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Playful Child-Drone Interaction

Generating Design Considerations and Identifying Safety Risks for Gesture Controlled Toy Drones through Ethnography with Children.

Master's thesis in Computer science and engineering

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Abstract

In preparation for this thesis, a literature study was conducted which identified a research gap between Human-Drone Interaction (HDI) and Child-Drone Interaction (CDI). This led us to further investigate the market for children and toy drones. This analysis suggested that there is a clear market for gesture controlled toy drones but without any research supporting the design of such. Which led us to adopt an Research For Design (RfD) approach with an exploratory nature. The aim of this was to investigate what should be considered when designing these toy drones for collaboration and playfulness as well as what possible safety risks may arise with these types of gestured interactions. This was done through qualitative studies with two groups of children, that we worked with on three different occasions. These meetings included an elicitation study through enactment, a co-design workshop, and commercial drone testing which were all video and audio recorded. After completion, we started gathering all of our data and prepared it for thematic analysis. This thematic analysis resulted in a set of design consideration for gesture controlled toy drones and also the identification of three main types of safety risks. In parallel to this, we started to diverge in the solution space of our problem, which included steps such as skewing and brainstorming to produce a number of different potential solutions based on the user requirements. This resulted in two different storyboards as the requirements for each group were significantly different. These included concepts of a play with the characters illustrating each individual child. We also produced a story based on our meetings with one of the groups to prime critical reflections around the usage of cameras as they showed a clear interest in this for the purpose of espionage. We then presented the storyboards and the story to the group it concerned in an evaluation.

Keywords: interaction design, toy drones, drones, participatory design, child-drone interaction, gestures, child-robot interaction, safety risks, ethnographic research, human-drone interaction

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Matilda Falkenby & Sofie Åkesson, Gothenburg, June 2022

Contents

List of Acronyms

HDI	Human-Drone Interaction
HRI	Human-Robot Interaction
HCI	Human-Computer Interaction
CDI	Child-Drone Interaction
HCD	Human-centered Design
UCD	User-Centered Design
CRI	Child-Robot Interaction
CTI	Child-Tangible Interaction
IxD	Interaction Design
PD	Participatory Design
RtD	Research Through Design
RfD	Research For Design
RiD	Research Into Design
ISO	International Organization for Standardization
T2i	Tangible & Tabletop Interaction Lab
WASP-HS	Wallenberg AI, Autonomous Systems and Software Program – Humanities and Society
VR	Virtual Reality
NUI	Natural User Interfaces
AI	Artificial Intelligence
GDPR	General Data Protection Regulation
UN	United Nations

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1
Introduction

Autonomous flying drones have been predicted to become ubiquitous in a near future. The term "Flying user interfaces" could become a research agenda as well as a medium for design in commercial products. This calls for extensive research focus overarching both fields. While HDI is rising as a stand-alone Human-Computer Interaction (HCI) sub-field, the gap between HDI and CDI becomes more apparent. Which was discovered through a literature study and market analysis (see appendix A and B). Combined this showed not only a large number of existing gesture-controlled toy drones on the market today but also a lack of existing design research to back the usefulness of said toy drones. In conjunction, this constitutes a problem both regarding the UN children's convention, which as of January first, 2020, is law in Sweden, which in the first entry of article 12 states

> *"States Parties shall assure to the child who is capable of forming his or her own views the right to express those views freely in all matters affecting the child, the views of the child being given due weight in accordance with the age and maturity of the child."*

and the lack of children's involvement in designing and developing toy drones [9, 62].

Social drones is a term proposed by Baytas et al., which defines autonomous drones that work in an inhabited environment [10]. On the market today there are many different types of toy drones aimed at children. Some are controlled using a remote and some using gestures. However, when researching the subject of CDI there seems to be a large knowledge gap in academic literature, which has also been suggested by Baytas et al. and Obaid et al. [10, 82]. When conducting a market analysis of gesture-controlled drones, many safety concerns and questions regarding gestures arose. For example, the shell around many toy drones had holes large enough for children, or even adults, to reach in and touch the propeller blades. Furthermore, good design in this area enables a broader age span and user group (e.g. younger children with less developed motor skills can also use it) by not being restricted to a remote control. This is both economically beneficial for the product owner while at the same time making the product more inclusive.

Drones have been on the rise for some time, whether it be researching within social drones, drones as companions, or simply toy drones becoming more and more frequent in child play. With HDI being a sub-field to Human-Robot Interaction (HRI),

there is another sub-level to HDI, CDI which has not been as researched as HRI or HDI. When conducting a literature study it was found that most studies within HDI had adults as participants [4, 5, 18, 34, 38, 42, 58, 60, 83, 112], while only one article, on the subject of drones, could be found that had children as participants (for complete citation see appendix A). However, this has not hindered companies from producing many different types of drones marketed to children. The lack of research behind these toy drones brings forth a concern that (a) the interactions might not be adapted for children's needs and (b) there is a lack of safety measures taken to, for example, accommodate children's small hands and fingers. This leads to the following research questions:

RQ1: What should be considered when designing gesture controlled toy drones for collaboration and playfulness within child-drone interaction?

RQ2: What possible safety risks can arise with these types of gesture interactions?

To tackle these issues and questions, we applied an exploratory approach. We did this by conducting three primary studies, an elicitation study, a workshop, and a commercial drone testing study. All three studies involved children between the ages of nine and eleven as both participants and co-designers. To gain more knowledge on both working with children and preparing for the primary studies we interviewed experts within Child-Computer Interaction and conducted a pilot study with two children, ages ten and eleven.

Although some of the studies found in the literature study related to gestures, most of them defined the word 'gesture' differently. In this presented work, we define gesture according to the Merriam-Webster definition [71]:

> *"a movement usually of the body or limbs that expresses or emphasizes an idea, sentiment, or attitude"*

Therefore we define gesture control as a movement of the body or limbs used for control.

2

Background

In this chapter we present the background foregrounding this project. This is to understand our position within this field and our underlying motivations. This includes the research grants, the literature study, toy drones and the online community, market analysis, and the first testing session of these. Finally, relevant theory supporting the choice of context in our research question is described.

2.1 WASP-HS

The Wallenberg AI, Autonomous Systems and Software Program – Humanities and Society (WASP-HS) is a foundation that aims to contribute to improving human development within AI and autonomous systems [2]. The main focus of WASP-HS is:

> *"...on the ethical, economic, labor market, social, cultural, and legal aspects of the technological transition."*

One specific research project that received a grant from the WASP-HS foundation was **The Rise of Social Drones: A Constructive Design Research Agenda**. The Rise of Social Drones is a project proposed by the Tangible & Tabletop Interaction Lab (T2i), which was founded by Morten Fjeld at Chalmers University of Technology [1, 6]. Fjeld is also the principal investigator of the granted project, which focuses on how social drones will affect human lives and aims to research important questions such as:

> *"How can you design drones so that their use improves the lives of individuals and society? "*
> *"Is the technology even useful, or do the risks outweigh the benefits?"*

The subject of social drones in HDI is also associated with the subject of CDI, where research is lacking. This has led to the motivation behind this master thesis; the research conducted will contribute to filling the research gaps found within CDI. By researching what should be considered when designing toy drones, we contribute to the first research question which is asked within the Rise of Social Drones project. It also contributes to the second research question of the Social Drones project, by

researching the possible safety concerns with gestured interactions.

2.2 Literature Study

To obtain more knowledge, about the subject of drones and children's interaction, a literature study of more than 40 papers, books, and articles, was conducted (see the complete study in appendix A). The study used two different sets of keywords, which were identified as the themes of the research, that were inserted into Google Scholar, the study also included research received from an external party.

The two different keyword sets were used to research different subjects with regard to the main topic of children. Where each keyword set included different combinations of keywords for a wider search area. The first set, ***children, methodology, research, CRI, ethics, child-centered***, looked into commonly used methods in Child-Robot Interaction (CRI) that possibly could be applied to this thesis. While the second, ***drone, robot, play, gestures, children, HDI, HRI***, investigated more closely what research has been conducted within CDI.

However, some combinations of keywords had to be omitted, for instance, the combination of *children AND drone* in Google Scholar. Due to it mostly resulting in research referring to military drones and how children are being affected, or even murdered by said drones [11, 12, 14, 25, 57, 92, 109]. This was deemed unrelated to the subject of CDI with relation to toy drones and play in this master thesis.

2.2.1 Keyword Set 1

The first set of keywords, *children, methodology, research, CRI, ethics, child-centered* and some of the research provided by the third party, found in total 15 research papers, books, articles, and collections that were analyzed. The research concluded that there is not yet a unified framework regarding researching children in participatory design but a pattern has appeared where more and more studies trying to work towards that from different perspectives [82, 98].

When it comes to researching children as subject there is more established work [32, 41] and guidelines [51] to make use of. Alison Druin is an influential researcher when it comes to design of children technologies and participatory design with children [31, 33, 53]. She voiced the importance of children as design partners as early as 1998 and has continued on in this area [33]. Though, majority of the work within CRI, in which CDI could be considered a sub-field of, lies within the field of edutainment and learning experiences [66, 86, 91, 110] as also stated by Marguerite Loudoun[68].

So, in conclusion, there are a lot of different fields to draw knowledge and inspiration from when it comes to researching for and with children. The findings in the literature study indicate that there will be a challenge in combining and adopting these inspirations in an appropriate way within CDI due to the lack of a unified and well-established framework for this specific type of user interface. This work will therefore

be influenced by different fields such as CRI, Child-Tangible Interaction (CTI) and HRI for the development of a fitting methodology. Another important finding in relation to ethics is that the recent re-positioning of children's rights according to the United Nations (UN) convention on the rights of the child, has made the importance of participatory design with children even greater [9].

2.2.2 Keyword Set 2

In total 31 research papers, books, and articles were deemed useful and analyzed. The research involved the second keyword set, *drone, robot, play, gestures, children, HDI, HRI*, and some of the research provided by the third party. Within the research found, three main topics were identified, Play, Drones, and Robots. With the largest being Drones (see figure 2.1). When looking at the research found relating to HDI, much of the research mainly had adults as participants with some focusing on gestures. For instance, Cauchard et al. and E et al. mainly focused on the different kinds of gestures the participants might want to use and what cultural differences there might be [18, 34].

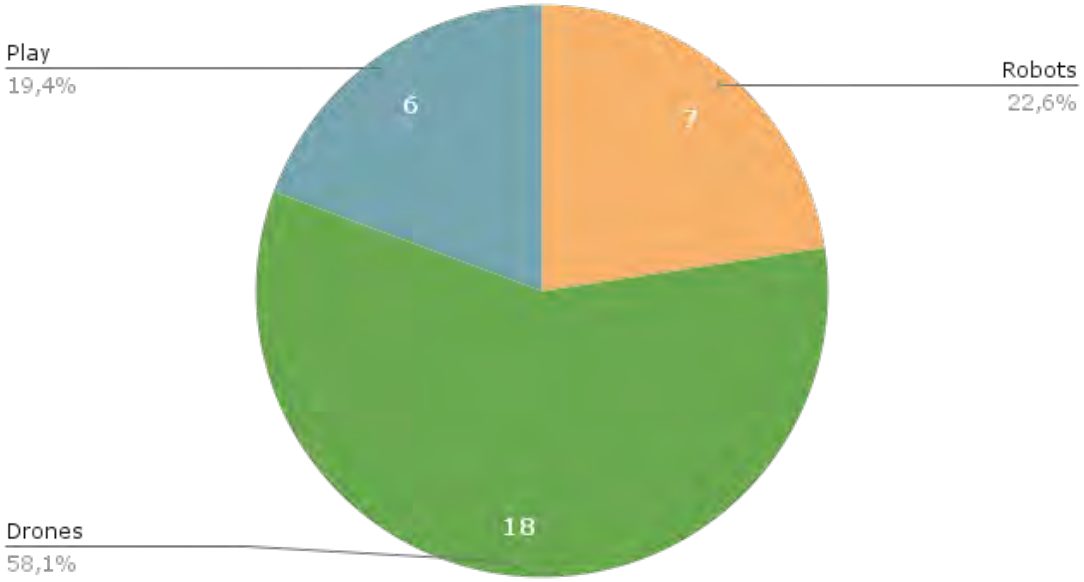


Figure 2.1: Shows the main topics of the research material found.

In the research analyzed, were five sub-topics identified (see figure 2.2). With nine papers being on the sub-topic of children, with seven out of nine papers having children as participants [37, 66, 88, 90, 91, 96, 110]. However, most of them were on the topic of robots, with only one being on the topic of CDI [91]. In said article, the authors, Rubens et al., had a workshop with 204 children between the ages of four to 16 years old where the children made their own remotes to control drones behind a glass window. However, the article seemed to be focused on teaching the children to program "programmable matter" in a fun environment and not on the

actual interaction between children and drones [91]. In contrast to this study, we are focusing on direct interaction between children and the drones, favoring direct play and the elicitation of gestures in a qualitative research manner.

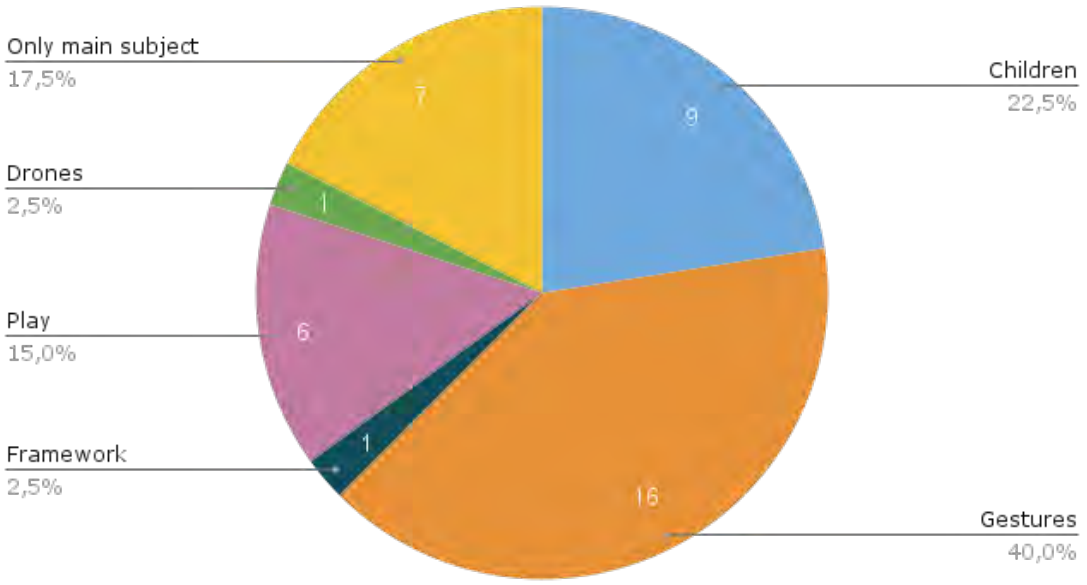


Figure 2.2: Figure on how many times each sub-topic occurred in the research material, note that each sub-topic can appear in a combination with another sub-topic except for "Only main topic".

2.2.3 Conclusion

In conclusion, there are a lot of different fields to draw knowledge and inspiration from when it comes to researching for and with children. Though there is a challenge in combining and adopting these in an appropriate way to fit the field of CDI due to the lack of a unified and well-established framework and knowledge for this specific type of user interface. Especially regarding children interacting with gesture-controlled toy drones. This thesis will instead be influenced by different fields such as CRI, CTI and HRI for the development of a fitting methodology.

2.3 Toy Drones

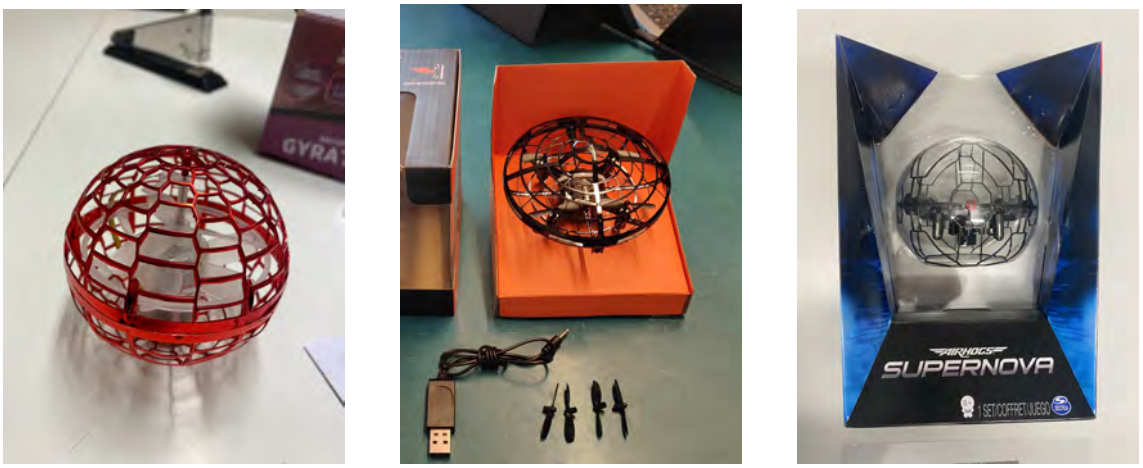
While there are many different uses for drones, such as military or photography, there is an entire market simply aimed at children. Many of these drones are mainly controlled using a remote, which only allows one user to play with the drone. However, newer models of toy drones feature gestures as a form of control. This allows for more multi-user friendly play, which according to Shahid, Krahmer, and Swerts is preferred by children compared to playing alone [96].

2.3.1 Online Community

With the rise of drones being used as toys, photography aids, or tools for programming education, communities for both children and adults have started appearing on social media platforms such as Facebook. Though many of them mainly focus on a specific brand, such as DJI Tello Owners Group or simple only DJI owners [27, 29]. DJI, Da-Jiang Innovations is a company that focuses on the manufacturing of commercial unmanned aerial vehicles, commonly known as drones, for aerial photography and videography [28]. First Person View drones (FPV) is another popular brand often used for racing where the drones are equipped with cameras where the controller is wearing a head-mounted display, which enables them to see a live stream camera flow from the drone while racing [39]. These communities are vast with many active members. Within these communities, members can obtain tips and tricks regarding drones and can also request help on different issues.

2.4 Market Analysis

The market analysis involved researching a variety of different online stores for gesture-controlled toy drones (see more details in appendix B). Although the drone's appearances were quite similar, the prices varied from 249-618 kr. Most of the drones featured a net-like shell around the propellers which is, according to the packages, to make them more crash-resistant (see figure 2.3).



