/A. Without a shared goal, the users would most likely end up dragging the cursor in several different directions accomplishing nothing. If they instead agree upon a shared goal, they can plan their interaction accordingly. Since it is likely that not everyone wants to read the same Q/A's, the shared goal can change throughout the interaction, making it highly negotiable.

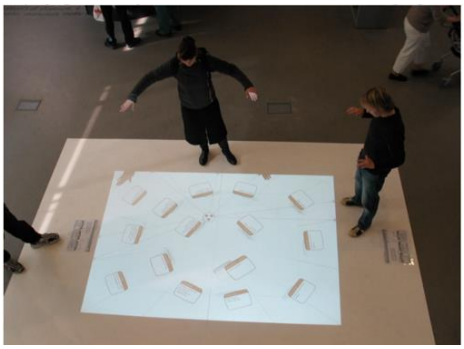

Figure 4 - iFloor.

The project experimented with playful interaction that encouraged people to communicate. However, the results showed that many people were reluctant to engage in iFloor because they did not understand the system. It is also interesting to note that users who did not initially know each other had limited collaboration in comparison to those who did. In low intimacy groups, the collaboration was confined to one user dictating the goal or asking the others to get off the floor. On the contrary, to others, the application functioned as an area where it was acceptable to talk to strangers who share the same point of attention [20].

2.4.2 Squeeze

Squeeze (Figure 5) [28] consisted of a house camera and a larger than one-person interactive sack chair that were installed in the home of three different families. The core idea was to support collective exploration instead of having co-experiences through watching others being active in turn.

Users could take photos with the camera which were then projected onto a wall near the sack chair. Others used the sack chair to navigate through the pictures. Dedicated interaction areas, placed in each end of the sack chair, encouraged collaboration among the users and invited to playful interaction. Depending on the activity performed, users could explore and interact with the pictures in different ways, such as rotating or stretching them [28].

Figure 5 - Sack chair from Squeeze concept.

Even though the users were intrigued by the playful aspect of the sack chair, they often had trouble figuring out who controlled what when moving around in the chair. The playful interaction and lack of controls were intended to be a teasing element, but ended up becoming a frustrating element for the users [28].
Common for both Squeeze and iFloor is the focus on co-experiences through playful interaction that brings users together and encourage them to communicate and negotiate.

2.4.3 Collective Controllers

In the third and final project, Petersen et al. [30] explored a CI concept that focuses on the connection between the users. In addition to verbal communication, the users were physically connected as they could feel the actions of their co-user. The concept consisted of two controllers with built-in weights that shifted according to the actions of the co-user (Figure 6). Both users could therefore feel their co-user's interaction, which was assumed to strengthen the sense of connection between the two. The goal was to navigate across a digital map in order to select and see slideshows placed at various locations. In addition, the users interacted with these slideshows through the controllers [30].

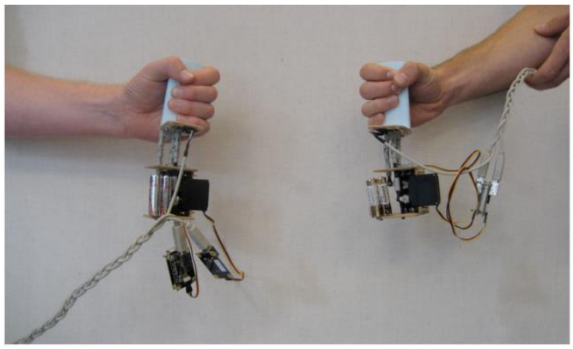

Figure 6 - Collective controllers.

The setup was tested in three different settings: 1) the users could not see each other and were not allowed to communicate, 2) the users could not see each other but they were allowed to communicate, and finally 3) the users could see each other and were allowed to communicate. The participants generally reacted positively to the fact that they could feel each other's presence. Despite the positive reactions, some of the users did mention that they might have reacted differently if they had not known their counterpart.

As with the iFloor, communication played an important role in how the users interacted with the system. Petersen et al. explained that when the users were not allowed to communicate they had trouble reaching the goal, despite being able to feel each other via the controllers [30].

The projects above show three different designs using the CI model as the core element. All three projects succeed in creating human-to-human interaction by providing a shared goal and an element of negotiation. In iFloor this was done by making the users move around a single cursor, in Squeeze by making the controller (the sack chair) too large for one person to operate, and in the last project, by making interconnected controllers.
The CI model is interesting to us seeing as the core element is to create a system that encourage human-to-human interaction. CI extends SDG with a shared goal and the element of negotiation, which encourage collaboration between the users. The goal of the CI model is to achieve an engagement level of collective action, which should be the goal of any collaborative system. This is why the CI model is useful to us.

2.5 Cooperative Gestures

In an investigation parallel to Petersen et al.'s CI model, Morris et al. explored SDG in a different direction. They explored how SDG could support cooperative gestures. Their focus was to define, analyze and evaluate cooperative gesturing as an interaction technique. In their article, they define cooperative gestures as: "*... interactions where the system interprets the gestures of more than one user as contributing to a single, combined command.*" [26].
According to Morris et al., cooperative gestures can be used to enhance users' sense of teamwork, increase awareness of important system events, facilitate reachability and access control on large, shared displays, or add a unique touch to an entertainment-oriented activity. They explain that educational systems can benefit from using systems like this because of the teamwork element. Children will learn to communicate, negotiate and coordinate actions, and it is required that all students participate in order to complete the task. Unlike the CI model, where the users' interdependence is fairly strict, Morris et al.'s cooperative gesture system is more loose since it consists of a combination of both single-user and cooperative gestural interactions. This means the users can collaboratively work on a shared goal, but do it in parallel with each other. The users can combine their interaction in order to create a single input that opens up for new functionalities which is not available for a single user [26].

To explore cooperative gestures, Morris et al. created a system called CollabDraw, an interactive tabletop with 11 different actions, where co-located people collaborate on creating diagrams, pictures, collages, and simple animations. Most of the actions required at least two people to work together in order to e.g. enlarge or combine photos. Actions could also be combined to amplify the effect, as when erasing a stroke. Each person is able to erase a stroke, but if all of the participants erased at the same time, a "clear screen" action would be activated.

From their findings in regards to CollabDraw Morris et al. created a taxonomy that consists of six axes for designing cooperative gestures [26]:

- *Symmetry*:
  - The users perform either identical (symmetric) or distinct (asymmetric) actions.
- *Parallelism*:
  - Describes the pattern of timing between the users' actions.
  - If the gestures from the users are performed simultaneously, then the action is defined as "parallel".
  - If each gesture is performed directly after another, then it is "serial". Unless everyone finished their action, the sequence will not accomplish anything.
- *Proxemics distance*:
  - The physical distance between users during the interaction.
- *Additivity*:
  - When more than one user performs a symmetric and parallel gesture, its meaning is being amplified.
- *Identity-Awareness*:
  - Focus that comes from designated roles.
  - Certain actions can be performed by specific group members.
- *Numbers of Users and Numbers of devices*:
  - Two or more users whose coordinated actions are interpreted by the system as a single input.

All of these axes consist of different ways of adding cooperation into interactive systems to enhance the quality of communicating and collaborating to complete certain tasks. Where Petersen et al. [29] focus on the overall interaction model, Morris et al. focus on the concrete interaction taking place between the users. Cooperative gestures can therefore complement the CI model by providing concrete interactions to the overall social interaction.

2.6 Social Relationship

Another aspect that affects collaboration is the social relationship between the collaborators. Boyd et al. [3] has explored how collaborative gaming can be used to support social relationships for children with autism spectrum disorder. They examined a game for the iPad called *Zody's world: The Clock Catastrophe*[2], which offers various ways of collaborating through five game modes with different controls. Boyd et al. combine the taxonomy from cooperative gestures with the work of Giusti et al. [14] who developed a set of collaborative patterns. This combination resulted in a framework on social relationships which consisted of three categories: *membership*, *partnership* and *friendship*. Each level has an increased level of intimacy between the players than the previous. Through their study, they found that these three categories could be defined as:

[2] Link to iTunes store: https://itunes.apple.com/us/app/zodys-world-clock-catastrophe/id821791253?mt=8 (Last visited March 2nd 2016)

- *Membership*
  - Being part of a group and participating such as being physically present and performing a small action that contributes to the group's activity.
  - Includes physical proximity between players and initiates participation through an interaction with the game.
  - Players interacts with the same device, but with different buttons.
  - Having dedicated roles for each of the participants.
- *Partnership*
  - Having two people, with specific responsibilities, achieve a mutual endeavor.
  - Collaboration through turn taking and/or coordinating simultaneous gestures.
  - Having symmetrical actions sets up situations where players need each other's help in order to complete mutual tasks through different roles.
  - Having the feeling of being needed and depending on the other.
- *Friendship*
  - Having mutual interest and an affinity for each other.
  - Sharing joy and demonstrating empathy.
  - Having rewards for winning a game which can be powerful motivation for continued participation.

These levels of intimacy are interesting in relation to how they can complement the CI model and cooperative gestures. Even though a user is engaging in a collaborative activity, there can still exist different levels of intimacy which might affect the collaboration. It could be useful to consider the level of intimacy when evaluating a collaborative game.

2.7 Coliberation

The final aspect we have chosen to include is coliberation. Interacting within a group requires a balance between the *ME* and *WE*. De Koven presents coliberation as the optimal state of collaboration (Figure 7):

"*When the WE and ME are in balance, there is mutual empowerment, what we might as well call the state of 'coliberation."* [6]

Coliberation is what happens when a group functions especially well. There is no dominant individual dictating the group's decisions while on the other hand, no individual is forgotten by the group. In many ways, it is similar to how Ludvigsen describes collective action. Instead of a brainstorm, De Koven compares coliberation to "*the good business meeting*" where every participant becomes deeply involved and the group becomes more unified. Just like collective action, when people are in a state of coliberation, they approach an interaction that goes beyond the meeting.

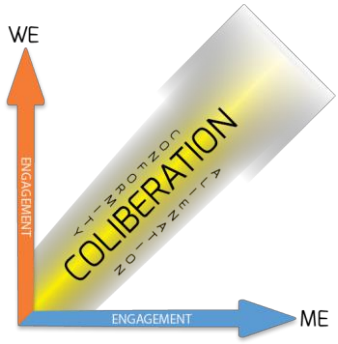

Figure 7 - Coliberation.

In relation to collaborative systems with a shared goal, it is important that every user feels like he is contributing actively to the task at hand. If there is no sense of the *ME*, it will be hard to achieve coliberation and the engagement will surely decrease. On the other hand, if there is no sense of the *WE*, it is not possible to collaborate and therefore impossible to achieve a shared goal.

2.8 Summary of Theory

All of these theories are useful in combination when designing co-experiences that encourage human-to-human interaction instead of human-to-computer interaction.

SDG is interesting because it provides a foundation for how to design for co-located people who operate a system with a shared output. However, SDG only provides a platform that supports collaboration, but falls short on the considerations that encourage the participations to engage in the collaboration.
Ludvigsen considers the use of context and what impact the system can have on the social interaction and engagement. He provides a conceptual framework that allows the designer to predict the effect an artefact has on the social engagement. This framework is also useful to evaluate prototypes in relation to the achieved level of engagement.
The CI model explores how SDG and Ludvigsen's framework can be applied in the design of co-experiences through a playful interaction. The research conducted provides knowledge on how negotiation can be used to find a shared goal and potentially achieve collective action. However, the CI model lacks concrete information on the actual interactions that can be utilized to achieve collaboration. This is where Morris et al.'s taxonomies are relevant. They provide a series of concrete interactions that can be utilized when building a collaborative system.
Boyd et al.'s three categories of social relationship are useful in the analysis. They can be used to validate whether or not the design choices are successful in achieving the desired level of intimacy. By considering the social relationship in our analysis, we can therefore define elements that increase, or decrease, the level of intimacy within a group.
Coliberation can be used to evaluate the balance between the individual group members and the group as a whole. It is important that everyone is interested in the shared goal and understands their own value in the team. It is relevant in both the design phases as well as the analysis.

3 Related Work

This section will present collaborative game theory and examples of collaborative games. We will further discuss how collaborative games can complement the previously mentioned theories to create a basis for our design.

3.1 Game Rules

Rules can either be established beforehand or during playtime. It often depends on what kind of game you are playing and these rules might change as you play. When playing a game, you agree to follow the rules and remain within the boundaries of play. This boundary is what Huizainga describes as the *magic circle* [16]. The magic circle isolates the game from the more serious tasks of daily living. This separation consists of a physical precinct – *a chessboard*, *ring*, *area*, *field*, *stage* etc. Besides the physical boundaries, temporal boundaries also exist through *a clear beginning and end*, which will mark the game off as a temporal interruption of ordinary life. The player is now located inside of the new world which are ruled by artificial rules or conventions that hold only within this enclosure [16].

Based on Huizainga's work, Hector Rodriguez suggests that serious games can address fundamental aspects of social philosophy and social science. This can be done by having a game where the boundaries of the magic circle are not yet clearly defined and its rules not yet finalized. The game therefore now consists of a process where the players have to negotiate how these rules and boundaries should be. The communication among the players will become the core subject of the game. In relation to children's play, Rodriguez also argues that the magic circle might be very loosely defined as there might not be a prescribed goal at the end [34].

Salen and Zimmerman argues that it often varies how new players learn game rules. This can especially be seen with board games and video games. Board games usually include a game manual you have to read beforehand in order to understand how the game is meant to be played. It is essential for the game experience that at least one of the players fully understand the rules before the game starts. Otherwise the game might suffer from regular breaks during playtime which in turn can ruin the flow of the experience [43].

In contrast, it is not necessary to know all the game rules from the beginning in a digital game as they can manipulate information. Every aspect of a computer's program - the internal logic, mechanisms for handling player interactivity, memory management – can be regarded as information. The information manipulation can be used to offer some, but not all, parts of the game rules in the beginning of the game. As the game progresses, the player will be offered additional parts. By doing this, the player will not have to understand all the game rules at the beginning of the game, but instead learn them as he plays. Often this is done through an interactive tutorial level where the player learns by doing. The result is that the game will not have to be paused in order to learn the rules. Instead the player can slowly learn the different controls while the immersion will remain uninterrupted [43].

The rules of a game can therefore encourage negotiation by being unstructured and loosely defined. Furthermore, exploration of the game can also encourage communication as the players must agree on what parts to investigate. These aspects are therefore useful to consider when designing the collaborative elements in the CI model.

3.2 Meaningful Play

Salen and Zimmerman explain that a successful game design is achieved through the creation of meaningful play. To create meaning we have to know which aspects of the game is able to do so. The game itself is not

the main factor in creating meaning. The pieces you move around, the layout of the board and the rules of the game do *not* create meaning. What creates meaning is the interaction between the players and the system of the game and the context in which the game is being played. When you play a game, you make choices, and these are what helps to create meaning [43]. Salen and Zimmerman describe two ways of characterizing meaningful play: descriptive and evaluative. Descriptive is characterized as:

"Meaningful play *in a game emerges from the relationship between player action and system outcome; it is the process by which a player takes action within the designed system of a game and the system responds to the action. The* meaning *of an action in a game resides in the relationship between action and outcome."* [43]

By following this definition, the system must respond with a clear outcome when the player performs an action, for example when pressing a button on a controller. The player should never doubt what the action causes. This is how all games generate meaning through play. The player is able to make a choice or action which has a pre-assigned outcome. With Nintendo's game console Nintendo Entertainment System (NES) and the game Super Mario Bros[3] we have a very clear indication of what the buttons do (Figure 8) [43].

Figure 8 - a) NES, b) Screenshot from Super Mario Bros.

By pressing the arrows on the left, the player will move the avatar in a certain direction and by pressing the red buttons the avatar jumps and shoots respectively. This definition of meaningful play is called *descriptive* because it can be used to describe relationships between cause and action. All games have aspects that can be characterized with respect to the descriptive definition, but according to Salen and Zimmerman this definition does not capture all the meaning. To cover all meaning in a game they therefore created a second definition of meaningful play called evaluative:

"Meaningful play *occurs when the relationships between actions and outcomes in a game are both* discernable *and* integrated *into the larger context of the game. Creating meaningful play is the goal of successful game design."* [43]

The authors especially emphasize the words discernable and integration in this definition. They define discernibility as:

"Discernable *means that the result of the game action is communicated to the player in a perceivable way."* [43]

[3] Wikipedia page for Super Mario Bros: https://en.wikipedia.org/wiki/Super_Mario_Bros. (Last visited June 2nd 2016)

To make the player's action discernable, there must be some form of visual or auditory feedback which tells the player that his action has been registered in the system. If you are playing a shooting game and shoots at an enemy, but he does not react at all, you cannot be sure whether you actually hit him. The player needs a confirmation that the bullet hit. If you on the other hand see the enemy move or hear him scream after he got hit, the system have effectively communicated to the player that his action has had an influential outcome in the game. The communication between the player and the system is what creates meaning. As long as the player does not know the meaning of his action, the result of the action cannot be said to be discernable. They argue that without discernibility the player might as well be randomly pressing buttons [43].
Integration refers to the larger context of the game. The player must understand that the consequences of the choices made, can affect the further gameplay. For example, repeatedly shooting the enemy will kill him. In their own words:

> "*Whereas discernability of game events tells players* what *happened (*I hit the monster*), integration lets players know* how *it will affect the rest of the game (*If I keep on hitting the monster I will kill it. If I kill enough monsters, I'll gain a level*.)."* [43]

It is important to have a meaningful interaction in order to keep a player engaged throughout the entire game. Without discernability and integration, the player cannot see meaning in his actions.
We find it interesting to investigate how discernability and integration affect the participants' engagement and understanding of the collaborative interaction.

3.3 Motivation

When creating games, there are many ways of motivating the players to continue playing. Csikszentmihalyi's flow theory [4] and Resnick and Silverman's notion of low floor, wide walls and high ceiling [32] describes how a game can keep the players motivated in every state of the game.

3.3.1 Flow Theory

Csikszentmihalyi describes *flow* as a mental condition where you are completely absorbed in your current activity. It is much similar to how collective action, coliberation and the magic circle are described. When entering a state of flow, the participants achieve a high sense of immersion and often lose track of time. To achieve flow, the goals have to be clear and there has to be immediate feedback. Discernability and integration are therefore closely related to the creation of flow. The flow is induced by a relationship between goals, feedback and a good balance between the perceived challenges and one's perceived skills. The participant must have confidence in his abilities to complete the task at hand [11].
Jesse Schell describes how the flow theory can be used in game design [37]. He argues that the flow theory can have a positive impact on the game experience. For games, there are five important factors: Challenges vs. Skills, Anxiety vs. Boredom and the one that is balancing them all: Difficulty [36].

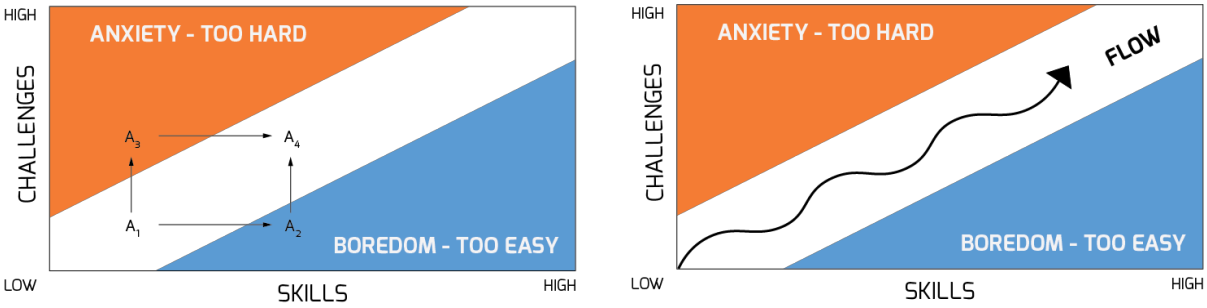

Figure 9 - The Flow Channels [37].