(a) Flying ball drone **(b)** UFO drone **(c)** Air Hogs Super Nova

Figure 2.3: Three examples of toy drones and their shells.

While researching the market, a concern arose regarding the net-like shells being large enough to easily fit children's fingers, which could cause harm due to the propellers. To gain more knowledge about safety concerns, the type of interactions the drones had, the differences between them, and more, the drones collected from the market analysis were purchased for use in both the pilot study and primary studies. In total 16 drones were analyzed in the market analysis, where eleven out

of the 16 drones were to be ordered and analyzed (see the complete list of drones from the market analysis in appendix B). However, only seven could be ordered due to stock availability (see the list of ordered drones in 2.1).

Name	Price (kr)	Gesture Control	Order status
Air Hogs Super Nova	618	Hand movements	Ordered and received
Flynova Pro Ball	339	Hand movements	Ordered and received
Smart Drone	249	Hand movements	Ordered and received
Litzee	289	Hand movements	Ordered and received
Gadget Monster UFO	249	Hand movements	Ordered and received
Kissiqiqi	359	Hand movements	Ordered and received
Flynova Ball	399	Hand movements	Not in stock
Gear4Play Flying Spinner	139	Hand movements	Ordered and waiting
Gear4Play Flying ball	249	Hand movements	Not in stock
Gear4Play Space Invader	249	Hand movements	Not in stock
UFO Drone	299	Hand movements	Not in stock

Table 2.1: Table of drones ordered to be tested.

2.4.1 First testing

The testing carried out involved a first impression look, a test flight of the drones right out of the package, reading the manual to ensure the drones were correctly handled, and then another test flight after a charge.

During the first impression of the drones, when looking closer, most of them had only three sensors one on the bottom and two on each side of the drone. This proposed a potential problem as when trying to use the gesture commands, the sensors were missed and the drone did not react. There was also some ambiguity regarding age appropriateness, a clear age limit was not always defined both when purchasing and on the box itself. Some of the drones had an age limit of eight, however, there were some hints in some of the product descriptions that these could be used by children of the age of three as well. Another finding was that they were marketed as having multiplayer interaction, but when tested it was not multiplayer friendly.

Before actually turning on the drones for testing, the net-like shells were investigated and tested to see if fingers could fit through the holes of the shells. One of us tested all of her fingers to see if they would fit. On four out of the five drones tested she could easily fit all of her fingers and touch the propellers, part from the thumbs. This was mainly due to the shells using a soft plastic material that could easily bend

without breaking.

This was also confirmed, by accident, when testing one of the drones out of the box. When activated, the drone sensors reacted to surrounding objects and flew up towards the ceiling. The testing room also had glass windows, which did not trigger the drone's sensors causing the drone to fly up, towards the ceiling and into the glass window, essentially getting 'stuck'. To try and stop it, one of us grabbed the drone from the air in flying mode and turned it upside down. When doing this, one of her fingers got inside the shell and was hit by one of the drone's propellers which shocked her.

Through this first testing analysis, it was concluded that the main issue was the gestures not being well developed and was lackluster. It was also concluded that there was a clear safety issue with said toy drones, namely the shells allowing adult fingers to easily touch the propeller blades of the majority of the drones. Meaning that a child's smaller fingers could get through the shells more easily.

However, it should be noted that the drone companies did not label the drones as having 'protective shells' for the sake of protecting the user, but as collision protection.

2.5 Designing play for play's sake

There is an extensive collection of studies within the field of CRI but where the main focus lies within edutainment and playful learning in regards to education or development [66, 86, 91, 110]. The heavy interest in this area has created a gap between designing play for learning and designing play *per se*. This was actually vocalized as early in 2003 by Verenikina, Harris, and Lysaght but where the focus was on computer-based games [105]. But play has been placed as a primary occupation for children which according to Lynch and Moore should imply that focus should be on enabling play [67]. Furthermore, Lynch and Moore define play occupation as

> *"play...undertaken for its own sake" or also "playing for play's sake"* [67]

They state that play occupation has primarily been viewed as a means due to its evident importance in regards to health, development, and well-being [63]. This has led to it being overlooked as an aim. They conclude by stating that play should be considered an occupation. With this view, play is seen as an aim, a right, and participation that contributes to the children's well-being. But playing is seldom done alone in the context of child play and a study by Shahid, Krahmer, and Swerts suggests that children prefer playing a game together with a friend when interacting with a social robot [96]. As drones enable a new digital space for children to play in, which has already been explored as a means but not yet as an aim [91], using play as an aim explores new ways of drone research.

3

Theory

This section outlines the different theoretical concepts and frameworks that encompasses our conducted research such as Interaction Design (IxD), Human-centered Design (HCD), User-Centered Design (UCD), Participatory Design (PD), HDI and CRI. These will help us delimit and choose methods and techniques appropriately. Furthermore, we will also present important areas such as design research involving children. The findings from these will aid us in the planning and design of our approach to the problem at hand.

3.1 Interaction Design

IxD is the foundation on which the following fields builds on. Sharp, Rogers, and Preece defines it as following

> ***"...designing interactive products to support the way people communicate and interact in their everyday and working live"***

It emphasizes the importance of a diverse set of skills from different fields such as psychology, computer science, HCI, entertainment and design etc.[97]. In areas where the technologies are becoming mature enough, the companies have opened up to the approach where their product is based on what people need, rather than the next new feature [93].

3.2 Human-Centered Design (HCD)

HCD is a major design paradigm and stems from fields such as ergonomics, computer science, and artificial intelligence [44]. The following definition to describe HCD is given by the International Organization for Standardization (ISO) 9241-210:2019 on Ergonomics of human-system interaction [54]

> ***"Human-centred design is an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques"***

Figure 3.1 places the current HCD research approaches on a two-dimensional scale where it treats the user as a subject or as a design partner and if it is led by design or by research. The landscape of HCD research is wide and sometimes approaches and methods overlap (as can be seen in figure 3.1). Based on the exploratory nature of this project and its application to a relatively new field there will be a need for a combination of approaches. The two main research approaches that will be adopted within this landscape are participatory design and UCD, which will be briefly introduced in the following sub-sections.

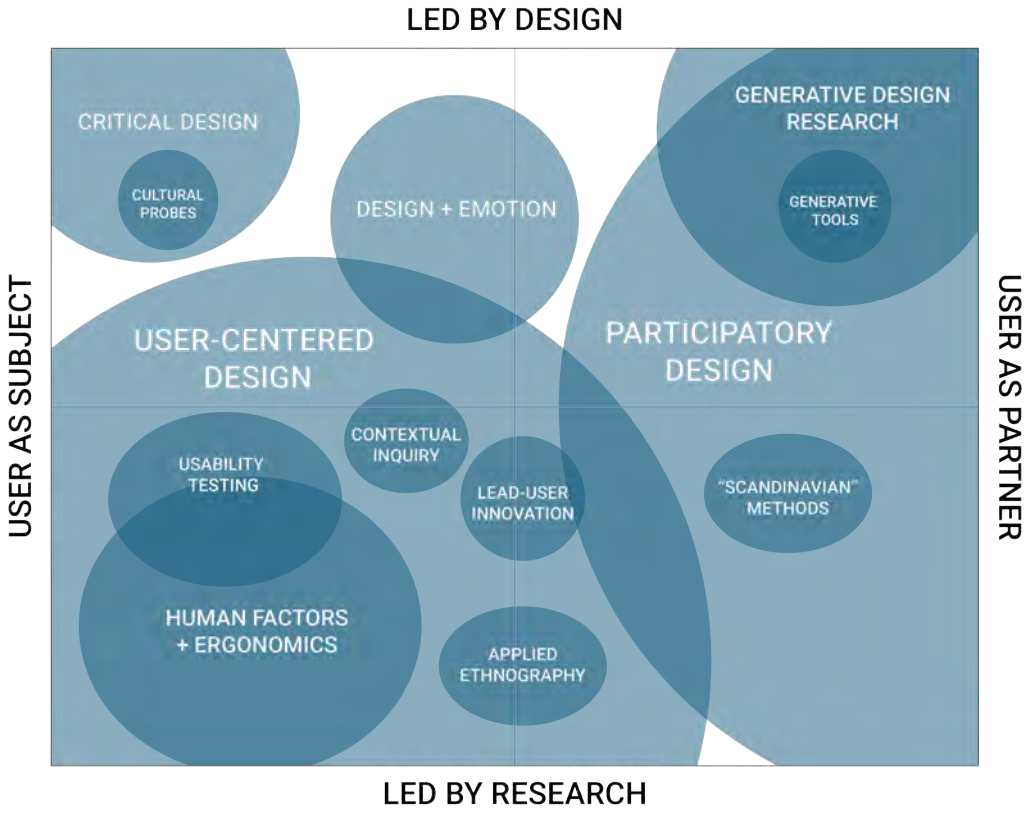


Figure 3.1: The current landscape of human-centered design research - inspired by the work of Giacomin [44].

3.2.1 User-Centered Design (UCD)

The concept of UCD is a broader term with an emphasis on involving the end-user in the design process of systems [3]. The distinction often made between UCD and for example, participatory design is that the users are more commonly treated as a subject to be studied and embrace a more passive role[3]. This can take many different forms such as answering interviews and questionnaires, performing specific tasks, and being the subject of observation. The term originated in the United States in the 1980s with Donald Norman as one of its founders [81]. Since then it has grown extensively in popularity and been adopted and further developed by names such as Ben Schneider [94] and Jacob Nielsen [78, 79]. This resulted in different design guidelines in the form of heuristics, golden rules, and principles of design that have

become popular guidelines within usability design today. Our work aims to both study children as a subject and to involve them as designers.Connell et al. is an example of a qualitative user-centered study where they examined Child-Defined Gestures with a Whole-Body interface in which they used a Wizard-of-Oz approach [21]. Obaid et al. did a similar quantitative user-centered study where they analyzed 300 gesture data which resulted in a user-defined gesture set, which could be used as input for software developers, engineers, or designers[83].

3.2.2 Participatory Design (PD)

PD according to Muller is described as

> ***"Participatory design (PD) is a set of theories, practices, and studies related to end-users as full participants in activities leading to software and hardware computer products and computer-based activities"***

Workshops, story-telling, dramas, and low-tech prototypes are a selection of examples of methods and techniques that could be used within participatory work [76]. Lupetti et al. involved some participatory actions with children through an workshop for the development of a robotic artefact in the context of playful learning [66]. This entailed three different activities mediated by a set of cultural probes[43]. Colombo and Landoni applied cooperative inquiry [31] method in their study which was aimed at designing and developing more engaging eBooks for children [20]. This method describes a process, which supports inter-generational design teams of new technologies aimed at children, with children.

In contrast to UCD, PD is a concept driven forward by the Northern Europeans which originated in a specific political context.It was a part of the Scandinavian workplace democracy movement. In this approach the user switches from 'subject' to 'partner' [93]. This movement has called for a descriptive distinction between the notions *co-creation* and *co-design*. Sanders and Stappers [93] describe co-design as following

> ***"[...]refer to the creativity of designers and people not trained in design working together in the design development process."***

In this sense, it becomes a special instance of co-creation which is considered a broader term covering any act of collective creativity. This changes the roles in the design process, researchers and designer becomes collaborating facilitators where the user are treated as experts.

3.3 Human-Drone Interaction

From the well established fields of HRI comes the sub-field of HDI [5, Chapter 6.3]. The HDI field has been on the rise as of late with projects such as The Rise of Social Drones [6], gaining research grants to explore the field deeper. However, the field is

still quite young with research regarding interaction with areal robots only starting about ten years ago [111].

Drones can be used in many areas such as photography, aiding the police in search of missing people, toys for children, education, and more. These drones can be controlled using many different mediums, such as remote controls, mobile phones, gestures, speech, and more.

3.3.1 Social Drones

Social drones is a term proposed by Baytas et al. [10] which they use to describe

> *"applications where an autonomous drone operates in an environment inhabited by human users or bystanders [...]"*

Figure 3.2 depicts where these drones are placed within the field of HDI regarding the type of user control and application area. This is based on the argument that if two or more agents occupy the same environment, social interaction is unavoidable, and therefore the same should be the case for autonomous embodied agents such as drones. By exploring existing gesture-controlled toy drones we can possibly open up CDI in the light of the term proposed by Baytas et al.

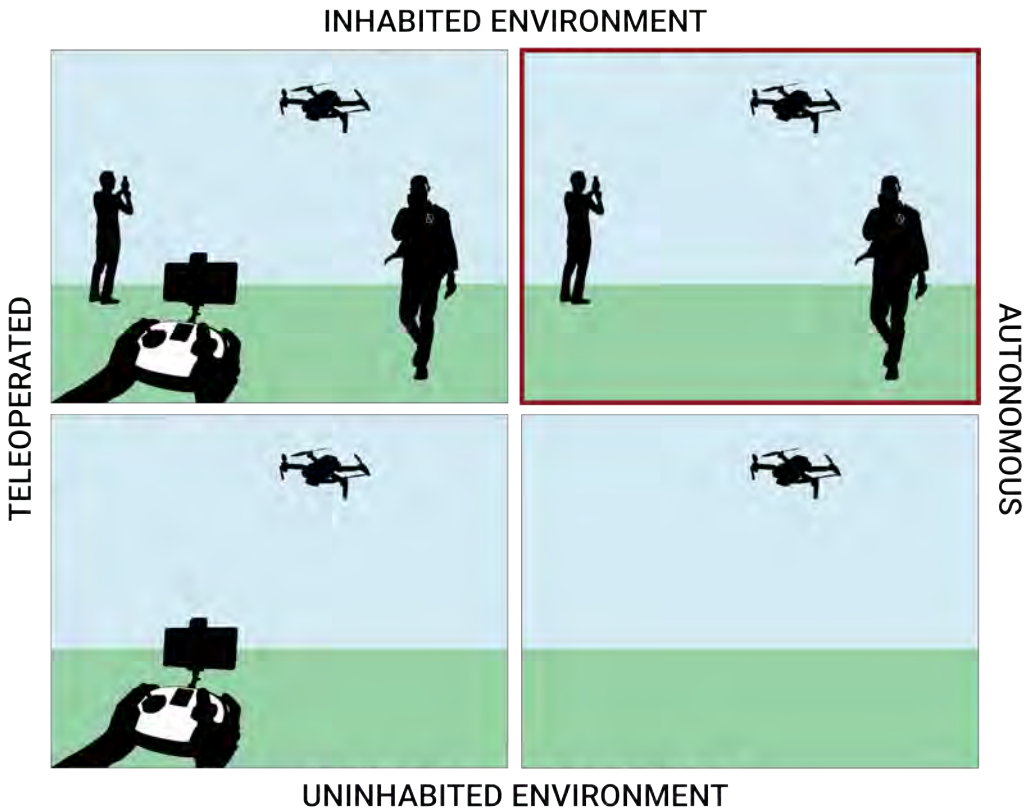


Figure 3.2: Depiction of social drones placement within the field of HDI - inspired by the work of Baytas et al. [10].

3.3.2 Gestures

When it comes to gestures specifically, some research has been conducted with authors such as Cauchard et al. and E et al., focusing mainly on the cultural differences between gestures used to control drones [18, 34]. The interaction between a user and a drone, when gesticulating a command, is an unspoken connection that relies on trust and understanding. A wrong move, a misunderstood gesture, or an unintentional gesture could have dire consequences such as the drone flying into other people that are nearby and could be hurt. However, since children start using gestures before talking [48], using gestures as a form of navigation for drones, specifically toy drones, could be easier to use between children as a form of non-verbal communication. Therefore improving this unspoken connection, can be important to make users, and mainly children, feel safe and comfortable.

3.3.3 Proxemics

Others, such as Yeh et al. are focusing on the proxemics that users would feel comfortable with drones. They also discovered that the sound of a drone can add to the stress of humans in the vicinity of the drone [112]. Which is an important remark with regards to this master thesis as children might be more susceptible to the sound of the drones since children hear differently from adults [108] and might be even more stressful than for adults.

3.3.4 Anthropomorphism and Drones

Recent work has shown that interacting through gestures in HDI gave rise to an experience similar to that of interacting with a person or a pet [107]. Furthermore, Cauchard et al. saw that the act of "guiding" a drone resulted in the user attributing qualities to it corresponding to the qualities of a puppy [18]. They also observed that failure of being able to guide could instead lead to them attributing negative qualities. These are important findings that are suitable for consideration within CDI.

3.3.5 Designing play with drones as a media

According to Caillois model you can distinguish play by categorizing it as "Ludus" or "Paida" play [17]. Where the former is characterized as "rule-bound, regulated, and formalized play" and the latter is "wild, free-form, improvisational play". Based on both the research question underlying this thesis and the fact that there is already some research done on specifically "Ludus" drone play in different areas of use [64, 99, 113] in combination with the actual definition of social drones (i.e. autonomous flyers that operate near human users or bystanders) [10] we argue that this is the most suitable play form to explore.

Alvington Silvester conducted a study with this type of play in mind in a Research Through Design (RtD) process. This was to understand the design of drone-based pervasive play. The study resulted in the design of 3 play experiences. He justi-

fies the choice of drones as a medium for game delivery by comparing it to other popular game media such as Virtual Reality and Digital pixels. This comparison demonstrates both why drones are an interesting media and also how it extends the game environment. It does this by not being restricted to location while at the same time providing the rest of the characteristics concerning feedback and social aspects of the drone. His work was influenced by prior work in the areas of drones as tangible objects, autonomous interactive drones, and anthropomorphism drones through movement.

3.4 Child-Robot Interaction

HDI has emerged as a sub-field of HRI while at the same time researchers have predicted that social drones can become ubiquitous in the near future as well as a stand-alone great HCI paradigm [10]. So, as of today in the light of the area of research surrounding this thesis, CRI becomes an important area of inspiration both for gathering knowledge as well as a guide in the choice of methods and their application when working with children.

In contrast to the lack of research within CDI there is an extensive amount of research within CRI, especially within learning experiences with robots [66, 86, 91]. For example, Obaid et al. did two pilot studies in which one of them compared two different prototyping methods in the design of classroom robots by involving children to inform the development of an elicitation method [82]. They compared their Robo2box toolkit and clay as elicitation methods. Their result indicated that these two methods could together complement each other in their respective shortcomings. For example, where the researcher wants to give freedom without bias or risk of priming the children, clay could make a good additional material to accommodate this. Furthermore, they also suggest using storytelling and interviews as complementary techniques.

3.5 Design for and with children

Research with children as subjects and partners is a complex area of study both in the light of ethical considerations and when it comes to the design of the study itself. Children entail a drastically different population compared to adults, which calls for the need to tailor methods and activities. Obaid et al. talks about the importance of age-appropriateness related to choice of material [82]. But with that said, this stretches over dimensions such as context, content, management, and engagement as shown by Mazzone et al. as well [69]. They also show that careful considerations to management seem to have a positive effect on the result of design activities with children which is why this project will give extra focus to the planning and testing of these. This will ensure that our work will generate qualitative results.

Furthermore, previous work concerning usability testing with children provides a good guideline when it comes to the grouping of ages [51]. Research with preschool

children seems to call for a drastic change in the design of the study because of the difference in cognitive development. Here language and other social and practical skills can become a significant limitation on an individual level when it comes to the chance of participating on equal terms. In addition, there are some clear safety issues to consider which shields challenges against the ethical aspect of this work. In contrast, intermediate school children between the ages of nine to twelve enable us to use established methods and do not necessarily call for innovation in regards to the use of material and props. In regards to the research question, we aim to focus on children between the ages of nine to twelve for the sake of not needing to comprise between the questioning of the method and the quality of the result.

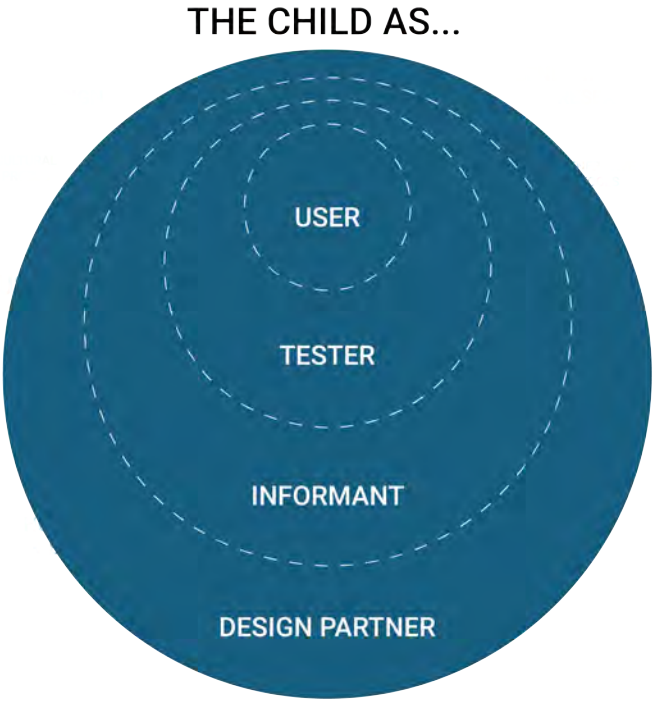


Figure 3.3: The roles children can encompass according to Druin [32].

To bring down the barrier that can easily occur when their opinions are voiced through an adult we will give the children a central role in this project where they will be treated as *design partners* by the definitions set out by Druin [32]. This encompasses roles such as *user, tester* and *informant* (which can be seen in figure 3.3). Most importantly all of this goes in line with the UNICEF convention on the rights of the child where they are now not just the holder of rights but should also be viewed as an active contributor to meaning-making in the world [9].

4

Methodology

This chapter presents the different methods, techniques, and approaches considered in this thesis. The specific methods and techniques are presented chronologically in accordance with the design thinking process.

4.1 Exploratory Research

Brown and Brown define exploratory research as,

> *"This kind of research tends to tackle new problems on which little or no previous research has been done"* [16, p. 38-50]

Which could be fittingly applied to the area of CDI as our literature study showed a lack of research in said area (see appendix for more details A). Furthermore, Hanington and Martin define exploratory research as it being:

> *"defined by user and product studies, intended to forge an empathetic knowledge base, particularly when designers may be working in unfamiliar territory"* [50, Chapter 39, p. 84]

. As our problem space is not yet clearly defined nor explored and our research questions focus on a specific user group and product we, therefore, deem it appropriate to conduct our research in an exploratory manner.

4.2 Research for Design

Research For Design (RfD) is a term created by Frayling in 1993 in his work *Research in art and design* [40].

> *"The thorny one is Research for art and design, research with a small 'r' in the dictionary - what Picasso considered was the gathering of reference materials rather than research proper."* [40, p. 5]

Unlike perhaps the more common methods such as Research Through Design (RtD) or Research Into Design (RiD), Research ***For*** Design is to focus more on groundwork

and practicing design. RfD could be seen as a way to prepare for a RtD or RiD approach.

With the RfD approach in mind, our work will not result in a high-fidelity prototype or solution, instead, it will be manifested in a concept or idea with a lower level of fidelity. This will be presented together with insights on implications for design within the corresponding area. This gives room for exploration of the problem space and can serve as a stepping stone towards applying a RtD in future research. The lack of studies within CDI and pure-play serves as the core argument for taking this stance. The commercial design of drones targeted at children is already a reality, and the research gap alone is a strong motivation to invest time to this end.

4.3 Ethnography

Ethnography is a qualitative analysis method and is essentially the art of observing natural behaviors. It is defined according to Merriam-Webster as [72]:

> *"the study and systematic recording of human cultures"*

Schuler and Namioka describes four main principles of ethnographic work; *Natural Settings*, meaning studying people during everyday life. *Holism*, focusing on the context behaviour occurring. *Descriptive*, describing how people actually behave. *Members' Point-of-View*, understanding the point-of-view from the subject studied [95, Chapter 7]. In other forms of documentation, such as interviews, information can be lost as there is often a mismatch between self-reporting behavior and observed behavior. As Schuler and Namioka describes:

> *"There is a well-known axiom in anthropology that what people say and what they do are not the same."*

By applying the method of Ethnography we can observe natural behavior appearing throughout our studies.

4.4 Participatory Design

Mostly credited to Scandinavia, Participatory design is a process in which the end users are actively involved in the design process. This is done by having end users be seen as design partners and experts in the design process, which allows them to be part of and affect the ideation and decision-making [50, Chapter 61, p. 128]. By applying Participatory design we can get insights in an open environment from the intended user group, in this case, children of the toy drones.

4.5 Methodological Difficulties in Research Involving Children

Children are a complicated user group to study not just in terms of ethical considerations but also in regards to planning, management, and execution. Careful and special attention to aspects such as management, content, context, and engagement is crucial when planning design activities with children [69]. In this work, there will be a need to combine approaches and methods from different fields and areas, such as established guidelines within usability testing with children [51], researching children's experiences from social science with a social constructivist perspective [41], combined with frameworks and methods within fields such as CRI and CTI [8]. The specificity of this user group has a strong implication on which methods are possible to follow. For example, issues of consent, deception, and cognitive ability are of particular relevance.

4.6 Design Thinking

Design thinking is an innovative approach that makes it possible to merge different approaches and methodologies from fields such as social science, engineering, design, and business [70]. According to Meinel, Leifer, and Plattner this approach encompasses three main characteristics namely *Exploring the problem space*, *Exploring the solution space* and last *Iterative alignment of both spaces* [70] (see figure 4.1 for a visual representation of this). Exploring both the problem space and solution space with the help of convergent and divergent thinking enables us to set grounds for innovation. As our work affects different stakeholders in all the fields mentioned above and the fact that it is categorized as a wicked problem, we argue that the philosophy underlying design thinking is a suitable guide for the outlining of this project.

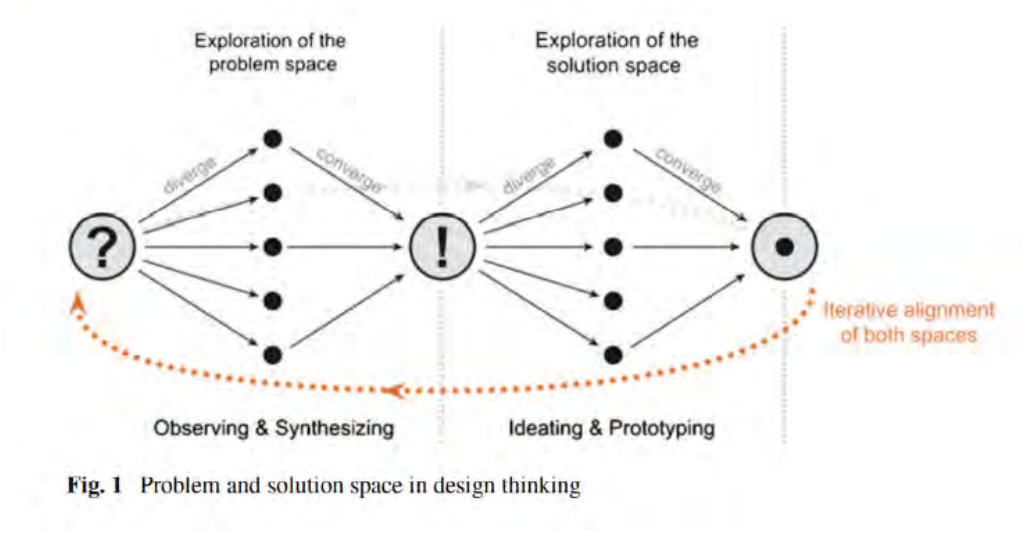


Fig. 1 Problem and solution space in design thinking

Figure 4.1: An outline of the design thinking process- borrowed from [70].

There exist a lot of different models of the design processes and it is up to the designers to choose appropriate models and methods accordingly. Jones' basic model of design [55] is an example of exactly that, a simple model which demonstrates how this design philosophy can be put into action. The model outlines three main stages of design *Divergence*, *Transformation* and *Convergence*. But as Jones himself says, this should only be viewed as basic elementary categories within the design process [55]. The design process is seldom a straight linear process [97], which explains the emergence of several different models and processes. The double diamond [22] is an example of a traditional and very usual framework to follow within interaction design, as it includes the valuable idea of iterative work. Therefore, with our background and research question in mind, it is not suitable for our project to align to a specific model of design. If anything, our project stops at the early phases, of the above-mentioned models.

4.7 Design Process

Due to this work's complexity and size, we have chosen to break up the process into more manageable parts (see figure 4.2). These parts are based on the theory of Design thinking, namely *Exploration of the problem space*, and *Exploration of the solution space*. Our intended outcome of this project is to deepen the understanding of how children optimally would like to interact and play with drones through an elicitation study with the help of enactment and design probes. While exploring this we will also investigate other important stakeholders' attitudes and feelings toward drones aimed at children (e.g. parents, teachers, other legal guardians, and family members). This will be done with the help of a questionnaire. The next step in the process finally involves the children, exploring the solution space in the form of a co-design workshop. The studies with the children will finish with testing existing commercial gesture-controlled toy drones. These studies will together serve as input for our ideation and prototyping session. In parallel, we will also synthesize our work through a thematic analysis. The result of the thematic analysis will produce the main body of our work.

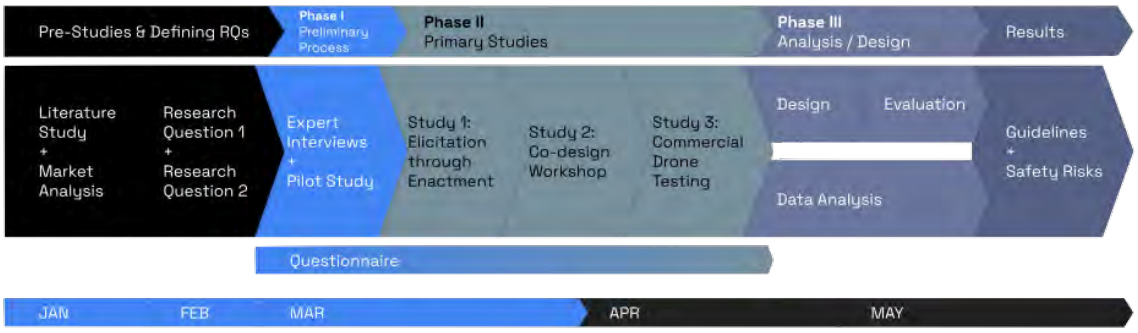


Figure 4.2: The design process through out this master thesis.

4.7.1 Exploration of the problem space

This section gathers descriptions and examples of our intended methods and techniques that are related to us exploring, i.e. gathering data and defining the problem, i.e. synthesizing data, the existing problem space.

4.7.1.1 Diverge

This stage presents the methods and techniques to be considered for the exploration of our problem space.

Elicitation study

Elicitation studies are most commonly used for generating user-defined input actions. This is a typical method to use when working with novel technology, such as Morris where they explored speech and gesture interactions for a sample of common web browser functions [74]. Other studies include works from Danielescu and Piorkowski, Tsandilas and Dragicevic, Felberbaum and Lanir, and Chan et al. who's all main focus is on gestures [19, 23, 36, 104]. The basic concept is to present the participant with an operation in which they later are asked to determine the action that caused it [80].

Design Probes

Design probes originate from the term cultural probes, where they were used to elicit inspirational answers and insights from the elderly in different communities [43]. These cultural probes were in the form of packages containing maps, postcards, cameras, photo albums, and media diaries. The maps for example were used as a means to gain insight into the elderly and their attitudes towards their environment. They used these with the help of inquiries in varied forms. Cultural probes could be defined as Boehner et al.[13]:

> "[...] a design-oriented way to acquire inspirational glimpses of communities targeted for design".

While some have stayed true to its original source its many varied uptakes have made the term somewhat of an umbrella term [13]. They have been used both as photo diaries [26], field trips [61], and as low-fidelity prototypes of smart glasses to investigate the design directions [49]. Probes can be seen as a way to provoke inspirational ideas and/or new ways of interacting. By doing so, we stay true to the nature of exploration as opposed to predetermining what should be elicited and therefore excluding other potential ways. Here, the probes are only limited to being something symbolically grounded, i.e. the children need to understand it. This could be something as simple as natural language on paper.

Wizard of Oz

This technique is very common within exploratory research where the researcher wants to test a product without actually needing to have it up and running. It defines a method where the researcher simulates system responses from a point where the participants interacting with it are not aware [50]. By this, the 'wizard', i.e. the researcher, can explore different interaction patterns in fields where established design patterns are not yet clearly defined such as within CDI. The technique is very flexible and can be used in an iterative manner as well throughout the entire design process. Though, the skills of the wizard with respect to timing, pattern, and system logic are important to increase the feeling of credibility of the simulation[50].

Enactment

In situations where it is necessary to explore interaction with non-existing technologies through low-fidelity means, Enactment is an appropriate technique to apply. In difference to the Wizard of Oz technique, enactment entails a role-play where participants get to act as a part of the system and the actuator. This provides the possibility of exploring future use and interaction without the inherent limitations of existing technology[84]. This has previously been used in research exploring whole body interaction to determine a number of design qualities [102] and within research relating to the future of highly automated cars[85] and as a part of the creation of a new design method[24].

Interviews

Interviews are a form of survey research that can take on different formats of either unstructured, semi-structured, or structured depending on what type of answers are desirable. Unlike questionnaires, interviews enable the benefits of a physical conversation where observations of bodily expression or nuances in responses can be captured [97].

Observation

Observation is an ethnographic method that can be applied at any stage of the design process. Observations entail the presence of the researcher in the context of use, and can be either covert or overt; involving participation or not. In this method, the documentation technique is paramount, varying from note-taking to videotaping. It helps designers and researchers get a holistic view of the problem under investigation; important dimensions such as context, goals, and tasks of users become a subject of investigation as well [97].

Questionnaire

A questionnaire is another form of survey research. It is a well-established technique and can be used in isolation but also in conjunction with other methods such as interviews. This is most suitable when you want to reach out to a larger number of participants. Questionnaires favor closed questions rather than open and offer an

opportunity to gather quantitative data. The researchers need to put considerate thought into the structure of the questionnaire to make it successful, e.g. you need to reduce the chance of ambiguity in the questions you ask; consider having closed questions with a range of answers including 'no opinion' or 'none of these' [97].

4.7.1.2 Converge

This stage entails the methods and techniques that we are considering for the synthesizing of the data gathered in the previous stage.

Thematic Analysis

Thematic Analysis is a method for qualitative analysis commonly used within psychology [15]. Which, according to Braun and Clarke encompasses six different phases (seen in figure 4.3) which are; *(1) Familiarizing yourself with your data, (2) Generating Initial Codes, (3) Searching for themes, (4) Reviewing themes, (5) Defining and naming, and (6) Producing the report.*

Table 1 Phases of thematic analysis

Phase	Description of the process
1. Familiarizing yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Figure 4.3: Phases of thematic analysis according to Braun and Clarke [15]

Important to note for this analytical approach, because they are guidelines, is to adapt the process to the data collected. Furthermore, as Braun and Clarke states in their step-by-step guide, this is a recursive process more than a linear process where you need to move back and forth between the different phases [15]. For example, collected video recordings could be treated as the iterative process:

1. Familiarizing yourself with your data

   (a) Watching all recordings, in parallel separately and flagging important events

   (b) Dividing up the work, watching flagged events and taking notes and transcribing

2. Generating initial code

   (a) Generating codes for flagged events, in parallel separately

   (b) Collectively going through all generated codes and generate collective codes

3. Searching for theme

   (a) Collectively searching for themes and minimizing the amount of codes

4. Reviewing themes

   (a) Dividing up the themes for each research question

   (b) Eliminating themes not relevant to the research questions

5. Defining and naming themes

4.7.2 Exploration of the solution space

This section gathers descriptions and examples of our intended methods and techniques that are related to us exploring, i.e. gathering data and defining the problem, i.e. synthesizing data, the solution space of our problem.

4.7.2.1 Diverge

This stage presents the methods and techniques to be considered for the exploration of our solution space.

Ideation

This phase entails different methods and techniques for ideation within the design team [52]. This is used to generate numeral ideas based on the results from exploring the problem space. This is then used as input for the converge phase where choices will be made. Methods used here could be for example brainstorming [56] and sketching [50].

Co-design workshop

A co-design workshop is a form of participatory design method which can be used within the generative research of projects. Co-design workshops involve direct contact with the target group. They often contain different co-design activities which contribute to the ideation process. This can also assist design teams in the choice of design direction. Careful considerations in regards to timing, logistics, as well as the choice of material are of critical importance. In addition to this, the proportion between numbers of facilitators and participants needs to be well-balanced [50]. All of this becomes even more important when working with children. A Co-design workshop describes an explicit form of a workshop, which is structured around a session of collective creativity within the design process between experienced designers and people not trained in design, often end-users.