In Figure 9, the player is represented by "A". The flow is found in the path going from A_1 to A_4. Here there is a fine balance between skills and challenges. As novice players have a low level of skill, there should also be low level of challenges in the beginning of a game. To create the optimal flow channel, the challenges must increase as the player progresses in the game and increases his skill level. If the challenges rise too quickly, there is a risk of the player moving into the anxiety state. On the other hand, if the challenges rise too slowly, the player will get bored and find the game uninteresting. Schell argues that the flow is not going to be a linear progress, but should instead be curvier with increasing and decreasing challenges:

"This will probably feel much more interesting to a player. It is a repeating cycle of increasing challenge, followed by a reward, often of more power, which gives an easier period of less challenge. Soon enough, the challenge ramps up again. " [37]

There are eight different mental states that support the flow theory (Figure 10): apathy, worry, anxiety, arousal, flow, control, relaxation and boredom. Instead of simply distinguishing between anxiety and boredom, these states describe the player's mental condition in further detail.

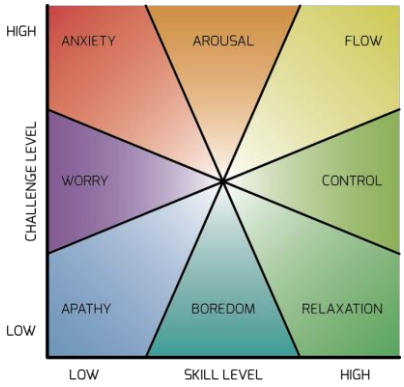

Figure 10 - Mental states of flow theory.

We find the flow theory interesting because it provides a tool that can be used in both design and evaluation of the field studies. The flow theory is useful when considering when and how the participants should be presented to challenges. Using the flow theory, we can further design optimal conditions for achieving and maintaining a magic circle.

3.3.2 Low Floor, High Ceiling and Wide Walls

Based on flow theory, the motivation depends on a balance between skills and challenges. A game can create a good basis for flow by following Resnick and Silverman's notion of low floor, high ceiling and wide walls [32]. Low floor means that a game is easy for novices to get started with. High ceiling refers to the game design that offers experts to work on increasingly sophisticated projects. Finally, wide walls refer to a diversity in play styles, allowing for different experiences.
If a game manages to contain all three elements, it is more likely for the players to obtain flow. Having low floor ensures that the challenges match the skill level of a novice player. The high ceiling ensures that the experienced player still has challenges in the later stages of the game. The wide walls can uphold a high motivation through the exploration of the game. As Banks and Potts argue, exploration is a great way of intriguing the player [1]. The wide walls provide more aspects of the game to be explored and is therefore necessary in prolonged use of a game.

These characteristics are useful to us as they assist in articulating specific design goals and creating optimal conditions for flow.

3.4 Collaborative Games

Plenty of games support multiple players, but not all of them qualify as collaborative. Zagal et al. [46] distinguish between competitive, cooperative, and collaborative games. Competitive games are games like chess where two players play against each other. Cooperative games are like Settlers of Catan[4] where players have the option to work together by trading resources. Even though the players can cooperate, there is still only one winner in the end. Finally, collaborative games are defined by having a positive interdependence, meaning that the players are bound together by a shared goal. The players are not required to collaborate, but can gain an advantage by doing so. Because of the positive interdependence, collaborative games can therefore only end in two different ways: either everyone wins or no one wins. Dillenbourg also emphasizes the existence of a common goal and negotiable actions when encouraging collaboration [8]. If the actions within the game are not negotiable, the interaction between the players becomes a hierarchical situation where orders are given and followed. To allow for negotiation, there must therefore be space for negotiation, meaning that the interaction actually can be negotiated [7].

Studying several groups playing a collaborative Lord of the Rings[5] board game, Zagal et al. [46] presents four lessons to consider when designing collaborative games:

1. To highlight problems of competitiveness, a collaborative game should introduce a tension between perceived individual utility and team utility.
2. To further highlight problems of competitiveness, individual players should be allowed to make decisions and take actions without the consent of the team.
3. Players must be able to trace payoffs back to their decisions.
4. To encourage team members to make selfless decisions, a collaborative game should bestow different abilities or responsibilities upon the players.

[4] Wikipedia page for Settlers of Catan: https://en.wikipedia.org/wiki/Catan (Last visited on May 2nd 2016)
[5] Wikipedia page for Lord of the Rings board game: https://en.wikipedia.org/wiki/Lord_of_the_Rings_(board_game) (Last visited May 2nd 2016).

They highlight that the collaboration should be optional and all players must have unique abilities that make them needed in different situations. When the collaboration is voluntary, the result is often a more enjoyable and engaging game experience. For example, they observed how a player sacrificed his own (in-game) life to allow the rest of the team to win the game. The process of such decisions are highly negotiable which creates more collaboration according to Dillenbourg's before mentioned notion of negotiability [8]. Johnson and Johnson [19] also highlight positive interdependence and individual accountability as two of five essential core components[6] in collaborative situations.
It is important that every group member feels like he has something to offer the group. When the players are able to trace the payoff back to their decision, it becomes clear whether or not they made the right decision. If a player can see how their selfish decision negatively affects the team, they might be more prone to make a different choice next time – thereby, learning to collaborate through actions and consequences [46].

Zagal et al. also presented three pitfalls when designing collaborative games [46]:

1. To avoid the game degenerating into one player making the decisions for the team, collaborative games have to provide a sufficient rationale for collaboration.
2. For a game to be engaging, players need to care about the outcome and that outcome should have a satisfying result.
3. For a collaborative game to be enjoyable multiple times, the experience needs to be different each time and the presented challenge needs to evolve.

In order to maintain a high collaboration in a game, it is important that none of the players feel left out. A collaborative game must not allow anyone player to be able to complete the entire game alone. A technique to avoid this is to follow the fourth lesson by bestowing each player with unique abilities that must all be utilized to win the game.

The theories within collaborative games are similar to many of the aspects from the CI model. Collaborative games also have a strong emphasis on shared goals and negotiation as a means to encourage collaboration. However, the two theories have different approaches of achieving the desired level of collaboration. Collaborative games focus on individuality and creating collaboration through competiveness and reflection on poor choices. It is very much about making the right choice in relation to the greater good of the team. This approach is best suited for games that focus on showing the players the potential benefits of teamwork, and not necessarily, a system implementing the CI model along with the other theories presented earlier.
Despite the different approaches, collaborative games can complement our chosen theories in many ways. Especially the third lesson is useful as it addresses how important it is that every player is able to understand how his decisions have had an impact. Both Jonhson and Johnson's notion of individual accountability [19] and Salen and Zimmerman's discernability and integration [43] become relevant here. Discernability have many similarities to feedback in HCI by how it communicates the user's action in a perceivable way. High discernability and integration are required if the participants must be able to see and understand their influence on the collaborative interaction. When they are able to actually make a difference, they can begin to feel responsible for their actions, creating a feeling of individual accountability. When all players have a

[6] The remaining three components are: (1) face-to-face promotive interaction, (2) social skills and (3) group processing.

feeling of individual accountability and are bound together by positive interdependence, they can begin to see value in their team members.

The game theories provide valuable aspects to consider when creating the optimal conditions for a well-functioning group dynamic. As the CI model focuses on the interaction between the group members, these aspects and considerations are relevant to include in the design process.

3.5 Games

This subsection will describe three games with collaborative elements.

3.5.1 Keep Talking and Nobody Explodes

Keep Talking and Nobody Explodes[7] is a computer game that relies on collaboration in order to disarm a bomb. The premise is that one player can see the bomb, through a Virtual Reality headset, and another has the bomb manual (Figure 11), which contains instructions on how to disarm it.

Figure 11 - Keep Talking and Nobody Explodes. One player sees the bomb through VR and the other holds the manual.

The two players must work together and rely on communication to disarm the bomb successfully before it explodes. As the bomb has a timer, the game uses elements of stress to engage players to make quick decisions through negotiation. Utilizing the fourth lesson from Zagal et al. [46], the two players are bound to collaborate as they have a difference in knowledge. This provides each player with different responsibilities and thereby creates positive interdependence as both are needed to disarm the bomb. The communication is established on the basis of a high sense of individual accountability and a shared goal.

The game serves as an example of how to obtain a level of engagement classified as dialogue without requiring the players to be co-located.

3.5.2 Spaceteam

Another example of a game that relies on collaboration is the mobile application Spaceteam[8]. The game requires collaboration in order to control a spaceship and ensure safe navigation through space. Every player has their own device which presents them with a unique dashboard. The dashboard contains different functions and a job that needs to be done (Figure 12). An example of a job could be to turn on *turbospeed*. The trick is that your dashboard cannot solve every task and therefore might not be able to manipulate the

[7] Link to the game: http://www.keeptalkinggame.com (Last visited February 16th 2016).
[8] Link to the game: http://www.sleepingbeastgames.com/spaceteam/ (Last visited February 16th 2016).

setting of *turbospeed*. This creates a positive interdependence between the players and presents a need for communication, placing them in at least dialogue in Ludvigsen's levels of engagement.

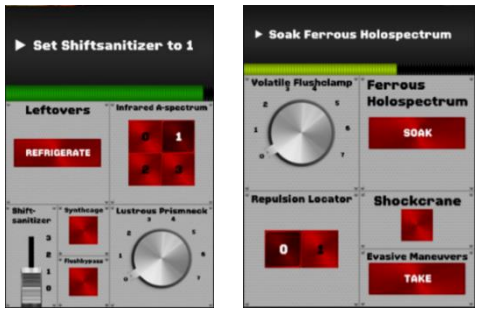

Figure 12 - Two different Spaceteam dashboards. Each with an individual objective.

Like the previous game, Spaceteam provides the players with different abilities in order to encourage communication. This creates individual accountability as the players are all needed and responsible for the completion of specific tasks.

3.5.3 Rakete

Rakete[9] is a mobile game in which you can play with up to five players simultaneously. Each player connects to a shared screen and uses a mobile device to control a spaceship. The objective is to collect boxes in space and finally land your spaceship safely on a platform (Figure 13). Each player controls a thruster that pushes the spaceship in different ways. There is a positive interdependence as the players rely on each other to navigate the spaceship safely through the level. The communication required to coordinate the thrusters creates a human-to-human interaction that allows the players to engage in collaboration much similar to collective action.

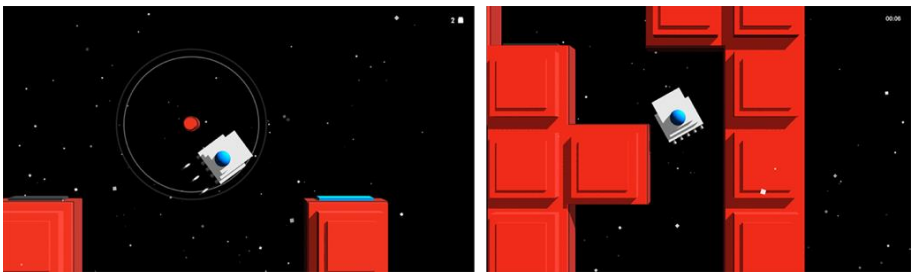

Figure 13 - Rakete Gameplay.

In contrast to the previous two games, Rakete utilizes one shared output as in SDG. Even though each player has an individual input channel, all inputs are accounted for. It can therefore be discussed whether or not Rakete fulfill all the characteristics within the CI model.

All these games show how collaboration is incorporated in games today and will be used as inspiration to implement collaborative elements in our prototypes.

[9] Link to the game: https://projects.mariov.ch/rakete/ (Last visited Marts 23rd 2016).

4 Design Process

The purpose of this section is to describe the entire design process while arguing for the choices made and analyze the findings for each field study. The section will cover methodology, design iterations, evaluation and analysis of results.

4.1 Method

Throughout the duration of our thesis we had an iterative approach to the process. The process was divided into six phases; *Plan*, *Prepare*, *Design*, *Collect*, *Analyze* and *Share* (Figure 14). The overall plan for this thesis was to answer our research question and share our results.

For each iteration we would prepare an evaluation, design a prototype, collect data using the prototype and finally analyze the data before the next iteration. The process will be described in further detail below.

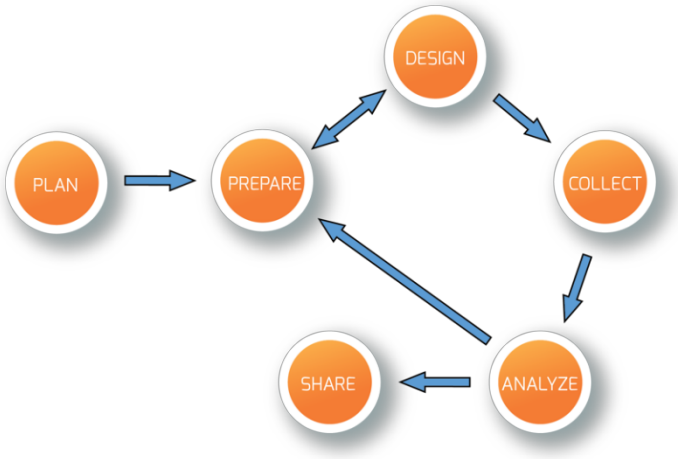

Figure 14 - Our process.

Before we began to prepare our evaluations, we started by conducting ethnographic studies. The aim was to gather knowledge about children's play culture by directly observing situations where children played and interacted socially. Observations are especially good for providing information about the interaction between people [42]. This kind of information can be difficult to expose through questions in an interview [35, p. 248].

After we passively had observed the children, we talked with the teachers and pedagogues, to discuss our findings and check if they recognized the same patterns or had other pieces of information to add. The studies allowed us to gain insight into the children's natural setting and obtain a detailed and nuanced understanding of the children's behavior.

Based on the patterns identified in the empirical data, we triangulated theories [35, p. 225] to create a plan for what we wanted to explore. By triangulating the theories, the shortcomings of each theory were complemented by another. Therefore, by combining several theories, we could create a set of comprehensive tools that could guide iterative process. For this process, we followed the *DECIDE* framework [35, p. 456]. The framework provided a checklist to help plan and guide our evaluation. Our process had an explorative approach to understand how the children's social interaction is affected by our prototype design.

4.1.1 Prepare

In the prepare phase of each iteration, we determined a goal for the evaluation. The goal was articulated by shortcomings found by observation or theory. The aim of the goal was to seek answers for a central area of concern. Furthermore, the goal helped to determine the scope of the evaluation and to guide our design in a certain direction. Additionally, the goal was broken down into several sub-questions, which helped to investigate specific areas of the observation. The specific goals of each evaluation will be elaborated in the respective section.

4.1.2 Design

The aim of the design phase was to create a prototype which could help us answer the goal and the questions of interest, set in the prepare phase. The prototype was designed by applying the collected data together with the theories, to build further upon our new understanding of the children's experience.

4.1.3 Collect

We used field studies as the method of evaluation. Field studies are useful when investigating how a product or prototype is used within the intended social and physical context of use [26, p.490]. By observing the children use the prototypes in their natural setting, we were able to analyze the children's activities as they unfold and describe the ways the artifacts were used and appropriated.
In each field study, we placed a computer on a table which featured the game and had the controllers connected. The only instructions we gave were how many players were needed and how much time they were given to play. Besides this, we passively observed the children collaborate and tried not to intervene during the sessions. The goal was to be unobtrusive and not affect what the children did during the evaluation.
The field studies helped to collect information about the children's experiences when interacting with each other and the given prototype. The main focus in all of the evaluations was the usability, the user experience and how the prototypes affected the children's ability to collaborate in the right context of use. Furthermore, each evaluation had a specific focus, which will be elaborated in the respective section.

During the process, we ran into difficulties involving the data collection methods. The teachers and pedagogues were unsure about the rules in regards to taking pictures or filming the children. We therefore decided that our primary method to collect data was field notes. We were allowed to take pictures as long as the children's faces were not visible.
In our last field study, we were allowed to video and audio record the sessions on the condition that the recordings only were going to be used internally in our group. Each group of children were also interviewed after their session had ended.

4.1.4 Analyze

The final part of each iteration was to analyze the collected data. The analysis was based on the results from the field studies and how they validated or invalidated our assumptions. Through our analysis of the results, we identified patterns which were further reflected upon in relation to the theories. These patterns included the children's behavior, social interaction and the user experience. The results from each analysis was used to articulate new questions that created foundation for the next iteration.
Figure 15 shows a timeline of the entire project.

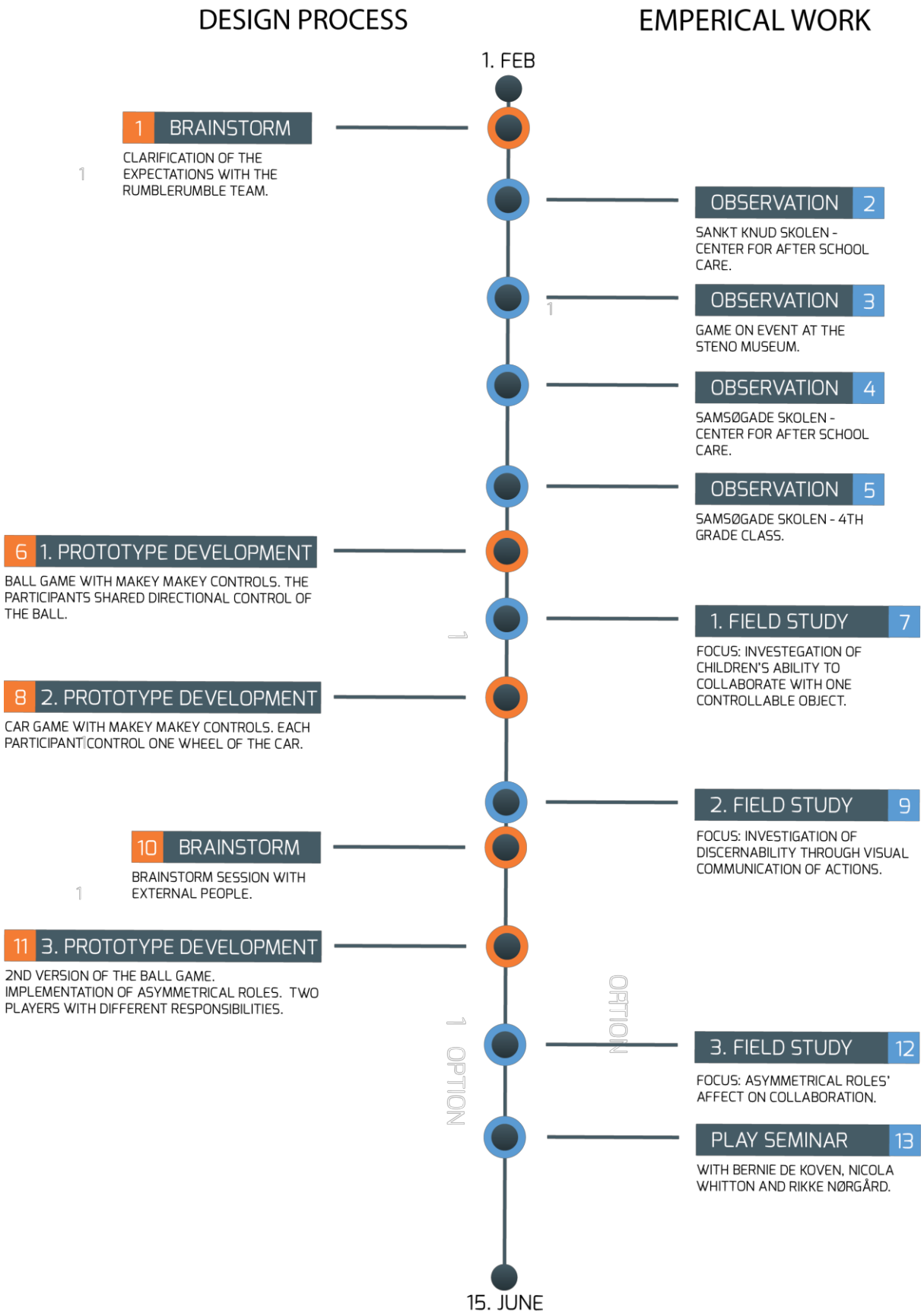

Figure 15 - An illustrated timeline of our project.

4.2 Early Empirical Work

This section will cover the initial empirical data collection that created basis for our field studies.
After an initial meeting with Huusmann Media where the purpose was to discuss the vision for the project and possible directions, we conducted ethnographical studies at two centers for after school care and in a lesson of a 4th grade. The context of interest was "places where children play together with digital content". At the centers for after school care, we wanted to learn more about how children play and interact with each other. The 4th grade helped to gain further knowledge on how children communicate and collaborate in a more serious context. The age of the children ranged from five to twelve years.
The following section is divided in two: findings from the observations and an analysis in relation to the theories, such as Ludvigsen's levels of engagement and De Koven's coliberation.
It should be noted that all quotes from the children are translated from Danish.

4.2.1 Sankt Knuds Center for After School Care

Many of the children who were present on the day of the initial studies, had their own smartphones or tablets and many of them used it to play games. The pedagogues told us that it is rare to see children isolate themselves with their device and that they will often spectate others if they do not have their own device to play on. Additionally, many also sat next to each other with their own device, playing the same game. This way they were able to help each other and discuss how the game could be completed. The most frequent social situations were therefore shared focus and dialogue while distributed attention was rarely found. If they saw an opportunity, the spectating children were quick to contribute with their opinion on how the task at hand could be solved or approached. This showed that the children had a strong desire to participate actively in co-experiences.
Besides their own smart devices, the center also had a PlayStation 4 that the children could use. Depending on the game, this platform allowed the participating children to engage in dialogue or collective action. Furthermore, it created shared focus for all the spectating children. As all the children wanted to play, there was a need for a queue system. This showed that the children would rather play themselves in contrast to watching others play. Without the supervision of an adult, the children could become frustrated with each other if they felt it was time for a change in the playing role(s).

The most important findings were:

- Many children own smart devices such as smart phones and tablets.
- They are very social when playing digital games. There are often several children gathered around a single tablet – despite the game being designed for distributed attention.
- The spectating children will often engage in a dialogue with the playing child.
- Even though it is fun to watch, it is more fun to be the player.
- It is crucial that the games have low floor. The children are quick to abandon games that are difficult to understand.
- The children love to tell stories of their accomplishments in the games.

4.2.2 Samsøgadeskole's Center for After School Care

The day we visited Samsøgadeskole was unfortunately during the winter break, which meant there was fewer children than normal. There was no digital setup for games that day so these observations are purely from physical play.

One interesting observation was a boy who was constructing a marble run track (Figure 16).

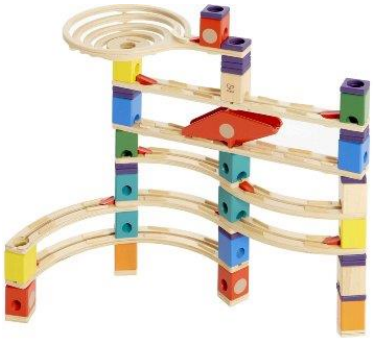

Figure 16 - Quadrilla: Xcellerator (Marble Run Game).

He was constantly reconstructing the track and rarely letting the marble run through. The marble was only sent through to test whether or not his construction was robust. A girl accidently overturned his creation causing a small argument between the two. She was laughing at the incident while the boy was telling her to stop as he did not find it funny at all. They quickly became friends again when she offered to help him rebuild the track. The destruction therefore created a social situation that allowed the children to engage in collective action. Their social relationship instantly became friendship as the girl showed the boy empathy and helped him rebuild the track.

A pedagogue told that they had a queue system on their digital devices. Each child was allowed 20 minutes of playtime before they had to give their spot to someone else.
The children preferred to play with someone their own age, but at times like the winter break (when the number of children in the center is reduced) they had no problem playing despite a difference in age.

The most important observations we made there was:

- It is often more fun to build something than to actually play with it.
- Almost all the children's activities happen in groups.

4.2.3 Fourth Grade Lesson

Even though a learning situation is not the context of interest, the observation proved to be beneficial for our general understanding of children's social behavior.
The lesson was divided into three parts: the children shared their experiences from the holiday, they all engaged in a physically active game and finally solved mathematical problems.
It was difficult to keep the children quiet, but the teacher managed to maintain enough order to allow the children to tell about their winter break. The children could not talk for long before being interrupted by another. Either they asked questions related to the story or made funny remarks to make the rest of the

class laugh. This showed that the children had a strong sense of *ME* as many of them loved to be seen and heard.

After everyone was done telling about their vacation, a pedagogue took control and prepared a game. It was only about half of the children who knew (or remembered) the rules. Those who knew the rules explained them to those who did not. There was no order in who told what to whom, which resulted in five different children explaining the rules to their nearest neighbors, creating small clusters of shared focus. The same situation occurred when new rules were presented at a later stage of the game. The children were interested in engaging everyone in the game. It was important that the rules had been presented and negotiated to the fullest in order to create a joyful co-experience where everyone could participate. The children quickly developed a strong sense of *WE* as they made this effort to include everyone.
During the game, some of the children tried to break or bend the rules in their favor. The cheating children were quickly discovered by their nearest neighbors who stopped the game to notify everyone of the cheater. The result was a pause in the game where everyone could participate in an open dialogue about whether or not it was a legal move in relation to the game rules. The children also displayed a strong desire to be part of the activity at hand. This could be seen at the end of the game when some of the children expressed "*I haven't had my turn yet.*".

In the last part of the lesson, the children were instructed to solve mathematical fractions. It was surprising how quickly the children calmed down and began to focus on the mathematics. Again, the children were not shy to help each other and explain how to solve the problems.

The key observations were:

- They are eager to ask questions.
- They love to tell stories and will interrupt others if they see a chance.
- They like to explain and teach each other.
- They are quick to correct each other – not always in a kind way.
- They love to tease each other.
- They will invent new words to make up for a poor vocabulary.

4.2.4 Summary of Observations

Our early observation taught us much about how children behave and interact with each other. We confirmed that the reaction to children's increasing use of technology is limitation, which was executed in three different ways:

- Restricting digital games to certain periods of the day.
    - At Samsøgaden the children in 3rd and 4th grade were allowed to use digital devices every day after three o'clock.
- Only allowing digital games on specific days.
    - At Sankt Knud's the children were only allowed to use digital devices on Thursdays.
- The queue system, allowing each child a predefined amount of playtime.

The most popular digital platforms were tablets/smartphones and gaming consoles such as the PlayStation. Many of the children strived to achieve digital co-experiences, but the level of engagement often only reached dialogue. The games played on tablets and smartphones did generally not support more than one player at a time, leaving the children to play the same game on their own devices or spectate each other.
Even when engaged in distributed attention, the children would often seek recognition from a pedagogue by telling of their accomplishments in the game.
The PlayStation was the only platform that came close to support collective action as the games played were designed for more than one player. This was therefore the only platform that was never used in situations classified as distributed attention.

The observations also showed that children are constantly negotiating. This is very interesting as it is a core element in both the CI model and collaborative games. As negotiating comes natural to the children, they could therefore be susceptible to engage in collaborative situations of collective action.
The children showed great interest in participating in co-experiences. They often grouped together around a single tablet and it was only a few children, which were observed playing alone. We therefore confirmed Jessen's statement that children use technologies as a tool to engage in social activities [18].
Whether it was mathematical problems or game rules, the children in general enjoyed to teach and support each other. Due to the children's significant interest in engaging in co-experiences in single player games, we see a need for collaborative games that can actively engage the spectating children. Therefore, we see value in exploring the possibilities of using the CI model to develop a game that engage children in collaborative interactions.

4.3 Field Studies

In the following section, the field studies will be described. Each description will follow a three-step structure of (1) presenting the goal and questions of each iteration, (2) how the prototypes were designed to answer the questions and finally (3) an analysis of the results based on the theories. Each field study builds upon the results from the previous.

4.3.1 First Field Study – The Ball Game

As the findings from the ethnographic studies showed, one of the most popular activities among the children was to play games on their smart devices. Often they either played together in groups or spectated each other and commentated on how they played the game. Even when they played different games, they still had an ongoing dialogue where they discussed the games and tried to help each other. As we were interested to design a collective interaction system, we saw a great opportunity to create a collaborative game which supports the children's current play culture. The intention with the game was to create a co-experience among the children that focuses on their collaboration and how they coordinated their actions.

The goal of this evaluation was to gather knowledge of the children's abilities and engagement in collaborative situations – would the children find it intuitive or confusing? Fun or tedious? Easy or difficult to learn?
The questions that guided the first evaluation were as follows:

- Will the game succeed in allowing the children to engage in collective action?
- Are children able to manage the required communication and coordination necessary to complete the game?
- Will the children achieve coliberation, or do they have too much *ME*/*WE*?
- How does the number of players influence their collaboration and coliberation?

To answer these questions, we designed a prototype which followed the core elements from the theories and related work.

4.3.1.1 Initial Prototype Development

The game we chose to design consisted of a single ball which could be moved in eight different directions. The objective was to collect boxes which had been placed on various locations on a track. It was designed using the SDG and CI model by letting the children share one screen and dividing the controls of the ball between individual input channels. Each input channel controlled a single direction, and the collective input moved the ball in the resulting direction. For example, pressing forward and left simultaneously moves the ball in a diagonal direction. Pressing forward and back simultaneously cancelled each other out.
To examine the children's ability to collaborate, the track was designed with perpendicular paths, straight paths with various widths where some of them were sloped. This was done to have a continuously challenging experience to support flow. To consider Zagal et al.'s second pitfall of engaging participants [46], a risk of falling off track was introduced. The consequence was that the children would have to start over. The intention was that there would be a consequence of poor collaboration, to increase the thrill of the game. Therefore, it would be satisfying to make progress and motivating the participants to continue. The track was designed in such a way that all directions were required in order to complete the game. Furthermore, the track was designed with an increasing level of difficulty to support flow (Figure 17).

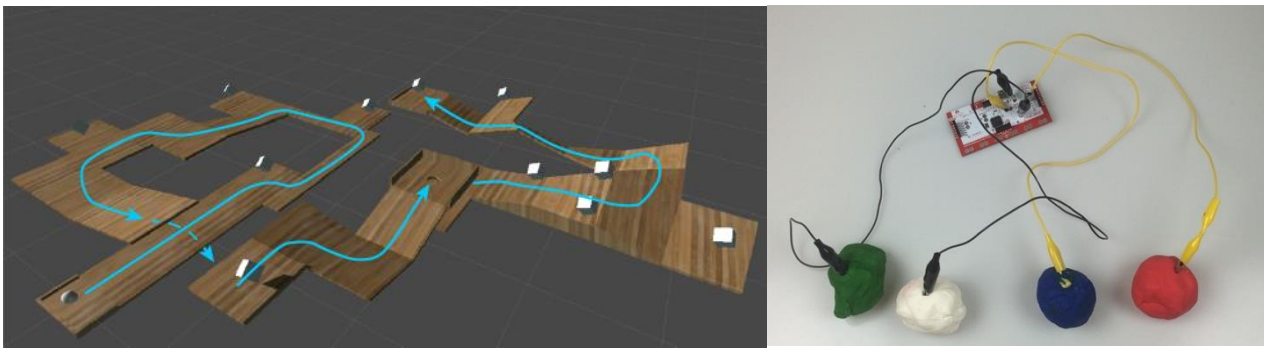

Figure 17 - Ball Game and the controllers

As the physical design of the controllers was not the focus of this evaluation, it was chosen to use Makey Makey[10] to facilitate the controllers. This technology provides an easy platform to quickly create controllers which can be divided between numerous players (Figure 18). By using the Makey Makey it is possible to emulate the keyboard with any conductive material. This made it possible to avoid having the children cram together to share a single keyboard. By having a separate controller, we aimed to increase the sense of individual accountability as it was clear that each player could provide input.

[10] Makey Makey create buttons from conductive materials. Website: http://www.makeymakey.com (Last visited April 1st 2016)

The physical part of the controller was chosen to be Play Doh as it allowed us to quickly create more controllers without any construction time. To control a direction, the children had to touch both a piece of Play Doh while keeping a connection to another piece which functioned as the common ground.
Furthermore, the children would have the option to shape and arrange their own controller, giving it a more playful touch. The final controller setup can be seen on the right side of Figure 17.

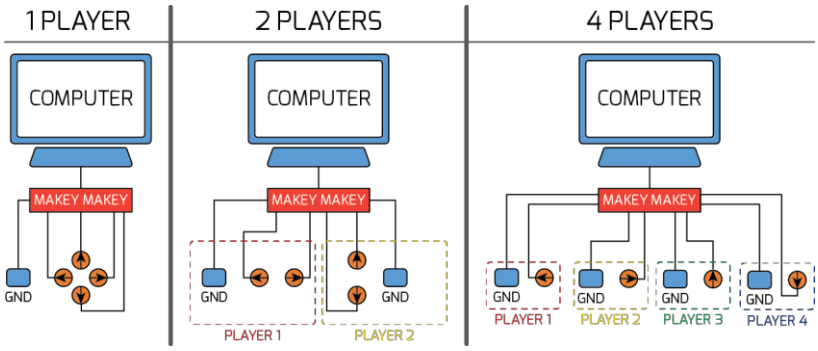

Figure 18 - Control setup for first evaluation.

The interaction of the ball was designed in an attempt to support two criteria: (1) having interactions that involved several styles of collaboration, and (2) individual responsibility. This was mostly applied when two or more players played at the same time.

The interaction schema (Table 3) was based on Morris et al.'s notion of serial and parallel actions. In this case we use serial actions as they are portrayed in Boyd et al.'s article [3]. Serial actions occur when the players take turns in order to perform an action that required different directions and different combinations. For example, when navigating through the first narrow area (Figure 17), it is required to first approach the turn by moving forward, adjust using right, then forward again to move over and finally left to exit the turn. This would require the players to negotiate on whose turn it was all the while coordinating their asymmetrical actions. The asymmetrical actions heightened the individual accountability as each player "owned" a direction and would therefore have a direct influence on the movement of the ball. The parallel action was present when multiple players simultaneously performed an action. By doing so, they were able to move the ball in a diagonal direction. This was required in the last part of the track where all sides were sloped which means the ball would never be able to stand still.
The interaction itself encourages negotiation as the timing and coordination between the players are essential in order to complete the game.

	Serial	Parallel	Asymmetric
Interaction for evaluation 1.	When taking turn to move the ball.	When moving diagonal.	All actions are different.

Table 3 - Cooperative actions for the first prototype.

The game was created using the Unity3D game engine. It was developed from the freely available tutorial project called "Roll-a-Ball"[11], and scripted using C#[12].

[11] https://unity3d.com/learn/tutorials/projects/roll-ball-tutorial (Last visited February 24th 2016)
[12] https://en.wikipedia.org/wiki/C_Sharp_(programming_language) (Last visited Marts 20th 2016)

4.3.1.2 Method

Participants. The game was tested with approximately a group of 15 children. The group consisted of both boys and girls between the ages of nine to twelve (Figure 19).

Environment. The evaluation was performed in an open room at Samsøgadeskolens center for after school care. The room was usually used as a place where the children could play games, read a book or just relax and talk to each other. This had both advantages and disadvantages. One of the advantages was that there was plenty of children to choose from since more or less every child wanted to participate.
The number of interested children was also the biggest disadvantage. Every now and then, the playing children's magic circle was disturbed as the spectators were loudly commenting.

Procedure. For the evaluation, it was planned to have the children divided into two groups of four, a group of boys and a group of girls. This was to investigate if there was any difference between how boys and girls collaborate and communicate when trying to reach a common goal.
Each of the groups played the game a couple of times, first individually, then in pairs of two, and finally, in pairs of four. After the initial test runs, the children could play the game with the amount of players they preferred.
The children not playing would be asked about their gaming habits and which devices they were playing on. This was done both to confirm the findings from the early empirical work and to see if any of these games were collaborative and something to be looked at.

Figure 19 - a) The group of girls, b) The group of boys.

Throughout the session, two of us would sit with each of the groups. This person would facilitate the evaluation. Other than vaguely explaining the game and making sure that the children remembered to play two and four, the facilitator was not meant to interfere with the children unless it was truly necessary. The third member of our group observed the children and documented any interesting observations.

4.3.1.3 Findings and Analysis

The evaluation was initiated with a queue system that allowed each child to play the game. After the children each got a feeling for the game, they were asked to play in groups of two. At the beginning, the girls had difficulties understanding the controls, which lead them to denying responsibility for their own mistakes or blaming the other player when they lost, but all in a good mood: "*I did not do anything, it was you.*". Even though they had a hard time completing the game and fell off the track several times, they were

still amused and had fun playing. Often when they 'died', they began to laugh instead of getting mad. Quotes like "*It is awesome to be a part of a team.*" further supports that they enjoyed to collaborate. Every time they managed to collect a box they expressed shared joy. Having boxes placed on the track therefore helped to increase the level of intimacy from partners to friends. As Boyd et al. explains, "*… rewards for winning a game can be a powerful incentive for continued participation.*" [3]. This means that the boxes created a satisfying feeling when collected and therefore functioned as a motivational element in the game. In contrast, the boys were quicker to understand the controls and how they should collaborate.

There were clear elements of dialogue and collective action as those who understood the controls guided the others who found it confusing. The spectating boys had a shared focus on the game and often pointed out mistakes that the playing children made. The frequent comments often resulted in the playing children getting frustrated. Overall, the boys were a lot more competitive, and often said things like "*I am better than you.*" and "*I am so good.*". This was also shown in how boisterous they were.

This difference between the groups is interesting in relation to how boys and girls act in collaborative tasks. It seemed that the girls were more prone to focus on the *WE* by supporting each other, while the boys had a hard time letting go of the *ME* as many of them felt a need to prove they were better than the others. This became very clear when the boys played as four. Especially one of the boys felt he was being too constrained by only controlling one direction and the game demanded too much collaboration. He was reluctant to negotiate the controls of the ball and felt a need to constantly tell the others what to do (which always favored what he wanted). This observation matches the suggestion from [30] "… *there are people who due to their personal values and preferences will rarely find it appropriate to negotiate the interaction in the way promoted by the CI model*". Having a big *ME* will affect the collaboration negatively, as the person(s) are not interested in working together as one unit. The bigger *ME* also affects their social relationship; it prevented many of the boys from entering friendship with mutual joy and affinity for each other and maintained a relation of partnership. If the boys would have been able to give each other recognition, instead of claiming all the glory themselves, it might have affected their collaboration in a positive way.