Skewing

Skewing is a structured ideation method that is entrenched in changing preexisting interaction-related properties [65]. Although presented mainly as an exercise for understanding interaction frameworks, Lundgren and Gkouskos also advocates for the use of Skewing as an ideation method. This enables interaction designers to produce re-designs of an already existing artifact with new interaction design features. Skewing requires a set of properties to be identified beforehand and is, therefore, more suitable for the redesign of existing artifacts. However, through pre-studies, a custom set of properties can be gathered, allowing for a playful approach to the problem at hand. In the work of Lundgren and Gkouskos, they describe five steps on how to proceed with the Skewing method:

1. Select an interactive artifact to redesign.
2. Select a suitable framework for analysis and redesign.
3. Analyze the chosen artifact using the chosen framework.
4. Start the skewing process by changing one or more properties.
5. Select the most promising/odd/interesting ideas or changes.

For our work, the method of Skewing can be incorporated in the ideation phase for our prototypes using data gathered from the primary studies.

4.7.2.2 Converge

This stage entails the methods and techniques that we are considering for the synthesizing of the data gathered in the previous stage.

Prototype

To give life to the generative research something needs to be built or created to enable evaluation. This operation is often called prototyping and can be performed at different levels. In the early design phase prototypes is often of low-fidelity, e.g. paper, mock-ups, sketches, storyboard, wireframes, etc. These often evolve to so-called high-fidelity prototypes that function more like the intended end product, and may have a more accurate look and feel [50].

Storyboards

Storyboards are a common prototyping tool that can help visualize context and convey important factors and aspects of a proposed product. Interaction designers can use this to show their user group how, where, and why their product works [50, Chapter 82, p. 170].

In the work of Truong, Hayes, and Abowd [103], they describe five important elements of a storyboard as:

1. Level of detail.
2. Inclusion of text.
3. Inclusion of people and emotions.
4. Number of frames.
5. Portrayal of time.

Storyboards can be used for many different contexts, Glebas shows how it can be used within animation creation [45]. Other works showcasing storyboards include the works of Goldman et al. for video visualization, Knauf et al. for modeling didactic knowledge, and Walker et al. for analytic visualization [46, 59, 106].

Evaluation

A natural step after the creation of a prototype is to evaluate it to inform what should be done in the next iteration. Evaluative research is comprehensive in terms of not only being concerned with performance measures but also preference, which entails both aesthetic and emotional responses [50]. The way of conducting this depends on the form of the prototype.

Critical Reflections

Critical reflection is a method used to try and encourage critical thinking, often with children in co-design workshops. With this method, children can get a reflection on ethical dilemmas, which can arise during co-design workshops, and make sense of their feelings [75]. The work conducted by Mott, Bejarano, and Williams describes using critical reflections with children in participatory design workshops focusing on robot technology [75]. They also emphasize on the importance of critical reflections within HRI and HCI. In this method, it is of importance that researchers adopting this method also try to overcome the researcher-child power dynamics [75].

5

Phase I: Planning and Preliminary process

In phase I of this project (see figure 5.1) we present the execution and process of the preparatory work conducted prior to the execution of our primary studies, for the purpose of enhancing our knowledge and understanding of research with children as well the possibility of detecting obvious errors in advance. This preparatory work entails expert interviews and a pilot study. We also present the outcomes of each of this step and how it affects the continuation of our work.

Figure 5.1: Phase I: Planning and Preliminary Process.

5.1 Timeline

The timeline for this master thesis was been divided into five phases, Preparatory Work, Studies, Data Analysis, Design, and Writing and Presenting (see appendix D for GANTT schedule). Where the latter was continuously conducted, especially the report writing within that phase. It is important to note that this process was not meant to be followed explicitly as it is difficult to plan for something we had never done before. So it should be seen as a suggestion of a time frame for us to keep during the process.

5.2 Consent and Study Ethics

When conducting studies that involve children, especially with children that are under the age of 15, it is important to not only get the consent of the child but also from the guardian of said child. According to the Swedish ethics authority (translated), *"The information should be adjusted to accommodate the person's age and prerequisites ..."* and *"When researching with children, the information should be aimed at both the child (if literate) and the child's guardian."* [35]. We did this by having one consent form, aimed at the parents of the children participating, and an informational sheet, adjusted so the children gave their verbal consent.

It is also important to follow the General Data Protection Regulation (GDPR) law when storing the consent and data of the children. This is because recordings, interviews, opinions, and other forms of personal details are sensitive information and so they should only be used for research purposes.

Since this project used drones to investigate children's interactions, some ethical dilemmas arose simply due to the use of drones. For instance, the propellers on the drones could potentially hurt a child if not properly watched and protected. This could in turn give the children scars for life, both mentally and physically. It is therefore important to not only follow the manufacturers' age restrictions but also exercise caution during the flights with the drones. For example having safety gear, which could be glasses and mittens, for the children to wear when flying the drone.

Because our studies use a participatory approach, where the children are our design partners. We have looked into the works of Spiel et al. for guidance. Although their main focus lies within children with disabilities, they consider their processes to be 'child-led'. This gives us insights on how to approach children as design partners [100].

This project will ensure that all of the above considerations and more are upheld by applying the UNICEF ERIC framework regarding research involving children using their guidelines [47]:

- Ethics in research involving children is everyone's responsibility.
- Respecting the dignity of children is core to ethical research.
- Research involving children must be just and equitable.
- Ethical research benefits children.
- Children should never be harmed by their participation in research.
- Research must always obtain children's informed and ongoing consent.
- Ethical research required ongoing reflection.

Their guidelines provide key questions to consider when working with children which gives a strong ethical foundation to rely on. Furthermore, It is also important to understand, that according to Quennerstedt, Harcourt, and Sargeant it is the individual scientist that is responsible that the study is being conducted correctly [89]. To support the process of designing the study we conducted expert interviews with people experienced in working with children. This contributed with some descriptive insights on how to apply these normative frameworks.

5.3 Expert interviews

Due to the complexity of research involving children, and our lack of previous experience, expert interviews were held to gather as much knowledge and insights on the subject as possible. As a first step in the recruitment process of experts, an inquiry was made using our local Slack workspace. From there we got in contact with either people at Chalmers University or someone else that fit into our inquiry. In total, five expert interviews were conducted where the participants varied in terms of experience, age groups worked with, profession, and educational background. The experts consisted of a professor, a senior lecturer, a researcher, a child culture designer, and an alumnus from Chalmers University. All of the experts were based in Sweden but the majority come from all over the world. Each interview session was either video recorded or audio recorded, depending on the form of the meeting. These were then transcribed to facilitate the synthesis of our result.

In each of the recorded interviews, we first asked for consent from the interviewees to record and use their answers within this master thesis. The setup of the interview consisted of an introduction of our background and a short presentation of our master thesis work and what it consists of. Then we prompted their initial thoughts on our ongoing research and research questions as well as our preliminary execution and process of our studies. This preliminary process included three primary studies, based on our findings in the literature study, which were in the order; Commercial drone testing, Elicitation through enactment, and a Co-design workshop. Which would then lead to a design and an evaluation. We proceeded to ask questions about their background, work, practice, and experience in the field. The interview was finalized by asking again for their consent and thanking them for their time.

Below, we present a list of the interviewed experts, with associated pseudonyms. The specific questions that we asked our experts can be found in appendix C, however, personal questions have been removed. Specific questions where the expert gave answers that contained identifying information were dismissed.

5.3.1 John: Associate professor

We met John in person and recorded the interview via audio. John has extensive experience with both drones and children, age group nine to 13 years old, from previously conducted studies. However, his main area involves quantitative studies and mainly adult participants.

The interview lasted about 45 minutes and during the interview, we asked him questions such as related questions to his field of work, his thoughts on drones, and general questions leading to a discussion about our research questions. To wrap up the interview we also showcased the drones that we had bought.

As we presented our research study setup, which had the order of Commercial drone testing, Elicitation, and Design workshop, he advised us to change the setup as we would encounter an order effect:

> *"[You] will have an order effect in your studies, what will happen is that, okay, they play with these drones. They're very much biased by what they have seen and what they have played with. And this will imply that both gesture interaction or elicitation study, and the design workshop that you're planning will be heavily impacted by this first session."*

He suggested that if we remove the first study, Commercial drone testing, the rest of the studies would be based on what the children had seen in the media and from their own experiences. However, John pointed out that this could also lead to another challenge. Namely the challenge of getting the participants away from their preexisting ideas of what a drone is.

> *"[One of the challenges] is to really get people away from misunderstanding what the drone can do and cannot do. [Talking in general], like a lot of us think of drones as something maybe for surveillance or something used in not a social context."*

> *"[When we work with children], one assumption is that they are very much influenced also what they have seen in media. [That's another challenge] How do you actually ground that to your reality? So there's always a mismatch between what the, what the user expects from, let's say, a drone or a robot and what it actually can do. [This] usually influences how people interact with a drone, or a robot as well."*

When talking specifically about the elicitation through enactment study, John advised us to zoom in on what is important and on what exactly we want them to elicitate. He also cautioned us that we might see an order effect here as well, that the very first action has an impact on the rest. To accommodate for some randomization, he advised us to have many participants. John also presented a challenge with having children as participants when it comes to elicitation and enactments.

> *"I think what will happen is that, oh also it depends when you say children depends on the age group too. Because if it's a playful scenario, you might see a lot of gestures happening. Because it's a playful scenario, it's less of a command [and] more like maybe several commands in one."*

We then moved on to discuss the issues that could arise with the design workshop, John talked about his previous experience with workshops and that often it is difficult to get everyone's opinion. That we might encounter the challenge of having a

dominant actor in the group that might take over the design. John also advised us to give the children a context to design from in the workshop.

> *"It needs to have a context. So if you just say, 'okay design a drone', that's very difficult. Like you need to have some sort of context."*

He then gave an example of how he has previously conducted workshops and the context their participants were given. John also mentioned his previous experience when casually observing different user groups, their behavior with a Kinect [1], its limitations, and its effects during a demo. He first described that the general user group of adults would often get and do the given command without limitations.

> *"What we noticed is that with adults, you tell them a command, and they wait and then you tell them 'Okay do this [raises his hand]'. And they would do it, like raise your hand, for example."*

When it came to children he said that he observed that children often did something more when carrying out the command given, that the system often cannot handle.

> *"Now children, which is that, of course, that's their nature, they like to play and they like to discover and explore. They would, of course, listen to your command but they would do something a bit more. Like you always do something different, like they always do the extra extra thing. And the technical side of it does not support that. Like, for example, we used a Kinect, which was expected someone to raise their hands. Now, if the child jumps, the system would not recognize it."*

Another user group he observed was people with a technical background.

> *"Another observation with user groups is if someone is technical, comes from a technical background. They know the limitations of the system, so they would recognize the Kinect. "*

He said that the user's experience would make a difference in who explored.

> *"So it's, it makes a difference in terms of like the ones who explored, they know a bit more about the technology, or they have used the technology before they would most likely get a bit trite so they wouldn't go outside of the frame of the Kintect. But the one who do not know much about the technology they might actually do something completely different that does not go outside the boundaries of the Kintect."*

We moved on to ask questions about his thoughts on what the main challenge is today for researchers and designers when it comes to drones, to which he replied that the main challenge right now is to bridge the gap. To show that a drone can be a social entity, and to bridge said gap he thought that people need to see the

[1] A motion sensory input device

usefulness of a drone in a social context, not only as a practical aid but also as a social utility. He also talked about how bridging the gap between what designers design and what stakeholders want. In his experience with workshops, he found that there is often a mismatch between what designers want to design and what the workshop participants want.

To wrap up the interview we asked him if he wanted to see some of the drones that we had bought to test out during the studies, what his first impressions are, and if he might see any immediate safety risks with them. The first thing he mentioned was the safety aspect, not only that of the drones but also of the studies themselves. When talking about the studies John urged us on the importance of having a safety net available for the users, which also applies to all studies according to him. When asked specifically about the drones we showed him, he mentioned drone aspects such as sound, speed, integrity, and general safety.

> *"I mean, of course, it's a flying thing that's moving, and it's got the speed and the spin. So [the main thing] is to think about [so that the drone] doesn't like, go right into someone. "*

When talking about the specific size of the drones we presented, John said that the drones' speed and size play a large role.

> *"[talking about the general user], the size of the drone plays a huge role. ... Of course, [it's] common sense like [the larger the] drone, the scarier it gets in terms of speed and all that. I guess this one probably feels a bit more comfortable. Even if it comes towards me, it's probably not gonna do damage. But I would still be afraid if it came at [a] high speed."*

Because John has experience with children as participants he offered to send us a consent form, that he has used before, as a guide for us.

Towards the end of the interview we talked about our own perceptions on the safety of the specific drones we presented to him, we also mentioned that one of us got their finger hit by one of the drone's propellers when trying to stop it. To which John replied that it is dangerous, even if it does not physically hurt you, and that safety has a major role in how we interact with drones.

5.3.2 Melissa: Child culture designer

This was the only interview that was not recorded, which was due to external noise in the interview location. Therefore only notes were taken. The interview with Melissa lasted about 30 minutes where we asked her about her previous experiences, what she does today, and questions regarding our research. Her previous experience included conducting research with children, participatory workshops with children, and generally working with children. Since her main previous experience is within participatory design she mainly provided us with advice regarding our co-design workshop and having children as participants. It was also through her we got in

contact with our participants for our primary studies.

After presenting ourselves, what we do, and our research, the first thing she mentioned to us was the UN convention article 12 is now law in Sweden. Which she emphasized meant that children needed to participate in designs when it concerns something that affects them.

When talking specifically about play, and designing play for play's sake, Melissa mentioned that children communicate through play and urged us on the importance of letting the children discover for themselves. That we should get to know them through play, get to know their personalities and not put them on the spot.

Melissa also gave us advice, based on her own experiences, on how we should conduct the drone testing session. The importance of introducing ourselves, what we do, our objectives and goals with our research studies, and to show what we have already achieved. She also suggested that during the session we should lay out the drones, have the children together when playing with the drones, and let the children discover. To have activities with the drones and ask afterward if the children think that the activity was good for that specific use case. She was also the one giving us the advice of asking questions in an ongoing format instead of having one-on-one interviews.

We talked to Melissa about participants and how we had emailed a lot of schools to try and get participants. According to her, it was preferable to try and get participants from leisure centers rather than schools. She said that with leisure centers, the children can choose to be there and therefore it becomes more of a democratic environment. While at school, the children cannot choose to be there, and being present during school hours might make the children feel forced to participate.

Because she has experience with children as participants she offered to send us a consent form that she uses as a guide for us.

Towards the end of the interview, we thanked her for her time and asked if she consented to us including her interview in our research.

5.3.3 Anna: Senior Lecturer

Anna is a senior lecturer who has been working with children for about nine years, mainly in child robot interaction and as a teacher. The main age range she has worked with were children in intermediate school, ten to twelve.

The interview was conducted and recorded via the video conference platform Zoom and lasted about an hour. During the interview we asked her about her experience when researching with children as participants, with participatory design, her thoughts about child-drone interaction in the future, and if she has any advice for us when researching children.

After presenting what we do, the background for our research, and our research

questions we asked her what she would have done if she were in our shoes. Anna said her first step would be to conduct tests with the drones in a safe environment by herself, before testing the drones with the children. She also emphasized the importance of safety, both in terms of safety gear and also in terms of the drone's behavior and proxemics.

> *(Translated from Swedish to English)*
> *"In fairly safe environments, I would have done tests first and foremost. And then to have children test them, with safety gear so perhaps they wear protective clothing, protective helmets and so on."*

She then talked about her experience with children and what is important to take into consideration.

> *(Translated from Swedish to English)*
> *"There are things in children, a certain lack of control and self-control, that one must take into consideration."*

She also mentioned that conducting such research is about conducting a lot of tests and that it can also be about designing together with users with participatory design and the like. When specifically talking about proxemics, Anna urged us to keep in mind the distance between the child, the drone, and the speed at which the drone gets close.

> *(Translated from Swedish to English)*
> *"Just looking at these distances, which you spontaneously want to keep. But then also the aspect of sudden movements and such, [that] you think about things like that. It's something that I think scares children that, if it gets too close too fast, anyone would [react]. That when [the drone] comes flying towards you, you overreact of course, when you do not know that you can really trust this thing yet."*

Continuing, we discussed with her the groups that we would conduct the studies with. We also mentioned our literature study and when discussing a certain article that we had found regarding experience and age correlating, she urged us to be cautious of this. That while experience tends to correlate with age, that is not always the case, and we should not go into the studies with such a mindset either.

> *(Translated from Swedish to English)*
> *"It is just that age tends to correlate to experience, that is the problem. If you have grown up in a home, with a lot of smart technology and gadgets like a smartphone or something. Then automatically you will be more comfortable around [drones], even if you are only eight years old. While someone who has lived on like a farm and that never have had a phone or anything at home and is 13 years old, will of course be terrified when they see a drone for the first time. [Just so] that you are aware that age, it is not the age that is significant but that it tends to be more common*

with technology experience the older [you are].”

We then showed Anna some of the drones that we had bought for the research studies, and their functionality, to get some of her thoughts on them. She explained her thoughts on what she thinks a user would like the drones to do.

(Translated from Swedish to English)
“What you would like, just as a spontaneous thought, what you would like with one [of those drones] is that, partly you want to be able to make it go up by [gesturing] in some way, but then you also want it to be able, instead of catching it in the air, [that it should] land when you want it to land. By bringing out a hand and [that it] should be able to understand it, or that there should be some special gesture for it. Because it would have been the most comfortable for most people, if it calmly and gently comes and lands in your hand when you hold out your hand.”

We asked Anna what age range she has worked with before, when answering that she has worked primarily with intermediate school children we asked her what her thoughts were on that age range. She answered that it was a good age ethical-wise and in terms of the children’s own understanding.

(Translated from Swedish to English)
“It is old enough to not [be] very ethically complicated and because you can talk to them. They are not too young to understand what is [going on] and they are not too old to think that it is silly either.”

She emphasized that it of course also depends on the child that is participating and that older children can be very interested in learning with robots for a pedagogical purpose as well.

When specifically being asked how it is to have children as participants and what is important to do she explained that, in her experience, it is important to understand children in general to some extent and have some competence. That actually being present with the children is important, rather than just reading a script.

(Translated from Swedish to English)
“[To] like act, reading from a script on a piece of paper, and like direct the children and expect them to do what you want. That is, it can be problematic sometimes I think when conducting research studies, and this just [knowledge] I have picked up. [Simply acting], It does not work.”

We asked Anna about her thoughts on child-drone interaction and the future, to which she answered that the drones need to be robust and have more functionality to them rather than just flying. That incorporating the drone into certain games, where she also gave some examples, could perhaps keep the children’s interest longer.

(Translated from Swedish to English)
“I think [the drones] need to be robust for [it to] work. That children

> *should not get tired of [the drone], that there must be a functionality to it. That it just flies around, it may not work in the long run. [In that case], it should be like a game, hide and seek or something with [the drone] flying away and hiding, so you have to count. So that kind of thing could certainly capture children's attention and keep them interested."*

Towards the end of the interview, we talked a bit more casually and she gave us some advice on literature that we could read. We finished the interview by asking her again if she consented to be recorded and thanked her for her time.

5.3.4 Noah: Alumni

The interview with Noah was conducted over the video meeting platform Zoom and was both video and audio recorded via the platform as well. Noah is an alumnus of the University and has some experience with children, both with researching with children, ages ranging from ten to twelve, and working with children of many different ages.

The interview lasted about 40 minutes and during the interview, we asked him questions such as his previous experience, his thoughts on the future of drones, and if he had any advice for us generally.

After presenting a summary of our planned master thesis, the research study setup, and our research questions he first asked us what our age group range was. To which we answered that our planned age range was between eight to ten years old, but due to circumstances will most likely be eight to twelve years old. Noah recommended we go with the age range ten to twelve years old because of his previous experience.

> *"I would definitely recommend ten to twelve. They are definitely a bit more capable. Eight, when [conducting research study it] was very tricky, very, very tricky. They were either like very good or quiet."*

Noah also mentioned working with teenagers, 13 to 16 years old. When asked what the largest difference is between the teenager group and the pre-teen group, Noah described it being trust and fear of judgment.

> *"Eight to twelve, I would say that you can give them almost anything, and they will pay attention, not pay attention to it, but be interested a little bit, if you have the right approach. Well, if it's more than twelve, you have to gain [their] trust, and [show them] that you won't be judging them for whatever they're doing. Because they feel so on the defensive side sometimes. So [sometimes] it was very hard to just like, get their thoughts and opinions because they felt [judged by] everything. "*

When talking specifically about the research study setup Noah gave the advice, similar to what John had advised us to do, of giving the children a context or a role for the design workshop.

> *"[Try not to assume that they are children] but try to give them a role of someone important, like someone that has the knowledge to do something, so not like 'Hey, I am here I have this thing that I want to do and I will give you this and you and I know that you might fail' or something. But give them a sense of confidence in what they will be doing, like 'We are here, [give them power] and you will be helping me that I will be trying to help you have fun' or something. So from the beginning, it should be like a very horizontal feeling that you want to give them in order for them to be comfortable as well."*

When asked about what his opinions are regarding the future of child-drone interaction. Noah replied that while he is not very experienced with drones he would probably think of the drones as more of assistants or aids to a certain goal, or game, but not the goal itself. When it came specifically to child-drone interaction, he suggested drones being aids for traditional games such as tag or duck-duck-goose.

> *"[Talking about tag], if it's chasing someone, or it's a group of children, [the drone] just hovers on top of you if you're it."*

This led us to the question of wanting to know what Noah would think is the most interesting thing to investigate when it comes to child-drone interaction. Noah said that he would mainly want to know how the children would interact with the drone if they have not had any interaction with a drone before, and that his first thought was that they might want to throw it. He also mentioned he would be interested in what the children would get out of a drone besides the technical aspect of it.

> *"I would say, how involved the children feel with the drones. Nowadays, besides technological interests that they might get when playing with a drone? How creative can they be with the drones actually?"*

Noah also talked about how hard it is to recruit children for research studies and advised us to request help from our institution early. That emailing schools, which we had done previously, would not produce much as it is a matter of trust. The institution has more of a trusted role when it comes to contacting schools, which individual students do not have, and requesting that help can have a great effect on recruitment.

Towards the end of the interview, Noah gave us some general advice about how to structure a master thesis, what is good to get started on right away, reference handling, and getting a mutual understanding of each other's expectations and knowledge.

5.3.5 Henry: Professor

The interview we had with Henry was held online on the video conference platform Zoom and was both video and audio recorded, through the platform. Henry has previous experience with children in research studies he has conducted, mainly with

high school students ages 16 to 19.

The interview with Henry lasted about 40 minutes. During this time we asked him questions such as his previous experiences with having children as participants, what advice he could give us regarding our research studies, and what he saw for the future of child-drone interaction.

The main advice Henry had for us was to decide early who the responsible adult is, both in general, during the research study, but also in the room during the study.

> *(Translated from Swedish to English)*
> *"[The question is], partly who officially is responsible for everything, and it is probably typically such a thing that in many cases or for the most part it does not matter. But sometimes, maybe someone can like [wonder] 'Who's telling me this' or any parent who might be wondering, 'Who's in charge of this?'."*

He emphasized that often it is not important who is responsible, but that it is vital to have decided upon it beforehand in case such question would arise from parents, or anyone else. Henry also mentioned that this could be important for when the children perhaps zone out or are behaving badly, that it is up to the responsible adult to handle the situation. Which, according to his experience when researching, could vastly differ. That some teachers are very much involved in the process, while others simply 'drop off' the children at the study and leave.

> *(Translated from Swedish to English)*
> *"An experience that I have, I don't know if this applies to the leisure center or the leisure leader, but it is that the teachers are very differently involved [in the study]. [I have had] studies with students where the teacher has basically 'Hello, this is Henry from the university. He is going to do a thing, bye' and then the teacher has just left and it has been me, as the facilitator that has been responsible, for the [children] to not be on their phones, tease anyone or something."*

When asked what he wish he knew before conducting studies with children, Henry said that formulating a consent form is harder than one might think and can often be overlooked as an easy task. That writing a consent form can be done in so many ways and needs to include all of the important information, but luckily there are templates online. Henry also advised us to have a plan B, that things can easily fall apart and that having a backup plan already laid out can save time.

> *(Translated from Swedish to English)*
> *"[Speaking specifically from his experience] That it can be so much practical stuff this with substitute teachers, who get sick and that it is always good to have a plan B if there is something that [goes wrong]. [Maybe] someone forgets the key to the leisure center and then all of a sudden you can not get in... It's so easy to think that [everything] will flow, but*

sometimes [it does not]."

We then moved on to ask Henry what his thoughts were on the future of child-drone interaction. He said, that he had very little experience with drones in general having only played with some toy drones before but he mentioned seeing different drone competitions. In one such competition, the drivers of the drones wore Virtual Reality (VR) headsets to steer the drone from the drone's point of view, which he thought was interesting.

Towards the end of the interview, we asked him once again if he was okay with us recording and thanking him for his time.

5.3.6 Conducting research with children

From each interview, we gained more knowledge of what to expect and consider when conducting research with children as participants. When talking to the experts, they emphasized on the complexity of conducting research with children. For example, the expert John made us aware of the order effect regarding our original setup with the studies. He also made us aware, from his own observations, of how children can act within research studies. From this expert, we also got sent a consent form to draw inspiration from when creating our own for the primary studies.

This is also something that our expert Melissa did as well, which aided us as we had two consent forms to draw inspiration from. This expert also urged us to focus on creating a natural and democratic environment with the children. By presenting the children with all of the drones at once, in the commercial drone testing, we would allow the children to choose themselves what and the order of playing with the drones. By also talking to the children during activities we would allow for a more natural and casual talking process with them, instead of putting them on the spot with individual interviews.

Which is something that our expert Noah also mentioned, that putting children on the spot could make the children close off. However, Noah also advised us to not have talks with the children in too large groups as this might create chaos and the children's attention might be lost. He also emphasized on the importance of documentation, not only for our reflection's sake but in general, to write constantly to not lose important reflections and happenings.

Another important complexity of conducting research with children was brought up by our expert Anna, she emphasized on how experience does not necessarily correlate with age. That experience only **tends** to relate with age, which is the opposite compared to what some articles stated in our literature study. She also urged us to not go into the studies with this attitude, as it would create a bias.

We were also urged by one of our experts, Henry, that deciding who was the adult in the room and who had the main responsibility was important to decide before. As this is often overlooked, he emphasized on that even though not often an issue

is it good to have this decided in case it becomes important. He also urged us to have a backup plan, in case anything goes wrong, for instance, if the leisure leaders got sick and had to cancel.

5.4 Pilot study

A pilot study was conducted to test the planned execution and process and to discover and resolve potential errors before the primary studies.Among other things, we intended to identify if the activities planned would be suitable for that particular age group. The planned execution and process to be tested consisted of three parts: (a) a design ethnography study,(b) an enactment session, and (c) a co-design workshop. While these three were to happen on six separate occasions with more children during the primary studies, during the pilot study they were combined into one session due to convenience and time limitations.

We also chose to have it in this order, even though we were advised to change the order from our expert John, due to our work being qualitative and thus some degree of an order effect is acceptable. And due to us not knowing in advance their prior knowledge of drones we believed it to be appropriate for them to have somewhat of an understanding before prompting them to design a drone, hence why we started with commercial drone testing and enactment.

Two children, male siblings between the ages of 10-11, were recruited for the pilot study through convenience sampling. Before the session, the guardian of the children signed an informational consent form. The pilot study was held in a media lab at the university for the first two activities, and in a prototyping studio at the university for the last activity. The pilot study was both video and audio recorded. During the entire pilot study the children's mother was present.

5.4.1 Introduction

At the start of the session, we introduced ourselves and explained what we worked with, and presented the goal of this particular study. Key terms such as drones were described and shown using pictures of a variety of commercial drones to further facilitate the participant's understanding of the term. The children were then also given an opportunity to ask questions. Information on data collection and handling was provided along with a distinct emphasis on the fact that their participation was voluntary and that they could at anytime withdraw or quit. The children consented orally to audio and video recording, picture taking, as well as handling of data.

An informational sheet covering the oral information, along with the printed questions of consent was handed out to each of the children (see complete information sheet in appendix F). As advised by our research and one of our experts this informational sheet was an adjusted version, appropriate for the children's age group and without the need for signing, unlike the informational sheet and consent form given to the guardian before the pilot study. The information sheet given to children was

greeted with hesitation and it was clear that whenever they felt confused or skeptical they glanced at their mother for clarification. It was necessary to assure them that they did not need to read it then (if at all) and that everything written on the information sheet was a repetition of the one given orally to them. We explained that the aim of the information sheet was to be able to be read afterward either by them or another guardian.

Besides consent and information about the study, a security run-through was held, where we reviewed the risks and what safety measures had been taken to avoid these. The children were provided with gloves, glasses, and hearing protection, the latter being optional. None of the children used the hearing protection, and due to the gloves being too small these were unfortunately not used either, which was important to consider for the next studies. The children were also actively encouraged to use their cellphones to take pictures or videos if they liked, and later share the images with us. We aimed at leading to a use of their own cellphone that would contribute to the study rather than distract.

The introduction took about 10 minutes and was not recorded because the children had just given their consent. However, some notes were taken during the session by the one of us that was not leading the introduction.

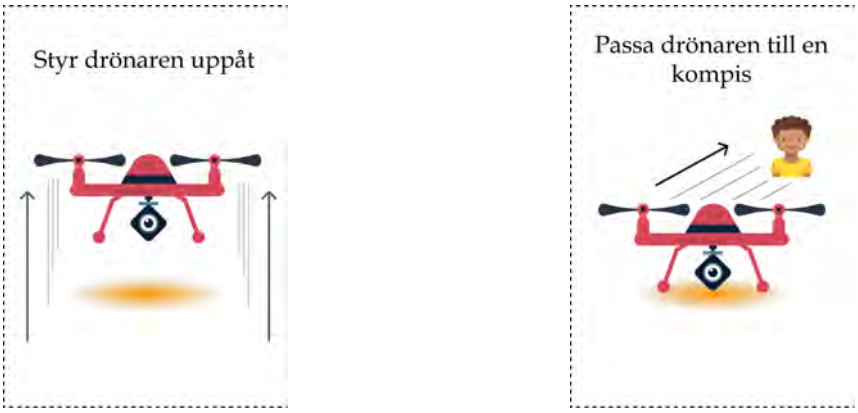
5.4.2 Activity one: Commercial Drone Testing

The activity consisted of testing each of the four toy drones, one at a time, with questions asked during and after each play session. This activity aimed to familiarize the children with the available gesture-driven drones on the market. The play session was around 5 minutes each since this was the approximate standard battery time for each drone. The four drones were lined up on a table and the children were free to choose which one they wanted to start with. The questions asked during the play session included how they felt, what they did, and according to the answers, space for clarification and further investigation. After the use of each toy drone, they were asked to summarize their experience.

After all of the drones were tested, the children were asked to choose a favorite drone, which they could play with a little more if they liked. However, this was not possible as the batteries of the drones were depleted. The activity ended with the children and us gathering in a circle on the floor to ask more about their overall experience with the drones.

5.4.3 Activity two: Elicitation through Enactment

This session lasted about 10-15 minutes and consisted of one of the children acting as a drone while another did gesture commands to the “drone” based on a deck of cards with actions given, after all of the cards had been gone through the children switched places. This activity aimed to elicit possible connections between gestures and actions performed by the drones. The cards were created with instructions on what action the drone should do (see examples in figures 5.2a and 5.2b).



(a) Steer the drone upwards **(b)** Pass the drone to a friend

Figure 5.2: Examples of two cards with elicited actions illustrated by text and illustrations that was used in the pilot study.

The cards described an action to be elicited by gestures with the aid of text and illustrations. A selection of cards were made for the pilot study. Afterward, they were asked about their thoughts and feelings regarding the activity, if they had anything they would like to add to the activity, if they understood the meaning of the cards, and if they could see this being an activity for their peers.

5.4.4 Activity three: Co-design workshop

The third and last activity was a co-design workshop. For this activity, we changed location to a prototyping studio where we were gathered with the children around a table. By this table, we had gathered prototyping materials such as clay, paper and pen, tape, scissors, rulers, aluminum foil, adhesive, and poster potty (see example of materials in picture 5.3). A wide selection of prototyping material was provided intentionally to allow freedom of choice and preference.

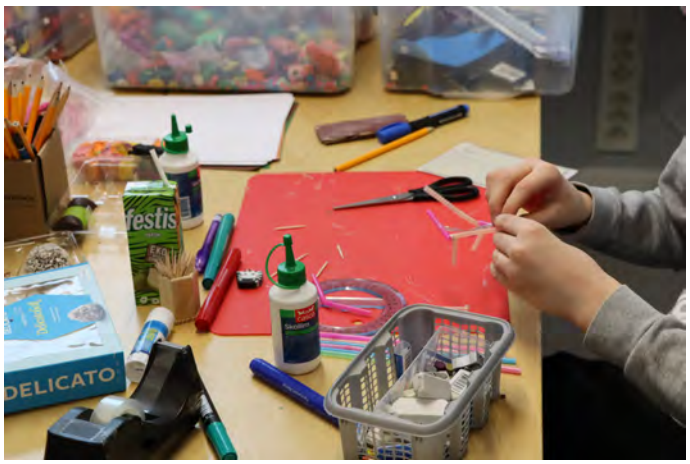


Figure 5.3: An example of the materials provided for the workshop.

The children were asked to do two assignments in the workshop. First, they were asked to create their own drone using any of the materials provided. The second assignment was to illustrate a play scenario of how they would optimally like to play with the drone. This activity aimed to understand children's own imaginary interactions with drones and do so in a manner that would integrate design knowledge.

5.4.5 Wrap-up

The pilot study was wrapped up with some questions on their general experience of the activities. They were allowed the finish whatever they had started and also given the opportunity to choose whether to bring their creations home or leave them with us.

5.4.6 Reflection & analysis

In this section, the different parts of the study is discussed and ends with a general observation section.

5.4.6.1 Introduction session

During the introduction, interesting topics and conversations came up. Although some notes were taken, we were not fully prepared for this session and the importance of taking notes in this part was even more essential due to the inability to record it. This part is very important for the purpose of setting the tone for the rest of the session, where the aim is to reduce and/or break down potential power structures between us and the children. It is also important to invite the children to a free forum for discussion where they feel they can speak freely. This led to several different questions and conversations, such as what video games they liked, which of the drones they thought was the smartest, and if they had any experience with drones before. It was also intended to have more in-depth conversations where we got to know more about the children, however, this blended together with the introduction.

Furthermore, the drones were visible to the children from the start, which made them somewhat impatient to get started. One of the participants seemed uncomfortable with being video recorded: his glance towards the cameras was skeptical. After explaining that the videos were merely for analytical purposes, that we were the only ones who were going to view them, and that their faces would be covered in any pictures used for publication, he seemed to accept this and did not show any further signs of discomfort during the introduction.

5.4.6.2 Activity One: Commercial Drone Testing

The children showed no resistance to putting on the safety gear and one of the children even thought that the gloves worked just fine, even though they were too small. However, since there was no backup plan to cover the lack of gloves, the children played with the drones without the gloves. We made it clear that they did

not have to use the hearing protection if they did not feel like it but the glasses were mandatory. One of the participants put on the hearing protection without hesitation or and explanation, but after being told that they were not obligatory he took them off (see picture 5.4).

Figure 5.4: Image of one the children wearing the safety gear.

One of the children specifically asked what the consequences would be if something breaks. This insecurity indicates that the introduction was lacking or not adapted to their understanding because this was explicitly stated in the information sheet as one of the things to cover before starting. We needed to clearly transmit to the children that it would be of no consequence if any of the equipment would break.

When transitioning from activity one to activity two, one of the children expressed a desire of not wanting to be filmed anymore. We asked the child if they did not want to be filmed anymore and reassured them that all of the equipment would be turned off with no consequence should they choose to not want to be filmed anymore. The child chose to not stop the filming and said that they only wanted to dance.

5.4.6.3 Activity two: Elicitation through Enactment

They understood the meaning of the cards and showed no signs of significant confusion regarding the text or illustrations. However, what we discovered was that an order effect happened: we observed that the children chose similar if not the exact same gestures that they had just performed when testing drones in the previous session. This was something that we had been previously warned of in one of our expert interviews.

Although an order effect was observed, another observation indicated that the children had different understandings of what starting a drone meant. When one of the children was presented with the card "Start the drone´´, they implied that pushing a button started the drone while the other child regarded the interaction of throwing it up in the air as starting the drone. Both of these interactions appeared on all of the drones which were tested in the previous activity. Since both of the children went through the same deck of cards, the child that went through the deck first was able to easily guess the other child's gestures as they were both similar and they remembered the contents of the cards.