While playing the game there was a clear difference between how the two groups interacted with both each other and the game. The boys heavily debated who would be allowed to go first and whose turn it was next whereas the girls were calmer. The boys were therefore very active in the negotiation from the start. But their negotiation was not directed towards the game itself, but rather the fairness of playtime division. It was very important that everyone was treated the same and got an equal amount of playtime. They ended up agreeing on how many times each of them could 'die' before they had to change players. This further supports the fact that they had a strong sense of the *ME* and focused less on the *WE*. In contrast, the girls were much better at taking turns without much debate. Some of the girls had to leave for a PTA[13] meeting so the rest decided to give these girls the first few rounds of play. In general, the girls were better at giving each other room to try the game.
Common for both groups were their lack of collaborative communication in the early stages of the game. Apart from a few shout outs, they were all relatively quiet while learning the controls as the discernability did not provide the level of low floor as planned. There was not sufficient mental or intellectual capacity to both learn the controls and communicate with each other at the same time. However, once they got familiar

[13] Parent-Teacher Association.

with the controls and the integration of both their own and the team members' actions, their communication increased. This clearly affected their collaboration in a positive way as they managed to get further in the game.

Another thing that varied between the two groups was the play style and the way they interpreted the rules of the game. In the beginning, both groups followed the intended rules: get to the end of the track and collect the boxes on the way. After a while, both groups found a way to "cheat" and bypassed parts of the track. An interesting difference was that the girls quickly decided that they were not allowed to cheat, while the boys would spend several minutes trying to master the cheating. This behavior is in compliance with Sicart's notion of players constantly challenging the rules of the game [39]. In the end, the boys also returned to following the rules as they agreed there was a certain prestige in completing the game without cheating. They would get an even higher degree of prestige if they could collect all the boxes as well.
The girls were not as focused on the competitiveness, but would rather just play to have fun. This was evident when one of the girls chose to ignore the boxes and instead only focused on reaching the end of the track. She was playing with Mathias [author] as it was near closing time for the center and most of the children had left to go home. One of the boys pointed out that bending the rules was not allowed, but she simply told him that it was more fun this way. Both Sicart and the flow theory are relevant here, as the girl had trouble staying motivated due to a mismatch of difficulty and her skill level. In order to avoid entering a state of anxiety, she therefore challenged the rules to match the difficulty to her current skill level [4, 39].
Earlier, the same girl also chose to divide the controls in a different way. The most common setup in both groups were having one player steer back and forth and the other steer left and right. Instead this girl chose to control forward and left, and her partner would control backwards and right. When she had gotten used to this way of controlling the ball, she proclaimed that it was easier with this setup. We believe that this was related to the fact that the speed and direction of the ball were vector operated. The ball would continue to move in one direction until an opposite vector was detected. The ball was therefore difficult to stop and by controlling forward and backward movements, you must constantly counteract your own actions. With her setup, she only had to concentrate on moving the ball in a direction. It was then her partner's job to counteract her movement. She therefore increased her integration by lowering the amount of aspects that required attention.

Despite the various ways the children chose to arrange the controls we saw that some of them still had difficulties understanding the actions of the ball. The fact that the ball did not come to a complete stop when they released the button confused them. We also noticed that while playing in groups of four they either lost track of the direction they controlled or did not understand their own impact on the ball. Drawing on the experience from Wendel et al. [44], it is important for a player to be able to distinguish himself from the other team members. This therefore revealed a need for a better discernability to increase clarification of your own actions.
In general, all of the children had trouble coordinating their actions between four players. They did not communicate with each other, resulting in them dying a lot. They were not aware of who controlled which direction, and therefore many of them often just pressed randomly on their own controller. This is a clear indication of lack of discernability as stated by Salen and Zimmerman: "*Without discernability, the player might as well be randomly pressing buttons or throwing down cards*" [43].

The girls were more patient than the boys and managed to play with four players for longer. This was primarily because one of the boys ruined it for the others by deliberately steering the ball over the edge of the track. However, all of the children preferred to play in pairs instead of groups of four, as it was easier to coordinate their actions. We believe that this was linked to the difference in discernability when playing two and four. Based on the failed four-player coordination, we are therefore convinced that the controls lacked discernability. The awareness of who controlled what was not clear enough, which resulted in a lower perceived individual accountability. Without discernability and individual accountability, many of the children completely lost motivation and entered a mental state of apathy. On top of that, the boys were victims to teasing. It will be troublesome to achieve a high level of collaboration if all the team members do not have the same goal. Especially if one of them has the goal of teasing the others by ruining the collaboration.

Both groups initially had trouble with the game, complaining about the difficulty. Despite this, they kept playing and only seemed to be more motivated to finish the game, saying things like: "*This should not be so hard.*", and "*I know I can do this.*". This indicated that having a game that looked easy, but still is hard to complete, is keeping them engaged. They were eager to complete the game, and show that they were better than the others. Their motivation was therefore based in competitiveness and the need to be the best.
The overall difficulty still seemed too high. Only two boys out of the roughly fifteen participants managed to complete the game. The girl who changed the control setup also managed to get to the end of the track, but without collecting all the boxes. This was enough to conclude that the game was too difficult as an overwhelming majority did not even get close to completing the game. It was therefore interesting that none of the children quit the game due to frustration with the difficulty. There must have been a difference in the actual difficulty and the perceived difficulty. The shared joy of collecting a box must have been providing enough motivation to continue despite the difficulty.

To summarize, the main findings revealed a need for further investigation in the following areas:

- A need for better indication of who is responsible for what actions.
- Discernability to further support the players' understanding of their impact.
- Linear difficulty curve to support a low floor and continuous flow.

4.3.2 Second Field Study – The Car game

The results from the first evaluation revealed the children both possessed the willingness to communicate with each other and the ability to coordinate their actions in an effort to reach a shared goal. As these are the core fundamentals in the CI model, the evaluation provided promising results for further exploration.
The first evaluation revealed several shortcomings in relation to discernability and integration. The goal of the second evaluation was therefore to explore further how discernability and integration can be better supported. As the children had trouble understanding their own responsibilities and influence, the evaluation specifically focused on creating a more visual representation of the individual roles. The questions which guided the second test were as follows:

- Will a better indication of the division of responsibilities create better discernability and integration for each participant?
- Does a visual representation of actions create better collective understanding of the partners' actions?
- How does a level progression system reduce the risk of participants entering the anxiety state?

4.3.2.1 Second Prototype Development

It was decided to keep the core gameplay, with a track and collectable boxes as the children showed great interest in these aspects of the game. The ball was replaced with a car to allow each participant to take control of a single wheel. Being in control of individual objects creates good conditions for a clear understanding of who is in control of what. By having each participant control a single wheel, the need for collaboration remained as a single wheel cannot make the car move. The interaction was therefore logically coupled as the actions from each wheel were taken into account and collectively moved the car. Due to the needed negotiation and coordination, the interaction of moving the car can therefore be classified as collective action.

The interaction was programmed in such a way that each wheel was able to accelerate forwards and backwards independent from the others. This meant that each participant had less influence as an individual, but created a higher need for close coordination between all four participants to move the car properly. This was an attempt to support coliberation and implement better discernability as each participant has a more visual responsibility in the team (supporting the *ME*) while being dependent on his teammates (supporting the *WE*). By giving each participant a clear responsibility, we aim to increase the feeling of contribution.

A light was implemented in each wheel to support the discernability visually. The lights would emit a color when a button was pressed. To increase the discernability even further, each of the lights were color-coded to match the color of the new controllers. The intention was that the participants could link their interaction with the controller to the corresponding wheel (Figure 21a). Being able to distinguish the wheels from each other should also help with the problem of forgetting which direction they controlled.

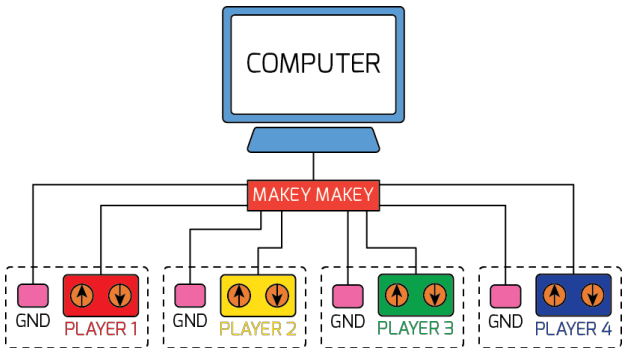

Figure 20 - Control setup for second evaluation.

Like the previous prototype, a Makey Makey was used to emulate the keyboard (Figure 20). However, the first prototype test showed that Play Doh was not the most suitable material to use as controllers. Due to its softness and the children's engagement, the Play Doh often got smooshed, which caused the wires from the Makey Makey to lose connection. Another thing was the need to hold a finger on a common ground

connection, which confused some of the children. Without a connection to the common ground, they were not able to use the controller. To overcome these problems, new solid controllers were created together with an armband, which functions as the connection to the common ground (Figure 21b).

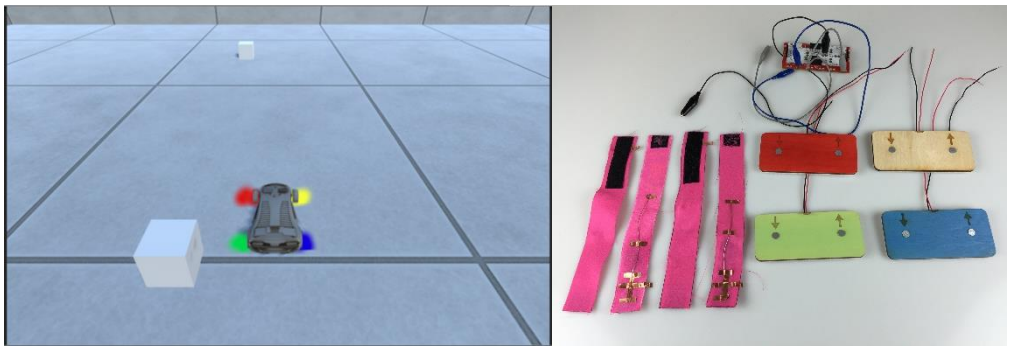

Figure 21 - a) Car Game gameplay, b) Controllers.

The design scheme for this prototype focused more on the timing and coordination between the players (Table 4). The controls were centered on symmetric parallel actions.
In order to move the car either forwards or backwards, the participants must perform a parallel action and accelerate the wheels in the same direction. To turn the car left, the participants must either simultaneously accelerate the wheels on the left side backwards or the wheels on the right side forward. Doing the opposite caused the car to turn right. The car could turn sharper through an additive action. This would be done by accelerating the wheels on the left side backwards, while simultaneously accelerating the wheels on the right side in the opposite direction or vice versa.
Symmetrical actions present the participants with identical interactions. By creating equal starting points for all participants, we aimed at encouraging the children's fondness of explaining things. When one child understood the interaction, he could explain it to the others. Therefore, the symmetrical actions were implemented to allow them to learn the controls collaboratively.

	Serial	Parallel	Asymmetric	Symmetric	Additive
Interaction for evaluation 1.	When taking turn to move the ball.	When moving diagonal	All performed actions are different.		
Interaction for evaluation 2.		When driving forwards, backwards or turning.		Moving the car forwards and backwards.	Two players can turn the car, all four make it turn faster.

Table 4 - Cooperative actions for first and second evaluation.

4.3.2.1.1 Level Design

To compensate for the high difficulty in the first game, it was decided to focus further on implementing low floor. This is also in compliance with Salen and Zimmerman's notion of using a tutorial level as a tool of teaching the game rules [43]. This was accomplished by creating three different levels, which progressively increased in difficulty (Figure 22). As it was assumed that the participants' abilities to control the car in the beginning were low, the first level was made to ensure they could drive freely around and learn the controls

without any risk of failure. The level was designed as a flat surface with surrounding walls. The second level consisted of a predefined track with surrounding walls. It was designed in an attempt to keep every participant activated throughout the game. In the first level, they could decide to only drive left, but this level forced them to use both directions. The last level was once again a predefined track but without walls, which introduced the risk of falling off the edge. The assumption was that the participants would now be familiar with the controls and could be challenged with a greater risk. The risk was further enforced by creating parts of the track that required the players to collect a box at the end of a path. The path was just wide enough for the car to fit but not wide enough to be able to turn around. The participants were therefore forced to coordinate closely in order to collect these boxes.

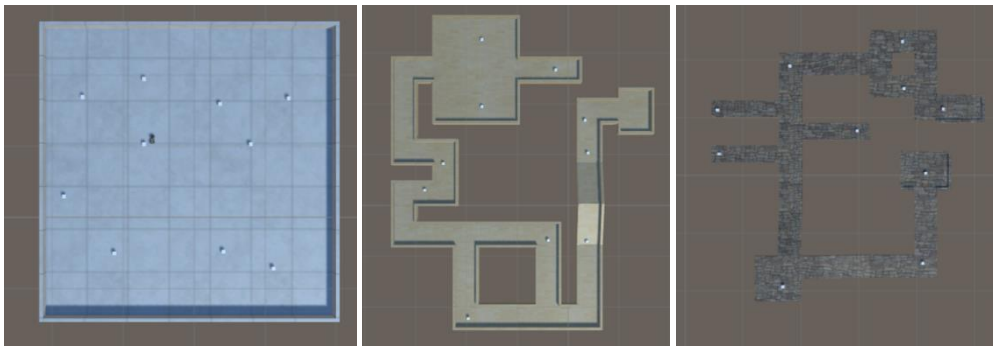

Figure 22 - The Three Levels in the Car Game: a) First level, b) Second level, c) Third level.

The progression in difficulty should also assist in keeping the participants in a state of flow. By the end of each level, the participants should have increased their skills enough to be presented with more difficult challenges.

4.3.2.2 Method

Participants. For this evaluation, we were interested in finding both new participants and some who participated in the first evaluation. We found three boys who had participated in the first evaluation. One of them was the boy who completed the game. The new players were six girls from second grade and one boy from third grade. In total, ten children played the game.

Environment. The second evaluation was conducted at the center of after school care at the Samsøgade-skole. In an effort to avoid distractions and keep the magic circle intact the location was changed to be in a closed off room where only the needed number of participants were present.

Procedure. One of the main objectives was to investigate the collaboration of four participants. Therefore, the six girls were instructed to divide into groups of four. Two of the authors [Asger and Mathias] joined the second group to make up for the two missing children. We are aware that this could affect the validity of the data. The authors therefore played as passive as possible in order to give space for the girls.
Each group was given approximately thirty minutes of playtime. At first, the children were not given any instructions to the game mechanics in order to observe whether or not they would understand the controllers and find a connection between the color of the controller and the corresponding light on the wheel.

As with the first evaluation, we observed the children playing while any interesting observations were written down for further analysis.

4.3.2.3 Findings and Analysis

At the beginning with the first level, the girls had a hard time understanding the controls and spent much time driving randomly around (Figure 23). At first sight, it was not obvious to them how the car was supposed to be controlled. They noticed the wheels lit up every time the car moved, but they did not see the connection between the wheel and the controller, as it was not clearly communicated to them. They had a breakthrough when one of the girls asked the others to stop pressing the buttons and instead take turns in order to figure out which wheel they were in control of. This increased the awareness of each other's roles. Despite this, it was still difficult for them to see how they were supposed to coordinate the wheels in order to drive in the desired direction. It was therefore clear to us that the integration of the controls was a problem for them.

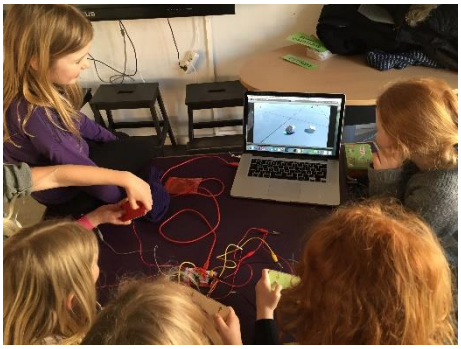

Figure 23 - The group of girls playing the car game.

As the girls made no real progress, they were given a few tips on how they should steer the car. With these tips they were better at coordinating their actions resulting in an increased control of the car. It enabled them to time their actions and make the car drive either forward or backward. Their biggest challenge was to turn it left or right. Their difficulties with this action can be related to the integration. None of them understood how their individual actions could be used in collaboration to perform "advanced" moves. Therefore, the game failed to communicate how they could fully utilize their individual skills in a collaborative manner. Even though they tried to coordinate their actions, it still seemed like they picked up the majority of the boxes through sheer luck. There was no real communication between any of them, and none of them took charge of where to go. Yet they were still amused every time they collected a box and they cheered on each other when they were close to one. The boxes therefore functioned as an element that transformed the children's social relationship into friendship.

With three boxes remaining in the first level, the second team of girls were instructed to take over with the two authors. This was done to let the two last girls get familiar with the controls before advancing to the next level. Halfway through the second level, one of the girls grabs the controller from one of the authors and tries to control two wheels at the same time. She proclaims she was doing better this way and urges her partner to do the same. The other girl then grabs the controller from the second author and the two of them continue to play the game with two controllers each. Though this improved their coordination a small amount, they still struggled with the controls. After some time, they discovered that the car could be

controlled with only two controllers (controlling two wheels either in the front or in the back of the car) and therefore disregarded half of the controllers to focus on one each. This further improved their collaboration and coordination.
When they reached the third level, two of the other girls were asked to join in again to see if they would be able to complete the level now that they knew how to control the car. Adding the two extra players turned out to reduce their collaboration and they did not get very far. The fact that the track did not have any walls to prevent them from falling off the track did not help. As they did not make any progress and their time was coming to an end, they were asked to stop and let the boys take over.

The boy who managed to complete the game from the first evaluation swiftly took a leading role proclaiming "*I know what to do. We have to collaborate!*". He repeatedly told the team what to do and how to do it. With his guidance, the boys quickly learned how to control the car. They figured out that the wheels lit up when activated, but never paid attention to the connection between the controllers and color of the lights. Unlike the girls, the boys therefore quickly began collaborating and completed the first level faster than the girls but not without difficulties. Like the girls, it seemed like they collected most of the boxes through luck.
It was clear to see that having played the game from the previous evaluation was an advantage in regards to understanding the controls of the car. The girls, who were all new players, spent a vast amount of time in silence while learning the controls. Similar to the results of the first evaluation, the girls got a significantly better control of the car once they started communicating. On the contrary, the boys quickly figured out the controls and were better at communicating with each other from the beginning. This might be because of the boy who quickly took the role as the leader. Despite their leader's former experience, the boys never learned to master the controls and neither did the girls. Having a leader did seem to affect their collaboration positively. This is in direct correspondence to Wendel et al.'s findings of how a leader increases collaboration in a group [44].

The boys had not played the second level for long before they proclaimed that it was easier than the first level. When asked why they thought so, they told us that it was because there was a predefined track they could follow, making it easier for them to coordinate what to do. In the third level, they felt more excited when introduced to the danger of falling off the tracks. This added a consequence for not collaborating other than just driving into a wall. As they progressed in the third level, one of the boys felt unneeded as he could not connect his interaction with the controller to what happened in the game. In the end, he just gave up and let go of the controller in frustration. The others continued to play and moments later discovered that they could control the car with only two controllers. This resulted in a second boy abandoning his controller, leaving only two active players. The two remaining boys nearly managed to complete the last track, but their parents arrived to pick them up before they succeeded.
The two boys abandoning their controllers clearly showed a lack of integration. Whereas the girls only had trouble understanding how to combine their efforts to turn the car, the two boys had lost their sense of individual accountability. They saw no value in their interactions and therefore decided that the game was not fun. Our observations therefore suggest a connection between loss of perceived individual accountability and loss of motivation. When a child has no sense of discernability and integration, he will slowly move into a mental state of apathy before he finally quits the game.

In relation to the visual communication of actions, the color-coded wheels appeared to have the intended effect as each participant knew which wheel they controlled. Despite never connecting the colors of the controllers to the wheels, both groups made use of the visual feedback they provided. In both groups, the color feedback sparked the communication which lead to better collaboration.
In general, it can be said that the discernability succeeded for the most part, but the integration mainly failed. Even though the children were aware of something happening, they never fully understood how it could be utilized for collaboration. The lack of integration caused two children to abandon their controllers. This reaction is similar to the previous evaluation where four players should collaborate, but many just pressed randomly on their controller. The prototype therefore failed in making each participant equally important. However, it succeeded in uncovering the need for being able to understand how your interaction is valuable to the team. It is therefore important that a system allows the individual players to understand their own impact, and how it is useful in collaboration.

In the first evaluation, the controls appeared to be too difficult on the account of the vector-based mechanics. In the second evaluation, the logic behind the controls appeared to be causing problems. Performing the parallel action of accelerating the wheels on one side forwards while simultaneously reversing the wheels on the other side in order to turn the car, confused the children. The advanced game mechanics did therefore not provide optimal conditions for low floor. The level design furthermore affected this in a negative manner. The lack of direction in the first level was not well suited as a tutorial. The open area required noticeably more coordination compared to the other two levels, causing the players to be in an anxiety state and become frustrated with the game. Using the open area as a tutorial level required the children focus on three aspects: (1) understanding the controls, (2) agreeing on a box to collect and (3) coordinating their actions. The second level therefore proved to provide a better basis for learning how to control the car as there was a predefined path, narrowing down the aspects that require coordination and collaboration.

The key findings from the second prototype test was:

- The implemented discernability was successful in relation to the overall awareness of who controlled what.
- The integration was unsuccessful as a majority did not understand how they should combine their actions.
- Complexity in game mechanics should be kept to a minimum in order for the players to focus on coordination and collaboration.
- A predefined path is preferred in a tutorial level when attempting to create optimal conditions for low floor and continuous flow.
- If the discernability is low, the communication will decrease as the participants focus on understanding the influence of their interaction.

4.3.3 Third Field Study – The Ball Version 2

Based on the findings from the second evaluation, we identify a need for greater awareness of who controls what. We found inspiration in Reynolds definition of role-clarity: *"Members of a group hold role expectations, which are understandings of their roles as well as the roles held by others in the group"* [33]. The awareness of who controls what will therefore be referred to as role-clarity. Increased role-clarity let the players

understand their own strengths and weaknesses and how the other team members' skills can complement their own. Designing for role-clarity can therefore create better conditions for discernability and integration as the players obtain a deeper understanding of their own influence.
This iteration therefore focuses on how role-clarity can be implemented in an attempt to create better discernability and integration. The guiding questions were:

- In what ways can role-clarity create better conditions for discernability and integration?
- How does role-clarity affect the awareness of responsibility between the participants?
- How does role-clarity affect the collaboration in general?

4.3.3.1 Third Prototype Development

We began the third evaluation by identifying how existing collaborative games utilize role-clarity. In Spaceteam, every player is aware of their own responsibility by the information provided through their individual dashboards. The game has good discernability as it is easy to see what the results of your actions are. The integration is also clearly communicated as you are aware of your responsibility on the team, and your actions can be used to solve the tasks. However, the participants have less knowledge of the others' responsibility, which creates a need for communication to solve the tasks. Each role is identical in relation to responsibility: equipped with a dashboard that allows solving of the distributed tasks.
We found it interesting to explore role-clarity with a focus on roles that differ in functionalities and responsibilities. We found inspiration in how a tank is operated. In a tank, there are four roles: a driver, a gunner, a loader and a tank commander. Every role is important to operate the tank successfully, and although they do not directly interact with each other, they do rely on a positive interdependence. The various roles in the tank provide a strong basis for how we could design for a better role-clarity. However, there is one role which stands out: the commander. The commander functions as a facilitator of communication between the others in the group. Creating such a facilitator role might be worth considering when designing for groups. Especially the second evaluation showed the potential for a facilitator role, as it increased collaboration when one of the boys guided the others on how to control the car. However, the need for a facilitator role never arose in the third iteration as it was decided to design for two players only. The reason for this was that both the first and second evaluation indicated that the children preferred playing in pairs of two. We also figured it would be better to start by designing for two players and later expand if the third evaluation proved successful. The challenge was then to make both roles equally important and engaging, so each player feel like they can contribute and thereby negotiate to avoid a hierarchical situation [8].

We saw an opportunity to support different functionalities through more advanced physical controllers. It opens up for more interesting interactions in contrast to the previous evaluations, which were simple buttons. Finally, the controllers could be wireless, which makes it difficult for dominating players to take control as the other player can simply move away with his controller. This helps to avoid Zagal et al.'s pitfall [46] of one player taking charge and making all the decisions for the team.

Through a brainstorm, the possibilities of different roles and interactions were explored. A simple concept was created, called "Two Space Brothers Who Are Also Miners", which revolved around two brothers who mine for minerals in outer space (Figure 24). The concept focused on two players where one player controls

the spacecraft while the other controls the space walker (the miner). As space is dark, the spacecraft must light up the asteroids in order for the space walker to get close enough to accomplish the shared goal of mining them. The two players are joined together with a tether to avoid the space walker floating away and getting lost in space.

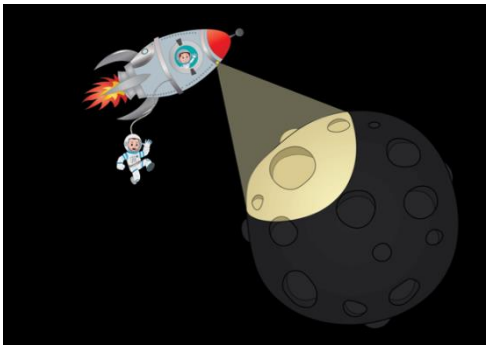

Figure 24 - Two Space Brothers Who Are Also Miners concept art.

We are aware that the input channels are individual and the collaboration therefore differs from the one found in the CI model. This kind of interaction therefore moves the collaboration out of the CI model and more closely resembles a collaborative game. The concept was never intended to be developed fully and thus only exists in order to articulate how far the division of interaction can go before exiting the collaboration found in the CI model.

Seven people were invited to participate in another brainstorm session. This was done in an attempt to avoid reworking the same ideas over and over again and get a fresh perspective on the task at hand. The goal of the brainstorm was to explore the possibilities of role-clarity in the interaction space between iFloor (from 2.4.1) and Two Space Brothers. These two concepts thus framed the design space of a small and large difference in the roles. The participants were therefore provided with a tight scope to avoid drifting in uninteresting directions.
Furthermore, we were interested in having them explore how the controllers could be designed to match the functionality of the roles.

4.3.3.1.1 Brainstorm Session

All the participants were chosen for their creative minds along with their experience in design and field of work. These people were:

- Maria Andersen – Architect, project leader and mother.
- Mathias Justensen – Creative sound designer currently working on his master's thesis.
- Sisse Degner – A former team leader at Lego and now educator in machine engineering at Navitas in Aarhus.
- Malou Stitz – Art Director at Johnsen Graphic Solutions[14].
- Sven Arnarsson – Digital Marketing Consultant.
- Mads Halse – Entrepreneur and owner of http://waveparkproject.dk/.
- Luyba Halacheva – Industrial Designer and part of Huusmann Media.

The participants were divided into two smaller groups (Figure 25). This was done to cover more ground in relation to exploration. We divided ourselves amongst the two groups in order to supervise and ensure an interesting discussion. After an hour of brainstorming, the two groups were gathered to present and discuss their results.

Figure 25 - One of the groups from the brainstorm session.

While supervising the groups, we kept our influence to a minimum to not affect their creativity. We only intervened if the discussion stalled or got off topic. By keeping our influence to a minimum, we hoped that the groups might stumble upon ideas or directions that we had missed in our own development process.
To spark the conversation, the groups were presented to both iFloor and Two Space Brothers. Two overall questions were also posed in order to keep them on track.

- How do we create equally engaging roles in a game that encourage dialogue and collaboration?
- How can the interaction of the physical controllers be mapped to the digital content in an intuitive way?

Using the results from the brainstorm and the collaborative theories, we present three types of roles (Table 5):

[14] http://johnsen.dk/ (Last visited March 16th 2016)

	Symmetrical roles	Asymmetrical roles	Separated roles
Actions	Symmetrical	Asymmetrical.	Both symmetrical and asymmetrical.
Responsibility	Everyone has the same responsibility.	Everyone has a different responsibility for the same object.	Everyone has different responsibilities for separate objects.
Input	Input channels affect the object equally.	Input channels, which are logically connected, affect the same object differently.	Different input channels affecting different objects.
Projects	iFloor, the collective controllers.	Squeeze, Keep Talking and Nobody Explodes, the tank example.	Single Display Groupware, Two Space Brothers. This is often where collaborative games with positive interdependence would be placed.

Table 5 - Categorization of roles.

Based on Boyd et al.'s [3] interpretation of Morris et al.'s [26] cooperative gestures, we define actions as the participants' influence on the controlled object. For example, the ball game from the first evaluation utilized asymmetrical actions because the participants each controlled a different direction. The effect of the actions therefore differed from each other.

Symmetrical roles utilize symmetrical actions to create equality between the participants. For example, iFloor has symmetrical roles. The participants perform symmetrical actions by either moving left or right to affect the cursor's position. The responsibility does not differ as all the users function as a gravity point for the cursor and therefore has equal opportunity in relation to how they influence the system. Finally, each player's influence decreases as the number of players increases. This can be exemplified through iFloor – when the number of participants increase, the current participants have less influence on the movements of the cursor.

Asymmetrical roles utilize asymmetrical actions to create a greater role-clarity. Each participant has different ways of interacting and influencing the system. This creates individual responsibility areas, which affect the same object in different ways. The advantage is that every user is aware of their role and how it can affect the object. In contrast to symmetrical roles, the influence of each user does not decrease as more users are added. Instead, new users are given new responsibilities that provide more opportunities for the object. For example, if only the driver and commander are present in the tank it cannot shoot. A third crew member could take the role of the gunner, enabling the tank to shoot. The disadvantage of asymmetrical roles is the limited number of available roles, resulting in a finite amount of users.

Separated roles are placed outside of the design space, but are included to cover the interaction found in collaborative games. In separated roles, the users have individual input channels just as SDG. Positive

interdependence and shared goals can still exist, but the users can act independently and are thus not required to collaborate. It should be noted that because the users can perform actions independently, a risk of distributed attention is introduced.

Beside roles, the brainstorm had a focus on physical controllers. One of the groups came up with the idea of using cubes as controllers. They have a simple shape that is recognizable by everyone. The affordance of the cube does not communicate a certain action and therefore offers many opportunities for different interactions [38]. This was beneficial as we wanted to implement several different interaction possibilities. Each side could represent a new functionality, which could be activated by shaking, turning, lifting and so on. However, the affordance does also result in a lower coherence as the interaction cannot be derived from the shape [45].

The main focus of the third evaluation was how the increased role-clarity in asymmetrical actions affect discernability, integration, perception of individual accountability and the overall collaboration. Secondly, it focused on the physical controllers and how they impact the collaboration.

4.3.3.1.2 Cube and Ball

Based on the children's limited understanding of the mechanics in the car game, it was decided to return to the game from the first evaluation. The ball game had great results in relation to level of engagement and fun.
The ball game went through another iteration with asymmetrical roles in focus. The iteration resulted in the creation of two asymmetrical roles: a ball and a modifier. One participant controls the directional movement of the ball, while the other modifies a set of abilities which affects the ball. To encourage communication further, it was decided that only one ability could be active at a time, which required a continuous change of the active ability. The idea was that each side of the modify controller represented an ability. To avoid overwhelming the participants with too many interactions, only three abilities were implemented. The three implemented abilities were: speed, jump and size. If this setup was successful, further abilities could be implemented in a future iteration. It should be noted that when the speed could not be modified it had a default setting.
By using asymmetrical roles, each player thus becomes responsible for their own area, increasing role-clarity and the individual accountability.

Instead of two identical cubes, it was decided to have distinguishable shapes as it communicates different interactions [45] (Figure 26). The intention was that just by looking at the controllers, the children would understand that the controllers differ in interaction.

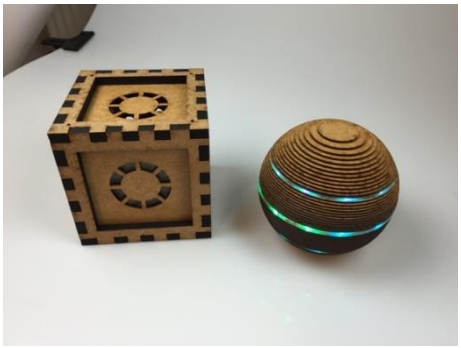

Figure 26 - Movement and Modify controller.

The modify controller was kept as a cube because of its affordance for many different interactions [38]. Along with a strong embodiment, this was thought to compensate for the weak coherence, placing the modify controller in the low end of Wyeth's control dimension [45].
The first version of the cube measured 10x10x10 centimeters and was just a plain cube (Figure 27a). This version was developed to confirm whether the various interactions discussed during the brainstorm session would make sense in practice. Keeping the size somewhat small helped to get an understanding of how a small-scale controller would affect the interaction. It was quickly discovered that most of the interactions could be performed with a single hand. This was undesirable as we wanted to avoid situations where one player uses two controllers at once. If one player could take control of all interaction, it could be an excuse for a dominating player to push away his partner. It was therefore decided that the controller should be of a size that required both hands in order to operate.
The second version of the modify controller measured 12x12x12 centimeters (Figure 27b). This size proved to be more suitable for two-handed operations.
At this point, most of the intended interactions for the modifier cube were in place, but there was no clear way of representing which ability was active. To do so, each side could have a different colored light, representing an ability and whether or not it was active.
As the different abilities were incorporated, the size of the cube once again proved to cause problems. The increased size and smooth surface of the cube made it difficult to maintain a grip. To compensate for the lack of grip it was decided to create a frame around the controller, giving the player something to grasp when using it. This completed the final iteration of the modify controller (Figure 27c).

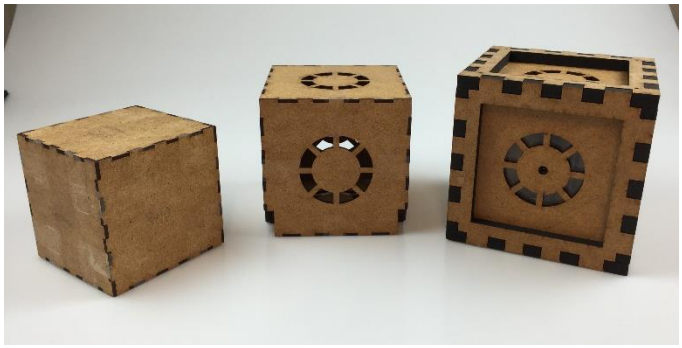

Figure 27 - a) First version, b) Second version, c) Final version of the modify controller.

The controllers used the Bluetooth based RFDuino[15] chipset to transmit data. The input data was gathered from an accelerometer and a gyrometer, which were transmitted to a host RFDuino attached to the computer running the game (Figure 28b). However, due to hardware limitations of the RFDuino, the lights could not be incorporated. To decrease the size of the chip, the developers have reduced the number of ports, which left only enough to support the gyrometer and accelerometer. Without the visual cues, the abilities were set to change automatically as the game progressed.

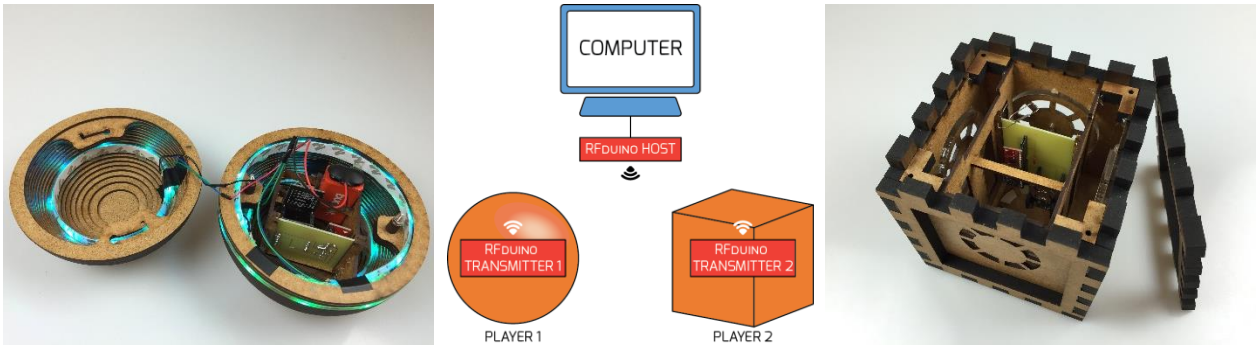

Figure 28 - a) Inside the movement controller, b) Control setup for third evaluation, c) Inside the modify controller.

The core interactions of the abilities were still functional. The participant controlling the cube could turn it either clockwise or counterclockwise to increase or decrease the effect of each ability. Turning the cube clockwise increase the jump-height, speed or size of the ball depending on which ability was active.
As a precaution, both the speed and size ability had a secondary functionality added to them. When in speed mode, rapidly turning the cube counterclockwise caused the ball to come to a complete stop until the speed was increased again. This was implemented as a safety feature to let the modifier intervene in case his partner lost control and was about to steer the ball off track. It also created another opportunity for the participants to collaborate by utilizing the feature to get by narrow passes in the game. The movement of the ball was similar to the one from the first evaluation, which meant that the children would probably have trouble to bring it to a complete stop. By utilizing full stop, it is possible to move the ball in straight lines, allowing for more precise control.
In size mode, yanking the cube upwards (like in jump mode) would nudge the ball a little so the players could get free in case their size change got the ball stuck in glitches.

The movement controller was designed as a direct mapping to the ball in the game (Figure 29). Wyeth argues that tangible user interfaces, which create an illusion that the artefact and the digital information are one and the same, create strong coherence [45]. To create the direct mapping, the ball in the game moved correspondingly to how the player interacted with the movement controller. Tilting the controller right would cause the ball to move right (Figure 30). This creates basis for a better connection between the player and the ball, resulting in better discernability. The size of the movement controller was chosen to match the size of the modify controller. This was done for the same reasons as with the modify controller, to invite for two-handed interaction and to hinder a player from using both controllers a once.

[15] A smaller Arduino: http://www.rfduino.com (Last visited May 20th 2016)

Figure 29 - Construction process for the movement controller.

As it was intended for the modify controller, a green and blue light were incorporated into the movement controller. As the light was static and should not react to the interaction, it was possible to implement it beside the RFDuino. The green light was intended to inform the player which direction was the front. The physical design of the ball further communicates how it must be oriented. By designing it so it can stand on its own invites to how the user should pick it up.