During the activity, we observed that the children showed some confusion regarding the objective of the activity, not specifically on how to perform the tasks but uncertainty on why they were performing the tasks. This was also confirmed when asked about their experience with this activity, as they expressed that they understood the meaning of the cards.

5.4.6.4 Activity three: Co-design workshop

They went straight for the pen and paper, with which they both drew an almost identical copy of the drones they just recently had played with (see figure 5.5).

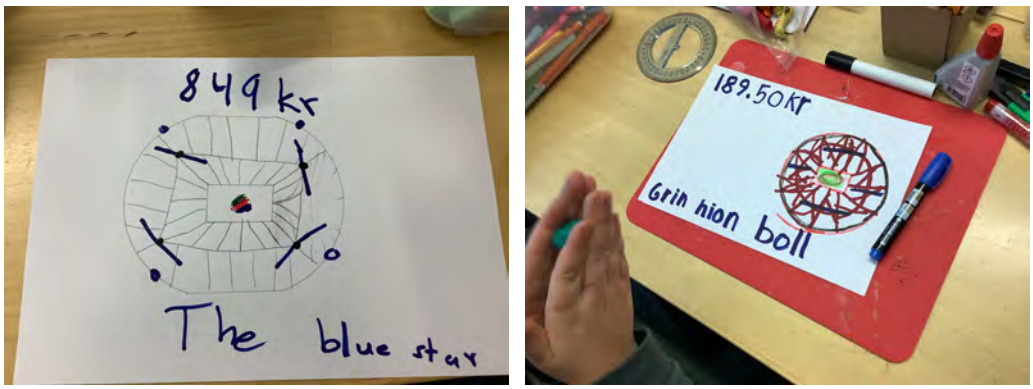


Figure 5.5: Figure depicting the two sketches made by the children in the pilot study.

The children talked a lot about the price of the drone which, according to them, was of great importance to determine the quality. After that, they went over to creating drones with the help of clay and paper. They were not inclined to imagine or draw a scenario or game in which they could play with the drone, they stated that it was too difficult. It also seemed that the children were too influenced by the commercial drones used in the first activity, as there was almost no room for their own imagination in their creations.

5.4.6.5 General observations

The presence of the children's mother made a clear impact on their behavior, it is not possible to say in which way they would have acted differently if she was not

present but it was a contributing factor nonetheless. Whenever they got confused or argued with each other they looked at their mother for approval, reassurance, and/or fear of potential repercussions. Naturally, parents would not be present for the primary studies but there will be a leisure leader with a special relationship with the children present. We concluded that despite this effect, it is best to have one of these leaders present in the room for the sake of security, both for us and the participating children.

5.5 Changes made to primary studies

Based on the advice we received from the expert interviews and the pilot study we decided to make some changes to the primary studies.

- We changed the order of the activities. This was done because we noticed an order effect happening after the children had played with the drones in the enactment activity. The order of the studies was changed to Enactment, Workshop, and Drone testing.
- A broader selection of gloves, smaller and larger ones that work the sensors of the drones, for this we tested a few colors based on what we had at home.
- Hide the drones from the children when they enter the room so that they cannot be influenced too much by the drones that we have bought.
- Getting the consent for recording the children as early as possible, to not miss important conversations.
- A detailed agenda, which could be a checklist of some kind so that we are sure that we go through all necessary information.
- Being extra attentive if a child does not want to participate any longer or show a desire to not be filmed.
- Clearly and repetitively informing the children that there would be no consequence if any of the equipment would break accidentally.
- Delimit our choice of materials for the workshop, as we are coming to them we chose to not bring a lot of materials due to convenience of transport. We decided to only bring clay, paper, tape, scissors, colored pens, and cardboard.
- For the enactment session, do not have the same children do the same cards. However, since our groups were more than two people this did not really matter.

6

Phase II: Questionnaire and Primary studies

In this chapter, we describe phase II (see figure 6.1)which is the execution and process of our primary studies along with the process of our questionnaire. We also describe the result from the questionnaire. The process is described chronologically. The different stages are described in detail where we show how we applied our methods and techniques described in the methodology.

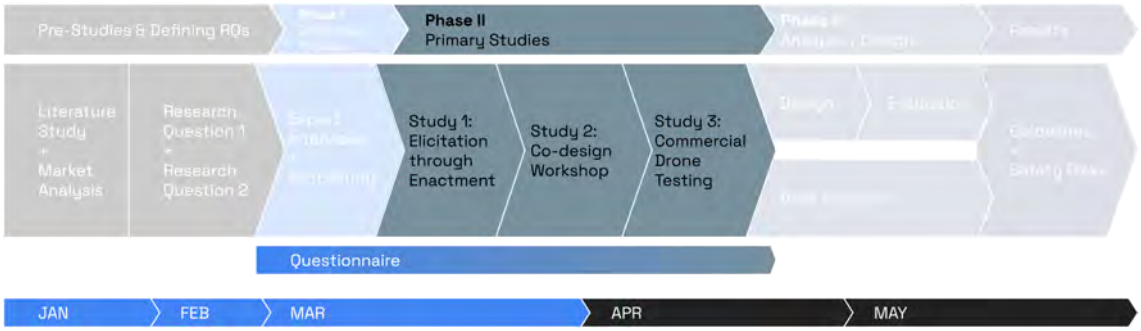


Figure 6.1: Phase II: Questionnaire and Primary studies.

6.1 Questionnaire

Before conducting the primary studies, a questionnaire was created and sent out on several social media platforms such as Facebook, Instagram, Slack, Family Life, and Discord (see table 6.1 for more details). This was to investigate attitudes, feelings, and experiences amongst several stakeholders, in our case parents, in relation to drones in general. This would help us get a multifaceted view of our problem. Two versions were created, one in Swedish and one in English.

We began to send out the questionnaire on March 11Th and accepted answers up until May 2Nd, 2022, a total of 52 days. It was actively shared with a selection of the interest groups listed, the questionnaire was shared twice in some groups while in others only once which was due to time constraints. The questionnaire collected information about their children's age group and their previous experience with

drones. It entailed five different sections, of various questions, in which the participants were categorized depending on their answer to the first question *Does your child/children have a drone?*. The participants were presented with four options:

- **Does your child/children have a drone?**
- Yes, they got it as a present
- No, but I have one
- No, but have used/borrowed
- No, or not yet

Platform	Forum	No of time shared
Facebook	Mums in Gothenburg	2
Facebook	Mums in Varberg	2
Facebook	UX sweden	1
Facebook	DJI Sweden - We who fly DJI-drones	1
Facebook	Drones and quadcopters	1
Facebook	Our personal pages	1
LinkedIn	Our personal pages	1
Instagram	Our personal pages	1
Slack	University Slack Channel	1
Discord	Design Buddies	1
Family Life	IT Forum	1

Table 6.1: Table showcasing to which platform and how many times the questionnaire was posted.

The questions differed in respective sections, with the purpose of the research and management of the data clearly stated at the beginning of the questionnaire. As an attempt to attract more participants to the questionnaire we included voluntary participation in a lottery for movie tickets. Which included three winners of two cinema tickets each to Swedish movie theaters. Complete anonymity was guaranteed under the conditions that they did not want to be included in the lottery of cinema tickets, which required their email address so that they could receive eventual prizes.

We provided the participant with a time of completion estimation to enable them to make an informed decision of whether they thought it was worth their time or not.

This was done by timing ourselves completing the longest section and rounding up, the time of completion was estimated to be approximately 5 minutes.

6.1.1 Results

The questionnaires received a relatively low number of answers (9 answers in English, 19 in Swedish), therefore the quantitative results are not of particular relevance.

A participant reports on how they chose a particular model of a drone for a child based on its software compatibility with higher-end models. This seems to indicate the possibility of the value of a more complex network of drone systems that suit both adults and children.

When prompted about risks, a participant considers that perhaps there are no risks for the children but rather:

> *"risks for bystanders if the child cannot drive them securely, or films persons in private contexts."*

A participant notes:

> *"they are fun but I will most likely not let my child use them until they are older since they feel somewhat unsafe and he may happen to fly it into someone."*

The participants were provided with a set of images of toy drones, and upon reflecting on whether or not they would consider buying these, the main mentioned reason for either a positive or negative attitude was the perception of safety and lack of understanding of how they actually work. Some participants could not identify any advantages of using drones or report on the need for adult supervision. But also mentioned them as a possibly good tool for exploring technology from a young age. Furthermore, the participants referred often to age appropriateness. Interestingly, more than one participant mentioned these would likely become boring quickly:

> *"be another gadget that is fun for a week and then never looked at again"*
> and
> *"I think they would get tired of it quickly."*

One participant manifests a consideration for others:

> *"I think there are many other gadgets the children can play with that are less disturbing to others."*

In terms of applicability and advantages of drones, a participant notes that:

> *"like all other toys, I do not think there are any direct advantages beyond entertainment. Possibly to see the world from another angle, for drones with a camera. Together with other technological toys, they make a good*

> *discussion ground for technology and society. Also, because the child is a girl, the parents have to do more to make them feel at home with technology (society counteracts this).”*

Another participant mentions they acquired the drone explicitly to take pictures.

The general impressions span widely, from considering them fun to scary. One participant mentioned that currently, the drones feel like a toy or a tool for filming but that they show great potential, and another mentions that they are scary but very useful in specific cases. Some participants reported on lack of knowledge of drones to be able to formulate an opinion.

6.2 Primary Studies with children

The recruitment process was started by sending out an email to a total of 35 schools in the area of Gothenburg. Furthermore, a registration of interest form was created which was shared in a Facebook group for mothers in both Gothenburg and Varberg. This did not provide any results as the interest form received zero answers. The schools contacted also did not provide any results as the schools either did not answer, did not have time, or were not interested.

However, one of our experts gave the advice of seeking out a leisure center as the expert themselves had experience with conducting studies with leisure centers. This resulted in us coming into contact with the leisure center in the suburb of Gothenburg, which accepted our invitation to collaborate. Our initial plan was to work with only one group, however, we decided to work with two groups when the opportunity presented itself because the groups were of different ages. This opportunity was provided by the same expert that advised us in contacting the leisure center. She facilitated the connection between us and an additional group of children at a leisure class in an English school in Gothenburg. Here the children were of the ages nine and ten compared to the first group, at the leisure center in the suburbs, who were of the ages ten to eleven.

For the purpose of introductions and familiarizing ourselves with the locations we made a visit for a meet and greet to both locations before initiating the first study. Before visiting the locations we decided amongst ourselves that the groups would be, at most, six children. This was decided due to convenience and as we thought that this was the maximum number of children that we could personally handle collectively. When talking to the leisure leaders of each location they also agreed with us, however, due to circumstantial reasons such as illness, after-school sports, and other reasons the groups were with five participants in each.

An information and consent form was sent via email to each of the groups’ leisure leaders, who facilitated the parental consent by handing them out to and collecting them from the responsible adults of the children partaking in the studies. This included information about dates and activities, the purpose of the research, risk,

and benefits, the conditions under which the children would participate, and more (for more details see appendix F).

6.2.1 Group 1

The first group (named group 1) was recruited at a leisure center in a suburban area classified as a *especially vulnerable area* [87]. From this leisure center, a total of five children partook in our studies, two boys and three girls. The age span was between ten to eleven years old, and all were Swedish-speaking. The children were picked by the leisure leader and were given the opportunity to decide if they had any interest in participating. At the meet and greet session we met with four out of the five participants.

All of the studies were held during the opening hours of the leisure center. During our sessions, the leisure leaders arranged other activities for the children not participating, as per usual activity. We introduced ourselves, explained what we do as interaction designers, and described the purpose, specific times and dates, and what the studies would entail, as recommended by one of our experts. This also gave the children a chance to ask any preliminary questions and to get to know us beforehand. They also got to play with one of the drones that we had purchased to get an idea of what we were referring to when speaking about gesture-controlled toy drones.

Only three out of the five children participated in all of the sessions that we conducted at the leisure center, one withdrew from the study before the first occasion. However, during the second session (the workshop) one more out of the five intended participants joined although for only that session. Another participant, out of the five intended, joined only the last session (the drone testing).

6.2.2 Group 2

The second group (named group 2) entailed a total of five children who were recruited at an international School located in Gothenburg through a leisure class outside of school activities. In this case, the leisure leader drew lots as to which of those who were interested would be allowed to participate in the study.

The children that were selected were two girls and three boys between nine and ten years old. Two of the children were only English speaking while three were both Swedish and English speaking. All of the children were present for almost every session apart from one, the workshop, due to illness. The main language spoken during the sessions was English so that everyone could understand. However, due to the Swedish children requesting, and having an easier time expressing themselves in their native language with us we said that they could answer us in Swedish if they liked.

6.2.3 Studies

The studies we conducted were in three parts; Elicitation through enactment, Co-design workshop, and Commercial drone testing. All of the studies were video and audio recorded using several cameras and audio capture devices. This was to capture as much material as possible and in every angle. Photos were also taken during these sessions. The different activities with respective groups were carried out in parallel to each other for three weeks at the end of March. For every session, one of us acted as the main facilitator and one as an assistant facilitator. The main facilitator led the activities with the children while the assistant facilitator was responsible for taking pictures and notes but also to ask additional questions and filling in the gaps.

6.2.3.1 Elicitation through Enactment

Before the beginning of the first study, an introduction was held with the children where one of us went through the information sheet orally. In this, we introduced ourselves again and presented information such as what a drone is, the purpose of our research, the conditions for the studies, and how the data collected was going to be handled. It was also clearly stated that their participation was voluntary and that they were allowed to withdraw from the studies at any moment (see more details in appendix F). In the end, we asked for their oral consent to the different conditions such as being video recorded and having their picture taken. The information sheet was then handed out to each child to do with how they pleased.

After every participant had given their consent we started the video recording and audio taping. This was followed by a brief conversation where we got to know each child better by casually talking to them in a group setting, e.g. what their favorite subject in school is and what they did in their free time. Most importantly, information about their previous experience with drones and/or robots, in general, was collected. During this part we started to notice that the children in group 2 were very interested in cameras.

For the first study, a total of 16 cards were created, illustrating different behaviors through text and pictures acting as design probes. Initially, the majority of the cards entailed fairly simple behaviors that suggest that the drone does not have any artificial intelligence. To further extend the children's imagination and not restrict them, three Artificial Intelligence (AI)-driven behaviors were included. This was also to see what gesture or interaction naturally occurs for different types of actions.

We asked one of the children to act as the drone and the rest to create a circle around the person acting as the drone. They were encouraged to try to control the drone with whatever they felt most natural, which could be voice, hand gestures, or body language. The only thing they were not allowed to do was to read out loud the action from the card verbatim, as we wanted the children to show or explain the action on the card. After one completed card the child in the middle switched places with the one acting out the gesture. This enables the one in the middle to see what action the shown gesture was supposed to portray, this card was later handed to one

of us and was considered used. This continued until all 16 cards were completed.

After completion they were encouraged to create their own cards, to see if they had any action to add and/or to capture any other ideas that may have flourished during the enactment (see figure 6.2). Drinks and snacks were provided during this sit-down and open-ended questions were asked throughout the session. Questions ranged from asking about their previous experience with drones, to how they would like their dream drone to behave and act.

Figure 6.2: Examples of two cards created by the children from each group.

The session ended with them being allowed to play with some drones, with the intention to end the session on a positive note. This helped us meet the children's expectations and avoid disappointment when participating in a study with drones as the main topic. Both groups got to try out a gesture-controlled drone, called Air Hogs SuperNova. However, group 1 got to test both a remote-controlled drone and the gesture-controlled drones. This was due to time constraints, as they had more time in difference to group 2 where they had a more strict time limit.

6.2.3.2 Co-design workshop

For this session group 1 was a total of four participants with one, out of the five intended, missing due to after-school activities. Group 2 was also a total of four with one missing due to illness. Before beginning the study we asked the children for their consent to us filming them, reminded them about why we do this, and that they could withdraw from the study at any time.

The material provided was cardboard, scissors, tape, clay, pen, and paper. As we had been advised by some of the experts we interviewed, in the workshop we gave the children the role of a design team whose task was to design a drone for their leisure center/club. During the session, questions regarding features, functions, and behaviors were asked. The workshop lasted about 45 minutes.

The children in group 1 focused on making dream drones with animal characteristics while the children in group 2 created dream drones with cameras and remote controls. This session was also concluded with a shorter playtime with a gesture-

controlled drone (Air Hogs SuperNova), and group 1 also had time to play with a drone with remote control.

Figure 6.3: Pictures of our set-ups for the co-design workshop with our groups.

6.2.3.3 Commercial Drone Testing

For the final session, the children tested four different gesture-controlled drones (see picture in 6.4), one at a time. Before beginning the study we asked the children for their consent to us filming them, reminded them about why we do this, and that they could withdraw from the study at any time.

(a) The Gadget Monster Drone

(b) The UFO Drone

(c) The Airhog SuperNova Drone

(d) The Aircraft Drone

Figure 6.4: Pictures of the commercial drones tested in the study.

The drones were all placed on a table covered by a blanket until the children were to decide. They were instructed to decide collectively as a group on which of the drones they would like to start with, as advised by one of the experts, Melissa. Due to both time and battery limitations, the children had approximately 5 minutes of playtime with each drone. Between testing each of the drones, the children were asked some questions about what they liked, disliked, and their general feelings toward the drone.

For group 1, the session was concluded with the children being allowed to have free play with all of the drones that were brought, one with a remote and all of the gesture-controlled drones. While for group 2, due to time constraints, the session was concluded after we had asked them the final questions regarding the last drone.

7

Phase III: Design and Analysis

In this chapter, we describe phase III (see figure 7.1) which is the execution and process of our design and our analysis which formed our final results. As the design and analysis process was conducted simultaneously, they are not described chronologically. The different stages are described in detail where we show how we applied our methods and techniques described in the methodology.

Figure 7.1: Phase III: Design and Analysis.

7.1 The Design

Based on our primary studies we created a design in the form of a storyboard to evaluate with the children, this was done by using the ideation method skewing, which we produced a storyboard from, and then evaluated with the children. In one group we also conducted a critical reflection using storytelling due to their insistence on using cameras.