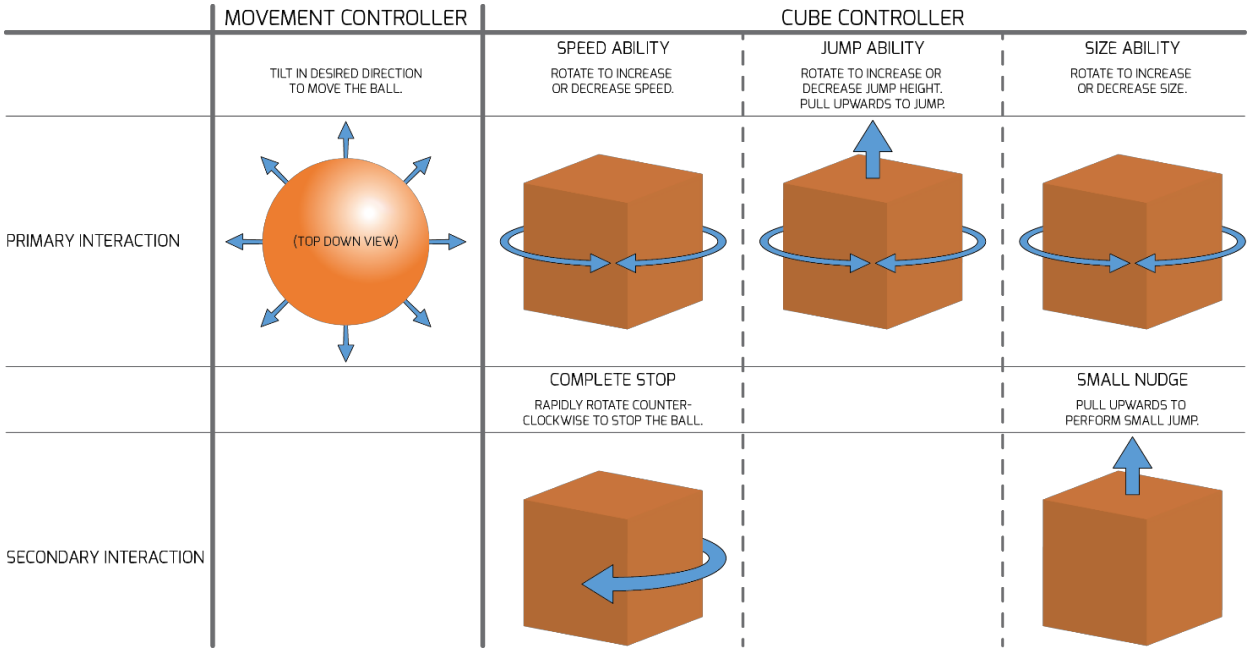

Figure 30 - Interaction scheme for the Movement and Modify controller.

The interactions included serial, parallel and asymmetrical actions (Table 6). The serial actions were implemented because they encourage negotiation. In the first evaluation, we saw that whenever the children executed serial actions they paused their interaction to plan the order of actions. Parallel actions were implemented as they require a precise timing and coordination in order to be executed. The asymmetrical actions are used to support the responsibility in the asymmetrical roles. By giving the controllers different functionalities, it was expected to increase the individual accountability.

	Serial	Parallel	Asymmetric	Symmetric	Additive
Interaction for evaluation 1.	When taking turn to move the ball.	When moving diagonally.	All performed actions are different.		
Interaction for evaluation 2.	Zigzag	When driving forwards, backwards or turning.		Moving the car forwards and backwards.	Two players can turn the car, all four make it turn faster.
Interaction for evaluation 3.	Increasing the speed after performing the stop function.	Timing when jumping or changing size.	Each controller works differently in both interaction and affect.		

Table 6 - Cooperative actions for the first, second and third evaluation.

It should be noted that despite designing for an equally divided responsibility, we were concerned that a hierarchical relationship, where orders are given and followed, can develop between the participants. This was because the movement controller essentially determines when to progress in the levels whereas the modify controller can be perceived as more supportive. They are still positively interdependent and the game cannot be completed alone by either of them.

4.3.3.1.3 Level Design

As with the second evaluation, the intention was to create low floor by easing the participants into the controls and different abilities. This was done through three tutorial levels where each ability was represented in succession to each other along with one or two minor obstacles. In an effort to overcome the mistakes from the second evaluation, the tutorial levels were created with a clear sense of direction instead of an open area (Figure 31). This way the participants could focus entirely on learning the controls and not on which direction they should take. After the tutorial levels, the participants were taken to the first of three levels.

Figure 31 - Tutorial levels. a) Speed, b) Jump, c) Size.

The three levels were designed to ensure that the players used the active ability in different manners. At the same time, it required the players to communicate and coordinate their actions in different ways in order to complete the game.

The first level focused on the speed ability (Figure 32). In an effort to tap the full potential of the ability, the level was designed to focus on two different ways of using speed. In the first half, the participants must drive

at a high speed to be able to clear the various ramps across the level. The second half required a slower and more precise driving in order to navigate the high amount of turns and narrow paths.

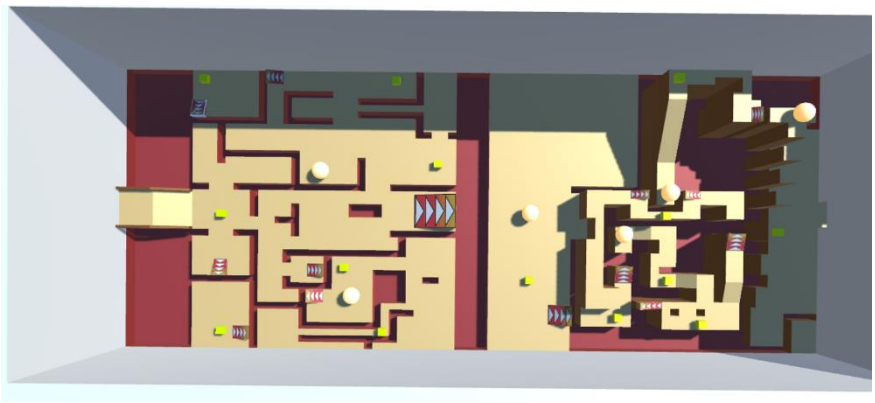

Figure 32 - Speed level for Evaluation 3.

The second level focused on the jump ability (Figure 33). This was also divided into two parts. The first half focused on the timing with which the jumps were performed, by having the players jump from pillar to pillar, increasing in height with each step. The second half required the players to perform jumps at a precise height in order to clear a maze-like obstacle course.

Figure 33 - Jump level for Evaluation 3.

The last level focused on the size ability (Figure 34). Unlike the other two levels, this was not divided into two halves. The reason for this was that it did not make much sense to have a part focusing on being small and one on being large. We would rather have the players fluctuate the size range throughout the level.

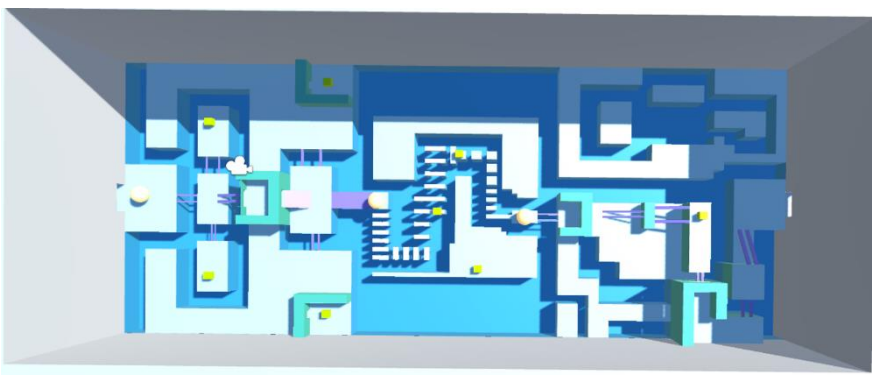

Figure 34 - Size level for Evaluation 3.

As seen in the previous evaluation, open levels are good at encouraging dialogue and negotiation. The levels were therefore designed with several routes leading to the next level. This way the participants had to agree on a route to follow, creating another aspect of negotiation.
Throughout each level, there was a number of boxes which the participants could pick up and rack up a score. This was done to motivate the participants to progress through the levels. Among these boxes, there were some large spheres which served as checkpoints. These checkpoints were located in strategic places so that players would not lose too much progress when they 'died'.
In addition to the score system, a timer was added. The previous evaluations showed that the children were focused on the playtime each player got. Therefore, the time aspect served as an easy way to communicate how much time each pair had played, and as another aspect of the score system.

In summary, the third iteration focuses on asymmetrical roles and on how it affects the collaboration. In an attempt to increase individual accountability and discernability, role-clarity was implemented. This makes it easier for the participants to experiment with the controls to understand the impact of their actions. To increase the perceived individual accountability further, two physically distinct controllers were build. The interaction supports asymmetrical, parallel and serial actions.
A video of the prototype can be seen here: https://youtu.be/DRVn5yVPeXY.

4.3.3.2 Method

Participants. In total, six children, four boys and two girls, played the game in teams of two. All the names in the following are pseudonyms in order to protect their identity. The chosen names for the children are Alex, Benjamin, Chris, Dennis, Emma and Freja.

Environment. The evaluation was conducted at Samsøgadeskolen and the context was chosen to be in a remote room closed off to outside disturbances. This was chosen to keep the magic circle intact and help the participants focus on the game without being interrupted by potential bystanders.

Procedure. The evaluation was performed in multiple sessions with a duration of half an hour. The first five minutes of each session were dedicated to learning the controls by completing the tutorial level twice. In the second playthrough of the tutorial level, the children were told to switch controllers. The reason was twofold: 1) it is easier to collaborate when you know the abilities of your partner and 2) in order to evaluate on the most attractive role it was necessary that the children had tried both of them. After completing the tutorial level, the children were free to distribute the controls as they pleased.
A short interview was prepared in addition to the game test (Appendix 1 - Interview guide for the third evaluation). These interviews were aimed at determining the children's favorite role and whether or not they enjoyed the game. Every play session was recorded on video to be analyzed later.

4.3.3.3 Evaluation of the Third Prototype Test

The findings of each session is presented in individual subsections and later analyzed as a whole.

4.3.3.3.1 First Session (Alex and Benjamin)

The pair in the first session were the same two boys who managed to complete the game from the first evaluation. One of them had also participated in the second evaluation. They were both excited to see how the game had evolved since they last played (Figure 35).

Figure 35 - Left: Alex, Right: Benjamin.

Despite never having seen the movement controller before, Benjamin quickly understood how to interact with it. Without any instructions, he picked the controller up and interacted with it just as intended. The modify controller on the other hand was not as intuitive as hoped. It required a few instructions before Alex understood how to interact with the controller. To begin with, he tilted the modify controller just like Benjamin did with the movement controller. When that did not work, he tried to flip it unto different sides to see if that did anything. When that did not work either, it led him to ask how to use it. He was told that he had to turn it either clockwise or counterclockwise in order to affect the different abilities. At one point in doing the tutorial, the need for the full stop function arose, but it was not apparent to any of the boys that such function existed. Once again, they were told how the controller functioned and how to operate it. The only interaction with the modify controller that seemed intuitive to the boys was the jump function.
After figuring out the controls, the two boys advanced in the tutorial level and quickly began to communicate. In moments of miscommunication, none of them were shy to grab the other's controller in an attempt to show his partner what he meant. Benjamin, who controlled the ball, gave orders like "*Do not give me too much speed here.*" when trying to navigate through a narrow pass. When jumping, the orders changed to "*Now, now, now …*". As the first five minutes were coming to an end, and they had not yet completed the tutorial level we told them to restart the level and swap controllers. They refused and responded with "*But we have not completed the level yet.*".

The first session did not last much longer as a pedagogue came by to get Benjamin for his drumming lessons. While one of us went to find a substitute for Benjamin, Alex stayed with the rest of us. He was not interested in waiting, so he proceeded to play the game alone, using both controllers at once. He managed to do so by holding the movement controller against his chest and using the cube controller with his free hand (Figure 36).

Figure 36 - Alex using both controllers at once.

He was able to slowly progress further through the level, which was surprising since the game was not intended to be played by one player using both controllers. After struggling for a while with the awkwardness of using both controllers, Alex asked if one of us wanted to assist him. At first, his request was met with hesitation, but he kept asking since he did not understand why we would not play with him. Finally, one of us joined him and played as passively as possible.

4.3.3.3.2 Second Session (Alex and Chris)

Not long after Alex asked for assistance we found Chris. The game was restarted to give Chris a chance to learn the game mechanics. As soon as Chris was handed the movement controller, he started swinging it around looking at the screen for feedback. Alex then interrupted him to show how the controller functioned. After introducing Chris to the controller, Alex was quick to assign himself the role of leader, telling Chris what to do and when to do it. This led Chris to become somewhat passive and only interacted when Alex tells him to do so (Figure 37).

Figure 37 - Left: Alex, Right: Chris.

After completing the tutorial once, they swapped controllers and played it again. Alex explained the controls/functions of the modify controller to Chris. When they reached the part of the tutorial which focused on the jump ability, an interesting observation was made. It was clear that Chris tried to jump higher by yanking the controller higher into the air.

At one point, the two boys became frustrated with each other because Alex thought that Chris was unskilled, and Chris thought that Alex was moving too quickly through the levels. It seemed Alex was just fooling around, while Chris became more and more frustrated as they continuously 'died' the same place. Every time they fell off the side of the path, Alex would use the full stop function to stop the ball midair and burst out "*We are not dead!*", while gesturing his hands over his head. Around this time, Dennis knocked on the door, and Alex suggested that Dennis could replace himself while he waited for Benjamin to return.

4.3.3.3.3 Third Session (Chris and Dennis)

The game was restarted to let Dennis learn how the two different controllers worked. Dennis learned the controls easily and he enjoyed the game while making his own sound effects. Once again something interesting happened when Chris and Dennis reached the part of the game where they had to use the jump ability. Even though Dennis was in charge of the movement controller, he yanked the controller upwards to get the ball to jump. Chris quickly became more communicative and told Dennis what they needed to do.

There was a shared joy when they managed to pick up points and completed difficult parts of a level. Despite this, there still was a clear difference in how Chris and Dennis wanted to play the game. Dennis was just relaxing and enjoying himself while Chris wanted to get a good score. Therefore, Chris naturally became frustrated with Dennis because of his attitude and indifference to in-game deaths. As they progressed, Chris got more irritated and for a short period stopped interacting completely – despite Dennis asking for help (Figure 38).

Figure 38 - Left: Dennis, Right: Chris.

They managed to complete the first level and proceed to the next. The second level was much easier, which resulted in Chris becoming more involved again. He proudly announced whenever he did something good: "*It was me who did that!*". An interesting observation was that Chris often moved the modify controller in the same direction as he wanted the ball to jump. Otherwise, they managed to complete the second level without any noticeable trouble.
When they reached the final level, Chris became more focused on the time and completing the game with a good score.

4.3.3.3.4 Fourth Session (Alex and Benjamin again)

After Chris and Dennis completed the game, it was time to let Alex and Benjamin try again. The game was restarted and they got to play through the tutorial level so they could get a quick recap of how the controllers functioned. Alex started with the modify controller and Benjamin with the movement controller.
They began to discuss whether they should focus on points or time. This sparked quite the negotiation but in the end, they chose to focus on completing the game as fast as possible.
As both Chris and Dennis did when they played, Benjamin tried to jump using the movement controller. In contrast to Chris and Dennis, Alex and Benjamin were noticeably better at coordinating their actions and had an overall better communication. Through their improved communication, they were able to find shortcuts by executing diagonal jumps, which resulted in a better time at game completion.

In levels where the speed could not be modified, they expressed dissatisfaction in relation to the default speed. They did not like how the previous active abilities suddenly were unavailable.
In the end, they completed the game without any major problems although they were quick to shirk responsibility when something did go wrong.
Since they chose to complete the game as fast as they could, they ended up having some time left of their session. This motivated them to try again with swapped roles, Alex with the movement controller and Benjamin with the modify controller. This time they agreed upon collecting as many points as possible and not focus on the time. As with their previous playthrough, the communication and coordination remained at a high and constant level.
When their time was up, they were about halfway through their second playthrough.

4.3.3.3.5 Fifth Session (Emma and Freja)

The fifth session involved two girls (Figure 39). It was apparent that they were not as used to games as the boys. They never fully understood the controls to the same extent as the boys. Throughout the session, they swapped controllers multiple times. This was quite interesting as they were the only group to swap controls spontaneously. This was often done in situations where they had trouble figuring out what to do next.

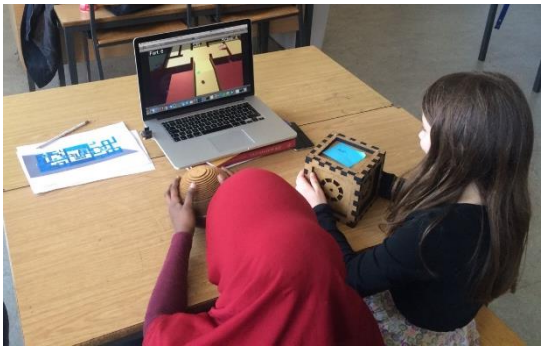

Figure 39 - Left: Emma, Right: Freja.

Both girls tried to perform a jump with the movement controller despite moments before having performed a jump with the modify controller. Likewise, they both tried to control the ball with the cube controller.
Throughout their playthrough, the communication was scarce. Most of their dialogue centered on apologizing to the other person when they did something wrong. From time to time, they would briefly discuss tactics, but these discussions often ended with one of them proclaiming "*I do not know what to do…*" and then they would swap controllers.
Just as Alex and Benjamin did, both Emma and Freja commented on the fact that the different abilities were changed during the game. This caused confusion as Freja multiple times tried to use secondary interactions in parts of the game where they were not available. Despite their troubles, they still seemed to enjoy themselves while playing.

4.3.3.3.6 Analysis of Sessions

Most importantly, we learned that the asymmetrical roles definitely created better discernability and integration. It was easier for the children to understand which controls each other had and how they could be utilized in collaboration to complete the game. With the exception of the girls, it was clear to all the children what their contribution was. This also caused much less frustration compared to the other

evaluations, as no child ever felt unneeded and quit the game. It is therefore apparent that utilizing asymmetrical roles increase both the perceived individual accountability and interdependence. This also corresponds with Johnson and Johnson's statement *"... by increasing individual accountability perceived interdependence among group members tends to increase..."* [19].