7.1.1 Skewing

Skewing was performed based on key observations from our meetings with the children, primarily from our observations and interviews during the testing of the commercial drones. We started with sorting out which existing features should be skewed and which requirements they should be skewed towards. We did this by categorizing them into, negative, positive, and neutral features and requirements. We then decided to go over each feature and requirement from the negative and neutral cat-

egories and skewed them separately. The result showed very opposite preferences and in collaboration with our supervisor, we were recommended to create different scales based on these opposites (see figure 7.2).

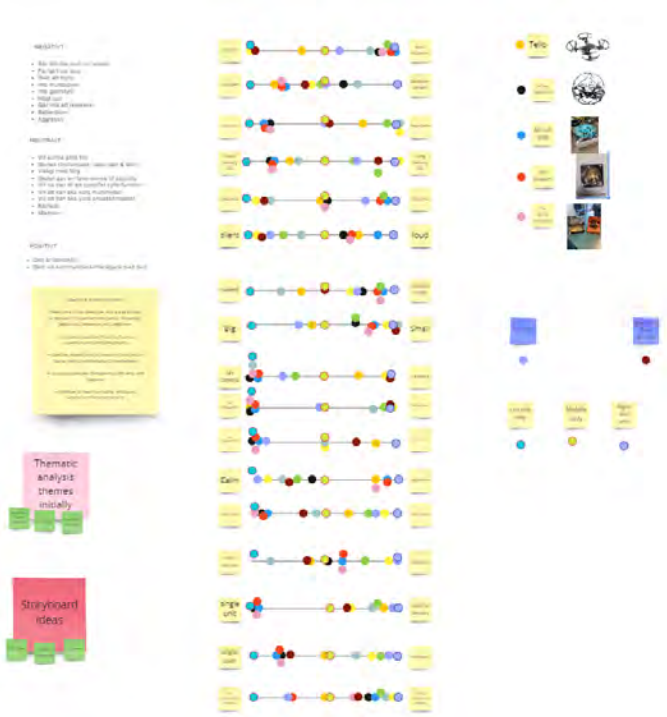


Figure 7.2: A screenshot of our Miro board where we performed the skewing.

In this way, our ideas were based on the requirement captured in our studies. In continuation of this, we placed every single drone tested in the studies on these different scales where we thought it fit the most. Then we tried to imagine our own dream drone which was defined with the help of these scales. Through these definitions, a sketch was generated for each dream drone with the help of brainstorming different solutions. This process was then repeated by playing around with the different scales, turning them up and down and ultimately resulting in a total of 16 different concepts and drones (see figure 7.3 for examples of the different sketches).

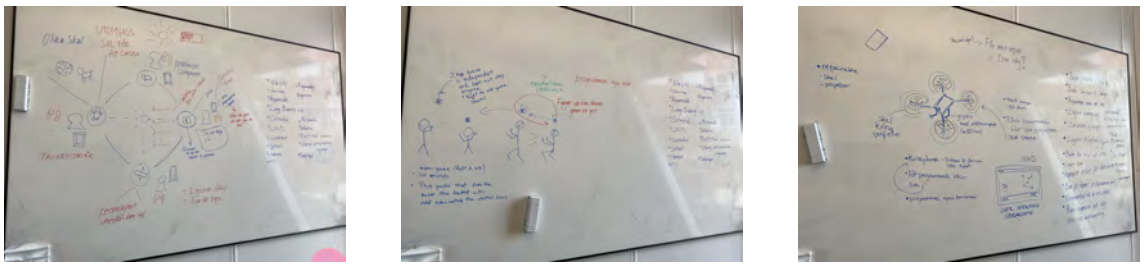


Figure 7.3: Three of our sketches output-ed from the skewing session.

7.1.2 Storyboards

From the Skewing session, we created low-fidelity prototypes for each group in the form of storyboards with the help of a digital tool called *Storyboard that* [101]. We tried to involve each child by illustrating them as a separate main character. Each of the characters had a child's name and we made the storyboards include each child as equally often as possible in the frames. In the storyboards, the children played a game with the drones (see appendix E). Which also included different important features and functions incorporated based on the result of our ideation, stemming from key observations from the studies with the children.

Furthermore, the storyboard for group 2 also included key ethical concerns that arose during our meetings with them. This was based on them expressing explicitly that they would like to have drones for espionage in different contexts but also their over-confidence of trust in drones when used by adults. This was an implicit way of encouraging critical reflection around the current ethical topics amongst the children [75].

7.1.3 Evaluation

An evaluation was held with the participants approximately three weeks after our final meeting with them. This was, not only, to get their opinions on our conceptual design but also to see if anything had changed or if any other thoughts had occurred during our time apart. Group 1 joined us at a prototyping studio at the Chalmers University with three out of the five participants. For group 2 we went back to meet with them at their school due to the complexity of travel during school leisure hours. Both meetings were only audio recorded. The session started with us asking if any new questions or thoughts had appeared during our time apart. After that, we asked the same questions as in the final wrap-up during the previous meeting. Then the storyboard was presented to them which ended with some questions regarding what they liked, what they disliked, if they would like to add something, and their opinions about the drone depicted in the storyboard. All questions were open-ended and free discussion was encouraged.

For group 2 we also included a story based on our meetings with them inspired by Mott, Bejarano, and Williams [75]. This story described our ethical concerns about their interest in cameras in different use areas together with a lack of reflections on the consequences and/or risks. This was used to prime them into a critical reflection on the usage of cameras concerning drones. This was orally presented verbatim, in both Swedish and English for the children:

> *"Some interaction researchers were curious about how kids would like to interact with drones when playing with friends in their free time and how they would like them to look and behave, especially those controlled through gestures. They were also interested in looking into if there could be any possible safety risk when using them. They decided to look at what type of toy drones were available to buy today and decided to let some*

children test these.

During their meetings with the children, three out of five children expressed a strong interest in using cameras on their drones for spying on their friends and family but also for the purpose of making practical jokes. The topic of police drones also came up. When probed with questions, e.g. how they would feel if a drone filmed them? How would they feel if a drone flew in the air around them where they play or live? How would it feel if they could not control the drone?

Most of the children felt that it was acceptable to film if it were only for a specific purpose during a shorter time. They also felt that it was acceptable for the police to film so that they could catch those who exceeded the speed limit on the roads. It was also clear that the children felt safe when adults controlled the drones and were not especially concerned if these were to inhabit their everyday environment under those conditions. One child said that it would not be acceptable without asking first.

The researcher thought it was interesting how some of the children did not seem to have any issues with using drones for filming in public and/or in their homes, nor did they have any bigger concerns about being filmed themselves. Their confidence in drones in the hands of adults was also a topic of concern. The researchers thought about how this would affect their behavior towards social drones in public environments. What if they rushed towards a drone without any hesitation and accidentally got hurt? Or if they got filmed by drone while doing something they did not want anyone to know and got them into trouble? "

After this, we asked them what they thought of the story and had an open discussion about it.

7.2 Thematic Analysis

To analyze all of the material we had collected during the primary studies we conducted a thematic analysis. The material collected consisted of over 170GB of video and audio recordings, which was approximately 30+ hours of data. The process for this was conducted in the following steps in accordance with Braun and Clarke [15]; *(1) Familiarizing yourself with your data, (2) Generating Initial Codes, (3) Searching for themes, (4) Reviewing themes, and (5) Defining and naming.*

7.2.1 Familiarizing yourself with your data

This step was divided into two sub-parts. For the initial sub-step we both went through all the data separately in parallel, as to get two different perspectives, by flagging different timestamps in the data where we observed interesting activities and/or events. We added the flagged timestamps into a *Google Sheets* document

where we also made a short comment about what was happening to indicate why it was flagged. Additional contextual information could also be added for further understanding, such as the start of the activity. The second sub-step in this process included us dividing the work, for efficiency, by taking one group each and going over the different flagged timestamps and their respective event once more. In this sub-step, we started to transcribe all the relevant conversations and describe all of the observations.

7.2.2 Generating Initial Codes

For step two we separately went through the different transcriptions and generated initial codes for the different time events. The codes were produced based on the two research questions we had. We generated, in parallel, separately the codes by going through all of the transcriptions for both groups, adding this to new sheets within the *Google Sheets* document. After which we collectively went through the codes again, merging our codes to produce the final set of codes.

7.2.3 Searching for themes

The generated codes along with their quotes were imported to two online whiteboards, one per research question, known as *Miro boards* provided by an online collaboration platform called *Miro* [73]. Each of the whiteboards was then used to search for different themes with regard to our research questions. A number of initial themes were identified through sorting and discussion.

7.2.4 Reviewing themes

Here we started going over the themes and their respective extracted data to see if any meaningful patterns could be identified. If not, we considered either removing some specific extracts and replacing them with another theme or even removing the theme itself. After reviewing, we refined the themes by adopting a more holistic approach. This approach entailed the process of viewing each theme and the thematic map in relation to the whole data set. This step was concluded by generating a first draft of a thematic map for each Miro board (see each of the Miro boards in figure 7.4).

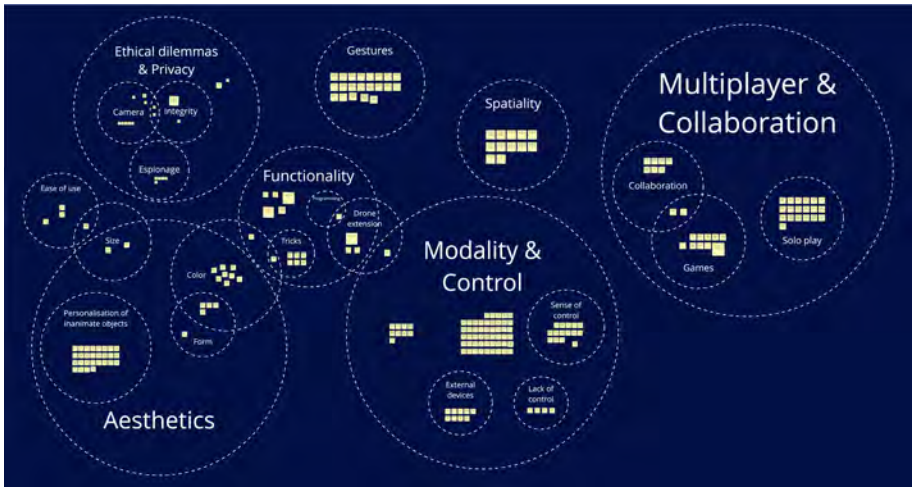
(a) Research Question 1

(b) Research Question 2

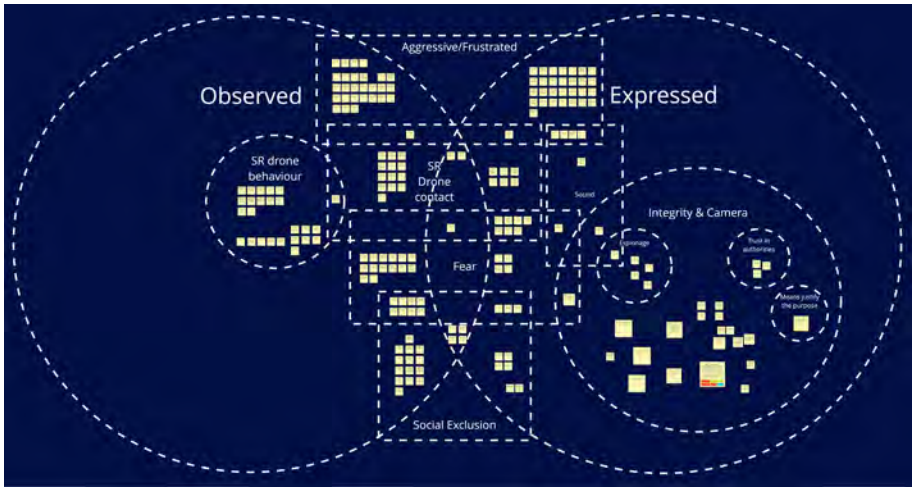
Figure 7.4: Miro boards for the Research Questions.

7.2.5 Defining and naming

In the final step, we began to refine the themes. Both naming and renaming themes with regards to how they related to our research questions but also how they related to each other. For instance, if a theme was very similar to another theme they would be merged. In the end, we came up with a thematic map for each research question which resulted in design considerations and types of safety risks (see fig 7.5).



(a) Research Question 1



(b) Research Question 2

Figure 7.5: Thematic maps for the Research Questions.

8

Results

This chapter showcases the results of the *Research for Design* process which was used to answer our research questions. The entails the results from the thematic analysis, and output from the co-design workshop and prototyping session. As previously been mentioned by Dourish, the outcome of ethnography do not necessarily conform to traditional outputs within HCI research as the techniques and methods are different and should not be seen as variants of ethnography [30].

These do promote implications for design in the form of bullet-lists, where ethnographic research do not. According to Dourish ethnographic research has still a lot to contribute to HCI and states the following:

> *"Ethnography provides insight into the organization of social settings, but its goal is not simply to save the reader a trip; rather, it provides models for thinking about those settings and the work that goes on there. The value of ethnography, then, is in the models it provides and the ways of thinking that it supports.[30]"*

Therefore, we present the results in the form of design considerations for gesture controlled toy drones and types of safety risks. These are presented in two separate sections for each research question foregrounding it.

> ***Research Question 1:***
> *What should be considered when designing gestured controlled toy drones for collaboration and playfulness within child-drone interaction?*

> ***Research Question 2:***
> *What possible safety risks can arise with these types of gestured interactions?*

8.1 Research Question 1: Design considerations for Gesture Controlled Toy Drones for Collaboration and Playfulness

When designing gesture-controlled toy drones for collaboration and playfulness, it is important to not only consider the different parts of the drones but also their' behavior. It is also important to test the toy drones with children, if they are the intended user group, to get their opinions and insights. In this section, we present our findings regarding our first research question in the form of themes for consideration when designing gesture-controlled toy drones. These are completely based on the finding from our qualitative studies conducted with the two groups of children.

The analysis, conducted through thematic analysis, resulted in seven core themes with additional sub-themes that we view as themes for considerations, namely *Input Modality*, *Desired Functionalities and Drone Behaviors*, *Collaboration and Playfulness*, *Previous Experience*, *Imagination*, *Aesthetics* and *Ethical Dilemmas and Safety*.

8.1.1 Input Modality

One thing that we observed during our studies is that the children requested different ways of interacting with the system, both when it came to the control and the functionality. Input modality concerns means they wanted to use to interact with the drone, e.g. camera, phone, programming, etc. Here we present the importance of sense of control and how that stands in relation to different input modalities such as camera, external devices, and gestures.

Essentially we noticed that sense of control was important for a positive user experience. However, they also requested more ways than one to control the drone, this often depended on their intended use.

8.1.1.1 Gestures

When it came to gestures, in general, it was clear that the children were not prone to only doing one gesture, instead, it became part of an embodied movement. For example, when doing the elicitation study through enactment we saw that they used their entire body, by moving to the side, for the more simple actions such as *"make the drone go to the right"* and *"make the drone go to the left"* (see figure 8.1 for example).

Figure 8.1: Image of one child showing to the other the action of *"Make the drone go to the left"*.

For the more complex actions, such as *"make the drone pick something up"* or *"go to a random friend"*, they either requested a new action card or they found other ways of showing this that did not include gestures. This could be due to confusion regarding the activity, however, two children explicitly told us that they wanted the drones to follow their movements:

> *"What if you could control it with your entire body?" - Peter*
> *"Do a cartwheel" - Peter*
> *(Quote from a child in group 2)*

> *"Oh it would be controlled by the eyes then?" - Matilda (Facilitator)*
> *"Yeah" - Peter*
> *"And what does it do if I aim my eyes at it, at a certain point?" - Sofie (Facilitator)*
> *"When you go forward, no you know what, the body, the body, when you go forward then it goes forward, when you go back it goes back with you, when you look up then it goes up, when you look down it goes down, when you look to the sides it goes to the sides" - Peter*
> *"So it follows you a bit?" - Matilda (Facilitator)*
> *"Ah, it follows the eyes and the body" - Peter*
> *(Conversation with Peter in group 1)*

During our first session with group 1, we accidentally showed them one gesture for stabilizing one specific drone, which we had found in the technical instructions. This resulted in the children constantly repeating this gesture throughout all studies with all drones. Even when they noticed that it did not work, they continued with what we chose to call the biased hand gesture. At the end of our studies, we started to see them slowly changing the way they interacted, but the biased hand gesture was still predominant.

First, it hovers then Adam and Lisa start trying to do the biased hand gesture at the same time
The drone then goes straight into the air
Adam pulls his hands away and says
"Isn't it the same?" - Adam
(Observation and quote from Adam in group 1)

It should be mentioned that the biased hand gesture was something that group 2 never learned or started doing.

It should also be mentioned that one child reflected on the fact that he did not feel that these toy drones were gesture controlled. According to one child, there seemed to be two ways of interacting with your hands:

Tor comes up to us and starts talking while the other children are playing with the drone
"The thing is, I don't feel like you're controlling it because you have to touch it [inaudible due to drone background noise]" - Tor
(Quote and observation from group 2)

"The negative thing is that, as I said to you, you don't control it, you have to hold it almost for it to move, or for it to go where you want it to go anyway. The positive thing is, but it's fun when something kind of flies and you have to be able to control it" - Tor
(Quote from Tor in group 2)

"What do you prefer, remote or with your hands?" - Sofie (Facilitator)
Other children answering
"There are several different ways to it with control or in different ways, but there are... As far as I know, there are two ways with the hands. It's that you stand next to it [he demonstrates how to do that, as you control the drones we had] so but also that it has something that it senses. But in that case remote" - Tor
(Conversation from group 2)

During the studies we started to observe the children, in both groups, using two hands to be able to control it, instead of doing specific hand gestures such as the biased one.

What can be said from this is that if they learn one specific gesture for an action, an order effect will appear with the gesture most likely being projected over to similar experiences. This is important to have in mind while defining specific gestures. Furthermore, other ways of interacting with the system should be considered if more complex actions are to be incorporated, which is supported by the children seemingly inclined to do something more than just gestures. Lastly, there seemed to be a need to distinguish interaction types between sensor-based drones and gesture-controlled drones. Most of the drones either explicitly stated that they were gesture

controlled or hand controlled which can be deceiving in the eyes of a child, leading to a negative user experience.

8.1.1.2 More ways of controlling it

Throughout our studies, it was clear the children did not just want to be able to control it with their hands, especially not as they worked today. They suggested several different ways of interacting with the system, such as programming, gloves, bracelets, camera, remote, voice control, and some imaginary ways that we present in a separate section. While many of these ways were explicitly expressed by the children, voice control was something we observed happening when the drone went out of reach.