Dennis and Chris were quick to blame each other for wrongdoings or praise themselves for good actions. Their social relationship clearly had an impact on this matter. Alex and Benjamin, who were the best players and friends, rarely blamed each other for mistakes. Instead they were fully focused on the game and how they could collaborate to overcome the encountered challenges. Being able to ignore a partner's mistakes shows that you are able to demonstrate empathy, which is a core element of being in a relationship characterized as friendship. Furthermore, they frequently expressed shared joy while playing, which supports friendship further. In contrast, Chris and Dennis were mostly in partnership and occasionally moved into a light friendship. There was no empathy between the two, and they often had different ideas of what was fun. In the interview, both of them also emphasized teasing as an element of fun. However, the observations showed that Chris also focused on completing the game with a good score while Dennis did not care much about any of that. Dennis would rather just fool around and have fun. Their differences made it impossible for them to increase their intimacy level to friendship permanently. Their dissatisfaction with each other was also revealed in the interview where Chris bluntly answered "*No!*" to the whether or not it was fun to play together. Dennis followed up by saying that the only thing that was not fun, was Chris. Here it is important to note that they were never hostile towards each other and the whole thing had a friendly undertone. However, it was clear that they were not close friends. Whenever they managed to pick up a box, they forgot their differences and experienced shared joy. The continuous reward of collecting boxes therefore temporarily increased their level of intimacy from partnership to friendship.
Their differences further resulted in Chris primarily moving between apathy, worry and anxiety in the mental states of the flow model. Dennis remained in a mental state of relaxation. This was expressed in situations where they 'died', and Chris would react with frustration while Dennis with joy or indifference. This points to the fact that different mental states between players affect the collaboration in a negative direction. Furthermore, it provides information on how the flow theory can be applied in relation to the CI model. The challenges and skills must be seen as the players' collective perception. If there is a mismatch in how the players perceive their challenges and skills, it is difficult to achieve flow. On the other hand, the flow comes within reach if their perception of the challenges and skills are similar.
Another possible explanation to Chris and Dennis' different mental states could be their interdependence. The different roles and forms of interaction must give a somewhat different perception of the game. For the most part, Chris controlled the cube and Dennis the ball. The following scenario happened several times. Chris really tries to provide the optimal conditions for the ball to progress. This did not happen because Dennis just rolled the ball over the edge. This showed a clear difference in the perception of *ME* and *WE*. Chris focused on utilizing his strengths to create optimal conditions for the team to progress. Dennis had no sense of *WE* as he only focused on how he could have fun while interacting with the game. Their interdependence makes it impossible for Chris to change this as it requires a change in Dennis' behavior. The misbalance in the *ME* and *WE* therefore cause frustration for Chris because his efforts are futile.
The nature of the social relationship is one of several crucial factors in play when two players must collaborate towards a shared goal. Stewart et al. also mentions that forced collaboration results in conflict if the participants have different agendas [41].

Score and time were initially added to motivate the children by encouraging their competitiveness. It was therefore interesting to see that score and time created two different ways of playing the game.
Due to their efficiency, Alex and Benjamin had time to start a second playthrough. In the first playthrough, they wanted to find the fastest route through the levels whereas in the second they changed to a slower and more explorative approach. In an attempt to find all the boxes, they carefully explored every part of the three levels. The children therefore interacted differently and changed their strategies depending on their agreed goal. This is in direct relation to the third pitfall of Zagal et al. [46] as the players can change the game experience by agreeing on a different goal.
Allowing for more than one focus provided different ways of playing the game. Depending on the chosen focus, the game experience changed. The children could negotiate both what route to follow and the overall focus of the playthrough. The small addition of time therefore increased the ways of playing the game and thereby increased the aspect of wide walls in the game. Adding additional routes and ways of playing would further continue to increase the wide walls in the game. This is valuable in relation to long-term interest and general replay value.

In relation to controller attractiveness, the concern was that the movement controller would be preferred as it is the one actually causing the ball to physically progress. This was not the case as both controllers were preferred for different reasons. Alex and Benjamin quickly chose a controller and identified themselves with the associated role. Their favorite controller was the one that they were best at using. Alex said:

"I like the one where you control the abilities most … I think that me and Benjamin are a good team when I am using the cube and he is using the round controller." - Alex [Appendix 2 - Transcriptions].

Benjamin followed up by saying:

"I do not know, I think I am best with the movement controller, but it was also fun to try the other one." - Benjamin [Appendix 2 - Transcriptions].

Their preferences towards the controllers were based on their collaboration and who was best at controlling what. They found the controllers balanced in relation to responsibility, and none of them felt more in control than the other. Alex suggested that the controls could be divided further and one player could control one ability:

"… I think it would be great if … [one controlled– red.] *the speed, one controlled size, one controlled jump so you could be all three at the same time."* – Alex [Appendix 2 - Transcriptions]

Benjamin commented that more players would probably result in more mistakes and thereby more frustration. Furthermore, it would be boring if your ability was not needed in a level and you were forced to just sit and wait:

"I thought the same, it could be fun if you could be more [players – red.]. *But I do not think I would find it fun, if you were so many because then there would be some who always would have to sit and do nothing (…) You*

would maybe also be angrier with each other because you would easily die because you were so many [players – red.] *around one small thing* [the ball – red.]*"* – Benjamin [Appendix 2 - Transcriptions]

Dennis preferred the movement controller even though he found the modify controller easier to use. Chris found the modify controller more appealing due to the teasing element – like hindering the player with the movement controller fulfilling his job. Like Alex and Benjamin, they did not seem to think that the controllers differed in responsibility.
The girls preferred the modify controller because they felt the movement controller had too much responsibility. As they had trouble understanding the game in general, they preferred the role that felt least responsible and worked more as a supportive role. This was also the reason for their frequent controller trading. Whenever they had been stuck for a while, they passed on the responsibility to see if the other could perform better.

In terms of controller attractiveness, the expectation of a leader role was invalidated. The expectation was that as the movement controller had more responsibility, it would also be more suitable as the leader role. This was not the case as the leader role was not dependent on the controller or the role, but instead the game experience. A clearly defined leader only occurred in situations where one player had more experience than the other. When Alex and Chris played together, Alex was quick to take the leader role as he had more game experience. Similar, Chris took the leader role when Alex swapped with Dennis. As the new players learned the controls, the leader role slowly disappeared and the responsibility became more equally divided.

The movement controller was a success in both physical design and interaction. Aside from a few situations where the children tried to yank it upwards to jump the ball, the interaction was easy to understand.
The modify controller was not as successful as all children required an initial explanation of the interaction. It was not clear that the active ability could be manipulated in terms of effect. Therefore, we had to explain briefly how the controller functioned. Of all the abilities, it was only the size ability and actually jumping the ball, that had a high discernability. The jump ability was intuitive to all children as all of them immediately tried to yank the controller upwards to make the ball jump up in the air. The size had a high discernability due to the immediate visual feedback of the ball's change in size. The speed had a low discernability as it had no visual feedback other than the pace of the actual movement. This often resulted in an unbalance in the power level of the speed. The same can be said about the power level of the jump.
It was also revealed that the change in abilities caused confusion among the children. It was not clear when the different abilities were available. In a further iteration, it would therefore be necessary to implement consistency and consider discernability in how the available abilities are chosen and presented.

5 Key Findings

This section will summarize and discuss the key findings from the three evaluations. The section also describe our considerations when designing for equal responsibility among group members engaging in collective action.

5.1 The Discernability and Integration in a Collaborative Setting

Discernability and integration are two of the elements we know from Salen and Zimmerman [43] that are important when designing for meaningful interaction. The participants must be able to see the significance of their individual actions to create a meaningful experience. In a collaborative setting, discernability and integration must also be viewed in relation to the collective perception. Each participant must have an understanding of how the team members can benefit the team. The discernability thus also contains an understanding of your team members' actions. If everyone understands what everyone can do, a discernability is successful. The integration must include an understanding of how each team member's ability can be used in the collaboration. The integration is successfully implemented when the participants understand how their abilities can be combined to achieve the shared goal.

In the evaluation from section 4.3.2 (the car game where each participant controlled a wheel), we failed to provide a sufficient integration. Most of the participants experienced discernability as they understood the connection between their actions and the wheel's reactions. However, many of them had little sense of integration as they failed to understand how they should combine their actions to move the car. Without a full integration their actions made no sense and the overall meaning disappeared. As a result, several participants quit the game.
We also observed how other aspects can overshadow a low sense of discernability and integration. A group of girls from the evaluation from section 4.3.1 (the first ball game where each participant controlled a direction), had a low sense of integration. They did not understand how to utilize each other, which resulted in many 'deaths' within the game. However, their continuous struggle did not affect their enjoyment which indicates that their affection of the co-experience overshadowed the negative effects of the low integration.

5.2 Responsibility through Roles

Children enjoy being a part of a team that collaborates towards shared goal. They are good at helping each other understand the game and how the objects should be controlled. However, the evaluations showed that too much focus on the team can result in a negative experience for some participants. To achieve coliberation, it is important that every participant feels needed on the team through a high perceived individual accountability. We suggest three roles (Table 7) that can be used to guide the design towards achieving coliberation and engage participants in collective action. The roles are defined by symmetrical, asymmetrical and separated roles. We are aware that these have been presented in section 4.3.3.1, but as they are part of the key findings we will describe them in greater detail here.

Common for all roles are the existence of a shared goal and a positive interdependence between the group members. In symmetrical- and asymmetrical roles, the interaction is based on the CI model, which means that the input channels are logically bound together.

Symmetrical roles

Symmetrical roles use symmetrical actions, which creates identical interaction for all participants. As the actions do not differ across the participants, it is possible for one participant to explain the interaction to the others. This further means that it is easier to obtain an understanding of the discernability and integration. If a participant understands his own actions he will also have an understanding of his team members' interaction. Using symmetrical roles provide a good basis for a low floor as the participants can work together in exploring the collaborative interaction.

However, the symmetrical actions also result in that the participants have no influence by themselves. They must instead continuously collaborate with the group to perform meaningful actions. This removes the room for individual excellence as all choices have to be discussed with the team. It can diminish the sense of individuality and result in a strong sense of *WE*, and it is therefore important to consider how to maintain a sense of *ME* in the collective interaction.

The game from 4.3.1 (first ball game, where each participant controlled a direction) provide a good example of how similar interaction can cause confusion in who controls what. Even though the game was not developed based on symmetrical roles, the example is still useful in relation to the similarity of responsibilities. Despite being an asymmetrical action, controlling a direction creates a similar responsibility among all participants. Some participants therefore had trouble distinguishing themselves amongst the others. The discernability was decreased in larger groups as they had more participants to distinguish from. Having four participants caused several of them to just interact randomly with the game as they were unaware of how their own actions influenced the game. It is therefore important to consider how the discernability is supported in larger groups.

Asymmetrical roles

Asymmetrical roles use asymmetrical actions, which creates different interactions, and therefore different responsibilities for each participant. As the participants are unique in their interaction, it creates a high perceived individual accountability. However, both discernability and integration are more difficult to achieve compared to symmetrical roles. With asymmetrical roles the challenge is to design each role with equal significance and in such a way that each participant can understand how they contribute to the group. In contrast to symmetrical roles, there is more room for individual excellence as you are less bound by the team. To some extent, you are able to make individual decisions, but still need to negotiate the overall approach towards the shared goal. This allows the *ME* to grow larger and let the participants identify themselves with their role. Asymmetrical roles therefore provide better basis for a balance between the *ME* and *WE*.

Section 4.3.3 provides an example of how one could implement asymmetrical roles. Each participant has a unique controller with a unique set of interactions, but both affect the same object. One controls the movement of the object while the other affect how it acts. The two participants must therefore combine their individual actions to achieve the shared goal. As the two roles are equally important, asymmetrical roles excel at support close collaboration with a high individual accountability.

Separated roles

For separated roles, there is no doubt who is in control of what, as participants are responsible for their own object. This naturally creates a strong sense of *ME*. As the collaboration is voluntary, the challenge is to create enough rationale for the participants to work together. If the designer fails to create a reason for the participants to collaborate, the level of engagement will most likely end in distributed attention.

On the contrary, Zagal et al. [46] describes how voluntary collaboration can result in a stronger sense of accomplishment because it was the participants' own choice to collaborate. We have no example of our own as we have not focused on Separated roles in the thesis. However, The Lord of the Rings game used in Zagal et al. [46] provide an example of separated roles. Each participant controls an individual character and they have a shared goal of getting the one ring to Mordor. They are not bound to collaborate, but it is beneficial as they are positively interdependent. The challenge of separated roles is thus to create a rationale for the participants to collaborate, otherwise they risk that *ME* will become too large.

	Symmetrical roles	Asymmetrical roles	Separated roles
Actions	Symmetrical.	Asymmetrical.	Both symmetrical and asymmetrical.
Responsibility	Everyone has the same responsibility.	Everyone has a different responsibility for the same object.	Everyone has different responsibilities for separate objects.
Input	One logical input channel affecting the same object.	Input channels, which are logically connected, affecting the same object.	Different input channels affecting different objects.

Table 7 - Three types of roles.

5.3 The Number of Participants Affects the Collaboration

When designing a system that supports collective action, the number of participants plays a vital part in how well the participants are able to collaborate. If the system has symmetrical roles with one shared area of responsibility and all of the participants have to perform an action simultaneously, it requires a higher level of coordination, as everyone has to agree on the decision.

When the number of participants increases, their individual influence decrease. This is best explained by exemplifying through iFloor. When two participants are using iFloor, they each represent half of the influence on the cursor. They only have to negotiate between themselves, which makes it relatively easy to reach consensus on a shared goal. When a third participant joins, their control is decreased to be a third. They also have one more participant to consider in their negotiation of the shared goal. As more participants join, their individual influence will continue to decrease and more participants must engage in the negotiation. While the option of dynamically adding participants is an advantage of symmetrical roles, it can have negative effects on the individual accountability. It is therefore important to consider how the individual discernability is maintained in both small and large groups of participants.

With asymmetrical roles, the number of participants does not affect the individual accountability. The individual accountability will remain the same regardless of the number of participants. The separated responsibility will ensure that the participants does not affect each other's influence. New participants are

simply given a new area of responsibility. The game from section 4.3.3 (the second ball version with a movement- and modify controller) provide a good example. If a third participant were added to the game, he would be given control of a third aspect. Instead of intervening with the current setup he would add more opportunities to the collaboration. In example, he could be given control of external factors, like the weather. This does not change the individual interaction of the current participants. Therefore, the new participant does not change the discernability of the existing ones. Instead he affects the integration as the new role provides more opportunities to complete the task.
The collaboration also differs from symmetrical roles. Depending on the task, it is not always necessary that all participants must engage in the negotiation. Some roles might not be needed to perform an action, and therefore there is no reason to consult them. For the designer, it is therefore important to ensure that the system is designed in such a way that all roles are equally needed.

For separated roles, the number of participants have minimal effect on the experience. Adding a new participant simply adds a new object to the system. Google Docs is an example of how a new participant does not change anything for the existing ones. As each participant has their individual mouse and keyboard, other participants do not affect their interaction directly.

5.4 Serial and Parallel Actions in Collaboration

Serial and parallel actions requires different considerations in collaborative settings. Coordination becomes especially important when supporting many participants and serial actions. When participants prepare a serial action, they pause their interaction to negotiate the order of actions. More participants can therefore result in a longer negotiation and increase the need for precision in timing. It only takes one poorly timed action to ruin the combination of actions which will result in everyone having to start over. This imposes a high responsibility on each participant in the chain. It is therefore vital that the participants maintain a high level of communication and coordination for the action to succeed. A way of promoting this could be to design for a coordinator role who facilitates the communication between the rest of the participants.

Compared to serial actions, there is less responsibility on the individual participant when performing parallel actions. The success of the performed actions does not depend on carefully timed executions, but instead happens in a dynamic manner. The dynamic interaction can therefore eliminate the consequence of one mistake ruining the entire action. For example, using the collective controllers [30] one participant could initiate a picture change (requires both participants to point the controller in the same direction) and wait for his partner to join. Parallel actions are more tolerant to pauses and continuous negotiations of what the participants want to do. In contrast to serial actions, it is therefore not necessary to have an agreed plan of action before executing the parallel actions. It is possible for the participants to adopt a trial and error approach where everyone counteracts or assists each other ad hoc.

The asymmetrical and symmetrical actions are included in the roles and therefore not discussed here.

5.5 Considerations about Introducing Participants to Collaboration

Through our evaluations, we learned that it is important to have a low floor by properly introducing the interaction to the participants. This is best achieved by letting the participants explore their abilities in a forgiving environment. In the first evaluation, the children 'died' a lot while learning the controls, which caused frustration for some. This could have been avoided by having a forgiving tutorial with no risk of dying.

This would have allowed the children to learn gradually how to collaborate without being punished for small mistakes.
The second evaluation showed that it is not enough to provide an open level where the participants can learn the controls on their own. Contrary to the intention, it resulted in the children becoming confused as they should both learn their controls and agree on a direction. It therefore showed the importance of minimizing the factors requiring attention. The challenge of understanding how to collaborate is enough in itself and does not leave space for learning much else. The tutorial level should therefore be as simplistic as possible and only focus on presenting the most basic aspects of the collaboration. Everything should therefore be predefined to let the participants fully focus on understanding their role and how it can contribute to the collaboration. The missing aspects can later be presented through the players' own exploration of the game or additional tutorials.
Succeeding in creating low floor through a tutorial level furthermore provides a good basis for a continuous state of flow.

5.6 The Effects of Challenges and Abilities on Collaboration

In a collaborative situation, the individual perceptions of the challenges constitute the collective perception. If the individual perceptions differ too much, it is likely that different mental states will arise among the participants. From our observations, we learned that the collaboration suffers from different mental states. For the designer it is important to create ideal conditions for similar challenge perceptions. When dealing with symmetrical roles, it should not be a concern as all participants are equal. In terms of asymmetrical roles, there is a greater risk for different perceptions as the roles are unique. It is therefore crucial that the roles are similar in difficulty and thereby achieve similar perceptions of the challenges. This can be done by creating a good discernability and integration for each role as this also increases their perceptive skill level. If all participants feel like their skill level matches the challenges, they will be similar in mental states.

5.7 System Complexity is Affected by Number of Players and Roles

The complexity of the game can differ depending on the choices regarding number of participants and the utilized type of roles. As a general rule, it can be said that asymmetrical roles require a greater system complexity than symmetrical roles. Supporting asymmetrical actions require that the game has enough depth for each participant to be unique. By depth, we mean that the roles must have a purpose and not be present just for the sake of supporting asymmetrical roles. If a game implements asymmetrical roles without an understandable integration for each role, the participants will move into a state of apathy as their contribution is perceived as meaningless. The previous example from 5.3 of how a third participant could control the weather is useful. If the weather is not required in order to reach the shared goal, his role would be useless. It is therefore important that the system has enough rationale for additional asymmetrical roles. It is also important to notice that the system increases in complexity for each added asymmetrical role.
A side effect of the increased complexity when utilizing asymmetrical roles is an increase in wide walls. When supporting asymmetrical roles, there are automatically more ways to play the game as the participants can simply swap roles to get a new game experience. Therefore, the increased complexity can be compensated with greater replay value.
Symmetrical roles are easier to implement as they do not differ in their interaction. If implemented correctly, every role has the same responsibility and therefore share the same discernability and integration. The tradeoff is that the game can only offer novel experiences and challenges in the level design and not in the interaction itself.

We did not focus on high ceiling in the evaluations and therefore lack findings on this matter. This would be a part of a future investigation.

6 Guidelines for Roles in Collaborative Design

Based on our findings and theories, we present a set of guidelines (Table 8). The guidelines focus on two types of roles and provide considerations that can be used by designers who wish to build a system that aims to achieve collective action. They must be seen in context of the key findings found in section 5.

	Symmetric roles.	Asymmetric roles.
Discernability.	Since everyone are equal in what they can do, it can be difficult to distinguish one's own action from the rest. This is especially an issue in larger groups. It is therefore important to consider how the individuals can maintain a clear understanding of their actions.	As everyone has unique actions it is easier to see the result of your action. It is important to consider how the group is aware of who does what in order for everyone to understand their collaborative possibilities.
Integration.	The meaning of the interaction is achieved in collaboration. It is therefore important to consider that the individual might not understand the interaction unless multiple participants are interacting simultaneously.	As each participant have different influence it is important that they are all equally useful. Consider that each participant clearly can understand how they are useful in relation to reaching the shared goal.
Responsibility.	Every participant has equal responsibility in relation to the shared goal. This can lower the sense of *ME* as the individuals have no impact on their own. It is therefore important to consider how the sense of individuality is maintained in the interaction.	The participants have different responsibilities, which help towards the shared goal. The challenge is to make all the roles equally interesting and needed to avoid any participant feeling inferior to others. It is possible to accommodate different play styles by implementing roles encouraging different ways of playing.
Number of participants.	With a higher number of participants, it becomes increasingly difficult for the individual to distinguish his influence among the others. It is therefore important to consider how the discernability is maintained in large groups.	As there is finite number of available roles, it can be beneficial to consider the number of participants on beforehand. Each new asymmetrical role will increase complexity of the system.
…	…	…

Actions.	There is no difference in consideration of serial and parallel actions in relation to the roles. Consider that performing serial action increases in difficulty as the number of participant's increases. Every participant has a high responsibility as a single failure ruins the action. Parallel actions are performed in a dynamic manner and no single participant can cause the action to fail.	
Collective challenges and abilities.	As all participants are equal, there should not be a large difference in the perceived challenges and abilities. It is easier for the participants to help each other understand their challenges and abilities.	As the participants have different interactions, there is a greater risk for a difference in perception of challenges. It is important to consider that no role is perceived as more difficult than others.

Table 8 - Our guidelines.

7 Discussion

This section will briefly discuss where our process could have been improved with our current knowledge of both children and collaboration.

In retrospect, we could have saved time by using existing products to answer the exploratory questions from the first evaluation. The physical marble maze game (Figure 40) has the same basic concept as our first prototype; navigating a ball through a track without dying (falling down a hole). We could have setup a situation where two children should collaborate by controlling one side each. Though not able to support four players at once, it could still have provided insight into how children behave in collaborative situations.

Figure 40 - Marble maze game.

The marble maze game could have provided us with results that could create basis for the first prototype, which then might answer more specific questions.
To gain the same basic understanding of their collaboration skills, we could also have exposed the children to an actual digital collaborative game like Rakete. This approach would have been more in line with our intended use context.

The limitation issues of the RFduino could have been avoided, had we tested the capability of them before we began construction of the third prototype. Fitting both the accelerometer and gyrometer required all but one port in the RFduino. The RGB lights required three ports, which was problematic. In retrospect, we should therefore have developed the concept fully before starting the physical and computational development. This would have allowed us to foresee these kinds of problems, resulting in a prototype which lived up to our expectations.

Additionally, it might also have been beneficial for us to consider using children as co-designers in the development process. As Melonio et al. states [25], children simply possess a knowledge about the world and what they want that adults do not:

"*It is critical to support children in the design process because adults do not experience the world as children do and do not have the same insights into the world as a child.*" [25]

By involving the children more deeply in the design process, we might have been able to avoid some of the problems which arose. Specifically, we could have substituted our brainstorm with a cooperative inquiry and involved the actual target group. Cooperative inquiry is a process that "… *enables adults and children to share*

their ideas yet minimize differences in age and communication styles." [10]. Using iterative low-tech and high-tech prototyping, we could have let the children help create the basis of the prototypes and ways of collaborating. This process could also have been used earlier in our process.

8 Future Work

In the following section, we will discuss some of the steps which can be taken in regards to a possible future direction of this project.

The next step could be to explore the asymmetrical roles' influence on the children's ability to collaborate. Specifically, we lack information on more than two players engaged in asymmetrical roles. As discussed in section 5.3, the number of players increases the requirements for communication and thereby affects the collaboration. It would therefore be interesting to observe the effects of asymmetrical roles on the communication in a group larger than two. A new role could control some kind of external force or the level itself. This would also require a new controller with a design which should complement the abilities of the new role.

In regards to controllers, the future work should also focus on making the modify controller more coherent. One of the problems with the third prototype was that the children did not understand how to interact with the controller. This indicates that the design of the controller did not communicate its use properly. When designing tangible controllers, it is key that the connection between what they control and what they represent is understood by the users. A focus would therefore be to create better connections between the physical design and interaction. Such exploration could also involve further investigation in the visual representation of the performed action.

It could also be interesting to investigate prolonged play in relation to both long-term interest and high ceiling. We are interested in identifying elements that allow participants to stay engaged and master their collaborative skills. This would require a long-term investigation with dedicated subjects and is therefore of less priority as the other areas are of equal importance, but require less resources.

Finally, it could be interesting to validate the findings using participants from different target groups and domains.

9 Conclusion

In this thesis we have worked with the research question:

"How can individual accountability support children's engagement to collaborate in a social game which aims to achieve collective action?"

We aimed at accommodating the children's desire to use technological devices to play while reducing the various concerns of anti-social behavior. From an extensive literature review, we have combined the design models from collective interaction and cooperative gestures with the guidelines from collaborative games. This resulted in an approach for designing a social game for children with collaborative gameplay as the foundation for achieving collective action. We designed three games which focused on different ways of collaborating. We performed three field studies to evaluate the games which consisted of an overall goal and supporting questions directed towards usability, user experience and exploration of the children's ability to collaborate. The results guided us in new directions of how we could improve the design and how the children would stay motivated to collaborate. The children had fun playing the games and showed great interest in collaborating, despite some drawbacks in understanding the controls and the difficulty in some of the levels. Most of the children were able to collaborate and combine their actions to reach the shared goal. We also observed how the children were able to use social skills, like teamwork, communication and negotiation while they played the games.

The results from the field studies combined with the theories allowed us to formulate a set of guidelines. These guidelines describe how roles can aid designers in creating a game or system which aim for collective action. The roles focus on activating the participants and provide each individual with an understanding of their contribution towards the shared goal. They assist in creating optimal conditions for a well-balanced group dynamic where collective action can take place.

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11 Appendix 1 - Interview guide for the third evaluation

Controllers

- Hvordan var det at bruge controllerne?
- Hvad synes du om Kuben/Kuglen?
- Kunne du forestille dig andre måder, man kunne styre kuglen på?
- Spiller I spil på jeres iPad, hvor flere spillere kan være med ?
- Hvordan er det at kunne spille sammen på en iPad, uden at skulle røre ved skærmen?

Roller

- Hvad synes du om de to roller?
- Hvilken af dem synes du, der havde mest kontrol over spillet?
- Følte du, at du gjorde en forskel i spillet?
- Samarbejde
- Hvordan var det at arbejde sammen om at styre et enkelt objekt?
- Følte du, at du var afhængig af din medspiller?
- Hvis ja, hvordan føltes det, at du ikke kunne gennemføre det alene?

Spildesign

- Var spillet svært eller let? - hvorfor?
- Var nogle af banerne sjovere end andre? Hvorfor?

12 Appendix 2 - Transcriptions

12.1 Alex and Benjamin

Author: Hvordan synes I det var at spille spillet?
Benjamin: Det var meget sjovt, jeg synes det var sjovere end det første kuglespil, men jeg synes det godt at man .. f.eks. når man har højden … øh … hvor højt du kan hoppe. At man godt må have lidt mere fart på.
Author: Nåh, man kørte for langsomt?
Benjamin: Ja, man kørte meget langsomt hvis man skulle prøve noget tid så kørte man nærmest … det var som man ikke kørte. Og så f.eks. jeg sagde også til Alex, at han skulle køre hurtigere og … eller han skulle køre for det lignede ikke han kørte når man kører lidt langsommere.
Author: Det var der i den første bane, eller bare generelt bare hoppebanen?
Alex: Jah
Benjamin: Øh… jah
Author: hvad synes I om selve controllerne? Jeg kunne se I…
Alex: Jeg synes det øh…
Benjamin: jeg synes det var sjovt. Men jeg synes også det var sjovt hvis man lavede sådan at man ku på terningen … eller altså som en … en mand så på den der kugle hvis du drejede den, styrede du det og hvis du hoppede kunne du hoppe med kuglen. Også kunne man så også få den der … sådan at du kunne gøre et eller andet så du enten kunne spille… altså 1-player eller 2-player
Author: Ja okay, så man ikke behøves at være to hver gang?
Benjamin: Ja.
Alex: Altså, jeg synes det kunne være fedt hvis det sådan var … øhm … så kunne der være sådan at man kunne være … altså … så var der fart, så var der en der styrede størrelse, en der styrede hop sådan man kunne alle tre kunne samme tid.
Author: Nåh, på en gang? Sådan at det ikke var opdelt sådan som det var her
Benjamin: Det tænkte jeg også, det kunne være sjov hvis man kunne være flere. Men jeg tror ikke jeg ville synes det var sjov hvis man var så mange fordi, at så var der nogen som hele tiden skulle sidde og ikke gøre noget
Author: Jaja, lige præcis
Benjamin: Fordi når du… af den der … så skal du … så hvis du skal hoppe det gør du ikke så tit, men du skal alligevel hele tiden gøre noget. Man ville måske også blive mere sur på hinanden fordi man nemt vil dø fordi man var så mange om en lille ting
Author: Så det er vigtigt man hele tiden…
Alex: Nej, det er din skyld!
Author: … Laver noget. Så det er vigtigt, at man hele tiden også selv laver noget, så man ikke bare sidder og kigger på den anden spille.
Begge: Ja.
Benjamin: Fordi ellers kommer man bare til at sige: Ej, det var din skyld og.
Alex: Det var dig der gjorde det!
Author: Hvilken controller var sjovest?
Benjamin: Det ved jeg ikke.
Alex: Jeg synes den der hvor man kunne styre tingene.
Benjamin: Det ved jeg ikke, jeg tror, at jeg er bedst med kuglen, men det var også sjovt at prøve det andet.

Author: Så du vil gerne spille med begge to? Det er lige meget hvilken en du får?
Benjamin: Ja.
Author: Fedt.
Alex: Jeg synes mig og Benjamin er et godt team når jeg brugte firkanten og han brugte den runde. Så vi fik på ikke engang en time … ikke engang to sekund …
Benjamin: Vi er også vant til at spille sammen f.eks. hjemme ved dig der spiller vi også mange andre ting … sådan som lego spil og sådan hvor vi … ja
Author: Hvordan synes I det er når man er to personer om at skal gennemføre noget sammen?
Benjamin: Jeg synes det er rigtig sjovt
Alex: Jeg synes faktisk det er fedt, så lærer man samarbejde og så noget
Benjamin: Det er også fedt når man gerne vil lave noget med sin ven. Så man bliver også bliver sådan … altså det er et spil som jeg synes ikke giver lige så meget … øh … altså sådan, det får en til at tænke lidt mere fordi man skal tænke over hvordan kommer jeg der over og kan jeg prøve at hoppe skævt derover. F.eks. der var et tidspunkt, der hvor vi prøvede at lave tid så skulle man hoppe derover og så derover. Så fandt vi ud af, at man bare kunne hoppe skævt der, og så derover, og så derover… og så spare tiden
Alex: Det er ligesom mig og Benjamin, vi skal hjem til mig og rive skuret ned og så skal vi lave et træhus.
Author: Fedt, det gjorde jeg også da jeg et barn.
Alex: Det sjoveste bliver at lave træhus. Ikke det der med at rive skuret ned.
Author: Nej, det er sjovere at bygge ting. Hvad synes I om selve banen?
Benjamin: Jeg synes det er sjov …
Alex: Altså jeg synes… altså de var rimelig svære, men
Benjamin: Jeg synes også de var meget sjove.
Alex: Jeg synes det det skal være sådan at man på et tidspunkt, hvor du kan vælge svær, nem eller normal.
Benjamin: Det skulle jeg også lige til at sige. Det ville også være sjov, hvis der var flere baner. Og hvis man kunne lave så man kunne bygge sine egne baner.
Author: Vi havde lidt forsøgt det der med at der var de tre første baner som var sådan ret nemme. Skulle der have været en i mellem som var lidt lettere end den sidste, men svære end den første?
Benjamin: Det ved jeg ikke, jeg synes bare der skulle flere baner og måske du kunne prøve at lave din egen bane også.
Author: Okay, jamen det var egentlig bare det. Tak skal I have.

12.2 Chris and Dennis

Author: Hvordan synes I det var at bruge controllerne? Var de nemme at bruge?
Chris: Nej.
Dennis: Jeg synes det var nemmest at bruge den med fart, fordi så var det ikke mig der styrede den.
Author: Hvad synes du? Hvis du skulle vælge en af dem? Hvilken kunne du bedst lide?
Dennis: Jeg kunne bedst lide at styre den
Chris: Jeg kunne bedst lide firkanten.
Author: Var det fordi I synes den anden for svær at bruge?
Chris: Naaaj, jeg kunne godt lide at drille Dennis
Dennis: Jeg synes også det var sjovt at drille med at blive lille mens vi stod på den der.
Author: Synes I at I lavede nok i spillet når I brugte den ene og den anden controller?
Dennis: Mener du med at samarbejde eller … eller hvis man selv skulle styre det?
Author: Synes I det var sjovt at være to om at gennemføre spillet?
Chris: Nej.
Dennis: hehe, jeg synes det eneste der ikke var sjov ved det var at Chris han var der og det var ham jeg skulle spille med.
Author: Tror det havde været sjovere hvis I skulle spille det alene
Chris: Jeg gad godt prøve det, men Dennis du skal da være glad for at det ikke var Alex du var sammen med eller Benjamin.
Author: Tror I det var sværere hvis I skulle spille det alene? Hvis I skulle gøre alting selv.
Begge: Ja.
Chris: Så skulle man selv blive stor og selv hoppe og … og så ville det tage meget længere tid. Fordi man skulle en ting ad gangen
Author: Har I prøvet at spille spil før, hvor I skulle være to sammen om at gennemføre et eller andet? På PS eller iPad?
Begge: Ja
Author: Kender I nogle spil til iPad?
Chris: Nej, jeg kan ikke huske dem
Author: Men du har prøvet dem? Skulle man så begge sidde og trykke på iPad'en på samme tid?
Dennis: Nej, ikke på samme tid … Jo, der er et spil der hedder Drive Ahead, hvor man har to pile og så gælder det om at man skal ramme hinandens hoved med en bil.
Author: Er det sjovt at spille?
Dennis: Ja. Men …
Chris: Det kan man også godt spille en.
Dennis: Det eneste der er kedeligt ved det … eller dårligt ved det er, at det er den samme iPad man skal sidde ved. Hvem der har mest plads og alt muligt.
Author: Hvis I nu forestiller jer, at det her spil var til iPad. Havde det så været sjovere at sidde med to controllere end at skulle røre ved skærmen?
Begge: Jeg synes det er sjovere at gøre det med controllere
Dennis: Ellers skulle man sidde sådan … Nej, lige ud! Til siden.
Chris: Også med et tastatur, hvis man skulle trykke på knapperne [Det hele bliver klemt]
Dennis: Det er ligesom det der … hvad er det, det hedder … der er sådan et spil med en kugle hvor man kører ligeud og så gælder det om at man ikke må ramme de røde. Kender du ikke det? Inde på Y8. Så styrer man

også med pilene … og sådan noget. Så kan man sådan også hoppe og sådan … så hopper man på mellemrum og styrer med pilene … hvor man sådan … det kender du. Det er mega sjov.
Chris: Jo, inde på Y8.
Dennis: Det minder også lidt om det der bare hvor man hele tiden kører og ikke selv bestemmer hvornår man stopper
Author: Hvad synes I om selve spillet? Var det sjovt?
Dennis: Altså hvis jeg … hvis der var nogen der spurgte mig: Hey, vil du have det her spil gratis? Så havde jeg sagt ja.
Author: hvad så hvis du skulle købe det?
Dennis: Så havde jeg også sagt ja.
Author: hvilken en af banerne synes I der var sjovest?
Dennis: Jeg synes nok det var… altså labyrinten var ret kedelig … den var sådan helt …
Chris: Jeg kunne rigtig godt lide den sidste.
Author: Der hvor man skulle styre størrelsen?
Chris: Ja.
Author: Hvorfor?
Dennis: Fordi der kunne man drille hinanden ved at man står på en der er sådan her … og man skal være sådan her for at kunne være der. Så kunne man køre op og skrumpe sig helt ned så man faldt igennem.
Author: Synes I spillet var for svært? Nu brugte I lidt lang tid til det…
Dennis: Nej! Eller jo … det var lidt svært, men altså … vi fik verdens score
Author: Ja, I har faktisk verdens bedste score. I er de første der har gennemført spillet i jeres alder. Der er kun en anden gruppe der har gennemført det og de er fra vores årgang eller det var nogle af vores klassekammerater… men I fik en score der var bedre end de to. Både tid og … så det kan I godt være stolte over
Dennis: Kontakt lige det her nr næste gang der er nogen der failer … eller slår min rekord.
Author: Ja.
Chris: Han skrev det seriøst ned..
Dennis: JA
Author: Jeg skal nok skrive til dig hvis det sker.
Dennis: 27…
Author: Og det var Dennis?
Dennis: Ja.
Author: Er det med xx eller xx?
Dennis: X X X X X X X
Dennis: 27 28 xx xx
Author: Kunne I forestille jer, at man kunne ændre kuglen på andre måder end de tre vi har nu her? Med at man kan hoppe, skifte størrelse og fart
Chris: Flyve?
Dennis: Ej, så kan man bare flyve over det hele
Author: Men det kunne godt være, at man kunne skifte …
Dennis: Altså f.eks. labyrinten, hvis man kunne flyve så det kunne det være at man kunne sætte væggene helt op i en evighed så man kunne blive ved med at flyve
Daniel: Jaja, så man skulle op og flyve efter kasserne i stedet?

Dennis: Mhhm [ja]
Author: Ja, … øhh følte I at I gjorde lige meget begge to? I spillet, nu spillede I jo begge to med begge controllere.
Begge: Jaah.
Author: I kedede jer ikke på noget tidspunkt hvor I synes den ene lavede mere end den anden?
Dennis: Jeg gad faktisk godt beholde firkantet hvis jeg skal være ærlig
Author: Fedt, men tak for det.

12.3 Emma og Freja

Author: Hvad synes du om spillet?
Begge: Sjovt og svært.
Author: Ja, jeg kunne godt se I havde lidt problemer med det. Hvad med selv controllerne? Var de til at bruge?
Begge: Ja
Emma: Men lidt svære, men jeg tror ikke det var det der var problemet
Freje: Efter et stykke tid så begyndte …
Emma: Det begyndte at blive lettere
Author: Spiller I også der hjemme?
Freje: Nogle gange
Emma: Ikke så meget computer spil. Mere på iPad
Author: Har I prøvet at spille noget på iPaden hvor I kan være flere personer om at spille? Uden I skal være …
Emma: Kun to.
Author: Eller hvor I bruger den samme iPad sammen?
Emma: Jah, men der spiller man mod hinanden.
Author: Der er ikke noget hvor man er sammen?
Freje: Nej.
Emma: Nej, det tror jeg faktisk ikke jeg har prøvet nej
Author: Skal I bruge den samme iPad når I gør det? eller har I hver jeres?
Begge: Man kan godt bruge den samme, men nogle gange … og nogle gange har man to
Emma: Hvis jeg skulle gøre det skulle det være på computer og så skulle jeg have en ledning og så kan vi spille til hinanden
Author: Hvilken en af controllerne kunne I bedst lide?
Emma: Den runde, nej faktisk firkanten
Freje: Det tror jeg også jeg kunne.
Author: Ja, I byttede ret meget kunne jeg se. Hjalp det når I byttede roller hele tiden?
Freje: Hmm, lidt, men man blev også lidt forvirret for så havde man lige vænnet sig til det
Author: Hvorfor valgte I at bytte så ofte?
Freje: Fordi der var nogen steder vi tænkte det var nemmere for den anden gøre det.
Author: hvordan kan det være I synes kuglen var bedre? Var den lettere at styre eller…?
Freje: Kuglen var nogle gange … [cut and end]