It was also noticed that proximity had an impact on how they wanted to be able to control it. The children preferred remote control, or other external devices when controlling the drone from a distance:

> *"I would like to have, if I would have, one with control and one with hands, because then you can use it for different things, for example, if you are going to scare someone you want to have control and if you are going to do something else you might want the hands if you are going to play with your friend" - Ira*
> *(Conversation with Ira in group 2)*
>
> *"So it is only a remote that applies, nothing else works?" - Sofie (Facilitator)*
> *"Of course it works with hands but I think, for me, it's better with a remote because then you can stand still and it [the drone] can fly away. If you want to search larger areas and see what's there or" - Tor*
> *"So you are saying that when it flies away you cannot control it with your hands?" - Sofie (Facilitator)*
> *"Because then you have to follow it and stuff, and then it's a bit more difficult" - Tor*
> *(Conversation with Tor in group 2)*

They seemed to like the idea of having external devices to be able to control it, not necessarily just a remote, but also gloves or for example bracelets. Two children seemed to believe it was actually the safety gloves, we had provided for them, that controlled the drone:

> *"What do you prefer, remote control or hands?" - Sofie (Facilitator)*
> *"With my hands! I really want to wear these gloves, and then I can move [as he talked about earlier]." - Abdi*
> *(Conversation with Abdi in group 2)*
>
> *"[...] there's a big difference between what I thought before and now" - Julia*
> *"Eeh I was thinking at the beginning when you were talking about drones,*

I didn't even know what drones were but then when I heard people outside saying drone, look a drone [...] then I knew it was one of these little kind of small aircraft that can fly and then I thought ah you control it for sure with a remote or something. Then when you told me and I got to try it out I knew it was dangerous that's why you have to have protection and the gloves make it so you can control it" - Julia
(Conversation with Julia in group 1)

"I want to have a remote, but also so that you can kind of put bracelets on both [arms] and then you can control it [...] so you can control it with your hands, [talking about the bracelets] so they can feel how you move" - Tor
Ira summarises what Tor just said and says she wants the same.
(Quote from group 2)

8.1.2 Desired Functionalities and Behaviors

During our studies, it became apparent that the children wanted the drone to do more than just being able to fly. Which they expressed with different desired functionalities, some of which could be in the form of drone extensions such as a functioning grip handler or a platform with wheels. So that the drone could land on it and drive on the ground as well as fly. They also expressed a desire for the drone to do different tricks, such as a cartwheel.

Furthermore, we discovered that they would optimally like it to be quiet and that they found the sound annoying. This becomes important in terms of what should be considered to make it more than just a toy that is used once and never again. By adding different extensions and functionalities to the drone, this could potentially create a long-lasting appeal and usage.

Here is a quote from Lisa, telling us explicitly that she would like it to do more than just fly:

"How would you have enjoyed a drone?" - Sofie (Facilitator)
"Well, I don't want a drone to just fly" - Lisa
"No, what else will it do?" - Sofie (Facilitator)
"Trix" - Sarah
"Yeah, trix" - Lisa
(Conversation with Lisa and Sarah in group 1)

In the two following quotes Tor from group 1 explains how his drone design work and that it has a "claw" (see in fig 8.2), then Sabina tells us about her design that also have wheels so it can both fly and walk (see in fig 8.3):

"What is the orange?" - Matilda (facilitator) ask Tor
"It's claws so you can pick things up" - Tor

Sabina shows how she made wheels on her drone.
"So that it can walk" - Sabina
"So that it can both walk and fly" - Sabina
"Is it important that it does that?" - Sofie (facilitator) to Sabina
"If it walks, it can film from below and it can also go up like that" - Sabina
"It's important to film?" - Sofie to Sabina
"Ahh" - Sabina
"Why?" - Sofie
"Because, I don't know... it's good" - Sabina
(Conversation with Sabina in group 1 during co-design workshop)


Figure 8.2: Drone featuring claw.


Figure 8.3: Drone featuring a platform with wheels.

Furthermore, the sound of the drone seemed to be something they would like to remove or at least wanted it to be as quiet as possible:

"What would a drone sound like?" - Sofie (Facilitator)
"Nothing" - Tor "Is it important?" - Sofie (Facilitator)
"As little as possible [about the sound]... I say" - Tor
(Conversation with Tor in group 2)

One also termed it explicitly as annoying:

"What do you think about the sound?" - Matilda (Facilitator)
"It was too loud" - Tor

"It was kind of annoying" - Abdi
(Conversation with Tor and Abdi in group 2)

8.1.3 Collaboration and Playfulness

We found that the drones, as they are sold today, did not promote collaboration or playfulness amongst the children. Even though some toy drones claimed to be for multiplayer use. Instead, the drones seemed to promote solo play, where the participation of others was seen as a disruptive factor. The multiplayer aspect did also add certain negative emotions, such as frustration and aggressive tendencies between the children. This aspect is demonstrated by the following quote from Lisa in group 1:

"If you were to play with these drones with your friends, how would that work?" - Sofie (Facilitator)
"The friend should move out of the way" - Lisa
"They should just watch" - Lisa
"Do you think it's best to have someone to do this with or..." - Sofie (Facilitator)
"Self, it is and independent thing!" - Lisa says firmly
(Conversation from Lisa in group 1)

To solve this issue, the children of the different groups attempted to incorporate some sort of systematic turn-taking. The success of which differed depending on the group. For example in group 2, one child introduced the idea of turn-taking in the following way:

"It is much easier if one goes at a time" - Tor
"Otherwise it just becomes..like [shows chaos]" - Tor
(Conversation from group 2)

Figure 8.4: The children discussing the turn-taking.

This was implicitly accepted by the rest. However, while this was implicitly understood within the group, there were incidents of impulsive behavior that caused frustration amongst the participants, in figure 8.4 the children can be seen discussing the turn-taking. One child also expressed at one point the desire to play as a collective group:

> *When a drone was to be thrown up into the air.*
> *"Hey, can't we play as a group instead?" - Sabina*
> *(Desire from a child in group 2)*

However, this desire was ignored by the other children.

Unlike group 2, the children from group 1 would themselves instead ask the others to let them play alone:

> *"Why, why?" - Steven*
> *"Please let me do it alone" - Steven*
> *(Desire from child in group 1)*

Even though the children introduced turn-taking, it still left two children feeling like they never got to play as much as the rest.

At one point, in group 1, the children started to become aggressive toward each other because they wanted to play with the drone alone. One child tried to solve this issue by requesting that everyone gets their own drone:

> *"Everyone can take their own [drone] so there are no fights!" - Julia*
> *(Plea from child in group 1)*

Despite the drones mainly promoting solo play with the children, some attempts of collaboration appeared albeit very short interactions:

> *"Here Tor" - Says Sabina while she pushes the drone to Tor*
> *(Attempt at collaboration in group 2)*

> *"[Push] it towards me Adam" - Sarah*
> *(Attempt at collaboration in group 1)*

> *Sabina pushes the drone towards Ira.*
> *Ira pushes the drone towards Peter but Sabina intercepts.*
> *(Observation of attempt to collaboration in group 2)*

8.1.3.1 Existing Gameplay to Promote Playfulness

When we asked the children what they could see themselves using a drone for when playing with their friends, the most common pattern involved them trying to apply it to existing gameplay. We also observed fragments of this happening naturally as well during play with the drones:

"Oh dude it's basketball" - Peter

"Hey everybody, I just created a game" - Peter
Peter throws up the drone, Abdi suddenly shouts, backs away, and then goes towards the drone.
Abdi and Peter are pretending that they have guns and are shooting at the drone to make it move around.
(Observation and quote from group 2)

When asked about what they wanted to play using a drone, some children answered:

"If you were to play with you friends with [the drone], what functions would you want it to have?" - Sofie (Facilitator)
"If we are playing hide and seek, and that every one hides so that [the drone] tries to come and find you" - Tor
(Conversation about play with drone in group 2)

"Could you see yourself use [a drone] for something special?" - Sofie (Facilitator) asks all of the children.
Other children answered here as well.
"Tag" - Sabina
(Conversation about drone usage in group 2)

Because of these observations and desires from the children, we suggest taking inspiration from existing gameplay as a means to promote playfulness and collaboration when designing such drones. We suggest promoting collaborative play by either making a game where the children use the drone or designing the drone so that it can be applied to existing gameplay by becoming a part of the game.

When designing our low fidelity prototypes we considered this by both applying existing gameplay and creating a game with the drones. In one of the storyboards, we applied the existing game of hide and seek. In the other storyboard we created a game using the drone as an aid (see appendix E).

8.1.4 Aesthetics

Throughout our primary studies, we have observed that shape, color, and size are of importance to the children. The children had also explicitly requested and expressed certain preferences in aspects of all three aesthetic categories. Below we present our findings and what we deem should be considered when it comes to these aesthetics.

8.1.4.1 Shape

Shape covers both how the children would like it to look, but also what should be considered regarding protective shells. We identified a pattern of anthropomorphism between the children and the drones. There was also one physical accident with the propellers. According to the drone packages, the shells are used as collision protection and not for user protection per Se. Here we suggest that the design

should be aimed at making the shells primarily for safety, as to avoid physical injuries while trying to incorporate forms and shapes inspired by different flying objects or animals. Furthermore, the differences in preference regarding shape and form suggest that it should be considered having the option of exchangeable shells. This way the user can choose which type of shell they want for their drone.

In the prototype for group 1, we implicitly describe the shells as being exchangeable, while our prototype focused on color exchange the prototype implicitly included shape as well.

> *"Everyone chooses different colorful round shells for their drones."*

During the final study, the commercial drone testing, some of the children expressed a preference for the shape of the drones. One child explicitly expressed a preference for a round shape:

> *"Which shape do you prefer the most?" - Sofie (Facilitator)*
> *Julia points to the round drone, the Airhog Supernova.*
> *(Interaction from group 1)*

Lisa from group 1 also told us that she wanted them to have different forms not just being round and gave big birds as an example:

> *"That they would be fun if they were colorful, that they would be cool big birds, different shapes, not just round." - Lisa*
> *(Conversation with Lisa from group 1)*

Personification of inanimate objects

We also observed that the children were drawn to giving the drones some human or animal characteristics. They also would often refer to flying objects when talking about the drones. Many of the children tried to communicate with the drones by talking to and projecting feelings onto the drones. Some children began to talk to the drones in a parental manner:

> *"Come baby, come" - Lisa*
> *She holds out two hands, palms up*
> *"I've got you...And I'm turning you over" - Lisa*
> *(Lisa from group 1 talking to the drone)*

> *"Come come, come to mommy" - Tor as he holds his hands and arms towards the drone*
> *He also waves for it to come back to him.*
> *"Come to mommy" - Tor as he continues to wave to the drone*
> *(Tor from group 2 talking to the drone)*

At one point Tor from group 2 became annoyed with the behavior of the drone getting constantly 'stuck' to the ceiling:

"Stubborn little kid" - Tor about the drone going up towards the ceiling
(Quote from Tor in group 2)

During the workshop, some of the children gave their drones animal characteristics, although not all were real animals:

"Butterfly, and then like mix these colors, so that everyone gets like these colors, so I only get a few parts of [the colors]" - Lisa
"I'm going to make a butterfly that flies" - Sarah
(Conversation during the workshop in group 1)

"I'm gonna make a Pokémon one" - Peter
(Quote from group 2 during the workshop)

One child also talked about animal characteristics during the last session:

"That it would be fun if [the drones] were colorful, that they would be cool big birds, different shapes, not just round" - Lisa
(Quote from group 1)

When referring to flying objects:

"[inaudible], you stupid UFO. It's insaaaane!" - Peter to the drone
"Stop it you little evil!" - Tor to the drone
(The children of group 2 communicating with the drone)

8.1.4.2 Size

In both of the groups, the children brought up the importance of size, whether it be concerning control or use areas. One child, from group 1, thought that if the drone was larger it was easier to control:

"I think the larger ones are much easier" - Adam
(Quote from group 1)

While another said that a large drone would require adult supervision so she preferred a smaller size:

"Is size important?" - Sofie (Facilitator)
"Yeah, it is very important with size" - Lisa
"Why is that?" - Sofie (Facilitator
"Because if you have a really really large on, then you can't [control] it yourself. Then you must always have an adult with you to like [inaudible], so this smaller one is more for beginners" - Lisa
(Conversation from group 1)

One child, from group 2, explained that the size of the drone was important when it comes to areas of usage. As a smaller sized drone could do more than a large one:

"Is the size important for the drone?" - Sofie (Facilitator)
Two children answer no
"I want it to be small" - Tor
"Why is that?" - Sofie (Facilitator) to Tor
"So that you can use it for as many different things as possible. If it is big then you can be used for some [use areas], but those things you can also do if it is small. Then you can fly into narrow spaces which you could not do if it was big. But you can play, for example, hide and seek with both a small and large [drone]. It will be harder to find a small drone compared to a large one, so.." - Tor
(Conversation from group 2)

Because of these remarks from the children, and what we have observed, we suggest that size should be taken into consideration. Not only as it should be adjusted to the intended use of the drone, but also the design should be adjusted to the intended user group.

In our low fidelity prototypes, we considered this and in one storyboard, for group 1, we chose to make the drones' shells exchangeable. While in the other we chose to make the drones small as flies as the children had previously discussed and expressed a desire for this:

"I would like a microdrone" - Tor (He also mentions that such technology does not exist yet)
"Sort of like a spy drone, so that it does not get seen, it is like this small" - Tor
He shows how small it would have been by holding his thumb and index finger to create a hole.
"Or you build a drone so that it looks like a fly" - Tor
This is something that Ira and Sabina thinks is a great idea. "Oh that would have been super smart because then it is small and you will not suspect that it is a drone" - Ira "Just a little bug" - Sabina

8.1.4.3 Color

During our studies the children, especially one child in group 1, would often express their desire for the drones to be more colorful:

"What do you wish it could do?" - Matilda (Facilitator)
"Be more colorful" - Lisa
(Conversation from group 1)

When asked what type of drone the children would want to buy.
"And I think that the color, a drone with one color fixes like EVERYTHING. Like if you want new phone case, would you really only take black, totally black, that is really boring like it is just boring" - Lisa
(Conversation from group 1)

This was also observed when the children would do the commercial drone testing. When presented with all of the drones, with three of the drones being of the same size and shape, the children seemed to be more drawn to the colorful drones:

> *"Ooh that one was very cool" - Julia while pointing to the copper colored drone*
> *"Why is that?" - Sofie (Facilitator)*
> *"Because it is like golden, this one is also cool" - Julia while pointing to the Airhog Supernova*
> *(Conversation from group 1)*

> *Ira grabs the golden drone and Peter grabs the turquoise drone impulsively when presented with the drones.*
> *(Observation in group 2)*

> *"Which one do you think is the best?" - Sofie (Facilitator) asking Lisa who is approaching with her drone*
> *She points at the blue drone and says "This"*
> *"I don't know, I just like it...It's good, it's colorful, it's just like it's just good" - Lisa*
> *"What is the most important with it being good?" - Sofie (Facilitator)*
> *"Colorful!" - Lisa says immediately and firmly*
> *"Like, it is really boring if you only have a black thing" - Lisa*
> *(Conversation from group 1)*

One child specifically also requested that the drones should have disco lights:

> *"What do you wish it could do?" - Matilda (Facilitator)*
> *"That is lights up, like a disco ball, like that one" - Sarah while pointing at a disco light bulb*
> *(Conversation from group 1)*

One child specifically requested to be able to change color, and to also have invisible mode:

> *"Just like Adam said, [inaudible], I would also like to have invisible mode, so I think that it is really good also. I want to also have one of those, but with colors so like you can, first lets say that my drone is gray, I press on invisible mode and it is completely invisible. Then when you press on 'Come back', then it is a entirely new color. And then how you know where the drone is, what is it called, control" - Lisa*
> *(Desire to have a color-changing drone from group 1)*

Although color, and other aesthetics, could potentially be seen as trivial aspects when designing. Adding aspects such as color could potentially create a long-lasting appeal for the children.

In our low fidelity prototypes, we considered this, especially in the storyboard for

group 1 as the shells for the drones in the storyboard were presented as exchangeable and colorful (see appendix E).

8.1.5 Imagination

Children's imagination can sometimes be overlooked as something that is not plausible. During the commercial drone testing, we did not observe a lot of natural collaboration and play. Instead, we listened to the children express different requests stemming from their imaginations, such as being able to control the drone with your eyes, your mind, or signage:

> *"How would you control a drone?" - Sofie (Facilitator)*
> *"With my mind" - Abdi*
> *(Conversation with Abdi from group 2)*

> *"What do you think is best, if you could control it with whatever you want, would you choose that?´´ - Sofie (Facilitator)*
> *Lisa gestures how she would like to control it by writing letters in the air.*
> *(Conversation with Lisa from group 1)*

> *"How would you have wanted to control it?" - Matilda (Facilitator)*
> *"With your hand" - Steven*
> *"With your eyes" - Lisa*
> *"Or with your eyes, perhaps walla!" - Steven*
> *(Conversation from Steven in group 1)*

The following excerpt is a description of what a fun drone should include according to Lisa in group 1. She describes the drone as needing something, she refers to it as "Spicy". Meaning that she does not only want it to be able to fetch things for her but also to have functionality such as invisible mode or that the drone should be able to change color:

> *"[inaudible because of chair sound] if you really want fun drones you really want to think about the color, the sound, and what the drone can do [inaudible], it's so boring if the drone can just grab [things], for example I say 'can I get a capri sun', then it just grabs a capri sun [inaudible]. You want something spicy, you want something odd with your drone" - Lisa*
> *"What's odd then?" - Sofie (facilitator)*
> *"Just like Adam said, [inaudible], I would also like to have invisible mode, so I think that it is really good also. I want to also have one of those, but with colors so like you can, first lets say that my drone is gray, I press on invisible mode and it is completely invisible. Then when you press on 'Come back', then it is a entirely new color. And then how you know where the drone is, what is it called, control" - Lisa*
> *(Conversation with Lisa in group 1)*

One child also reasoned about being able to draw things on a paper and then use it as an input to the drone, to identify real-time objects. He also talked about the drone being able to recognize different smells and how it could have an x-ray camera:

> *"Finding things you've lost?" - Sofie (Facilitator)*
> *"So I'm thinking, if you've lost something, like there's something in the dresser, the drone has x-ray cameras and it kind of knows what you have because it's checked it out before and then it also has a sense of smell so it recognizes my scent, so if there's something in the dresser, it can sense it" - Tor*
> *"And that you can also draw the thing and upload it and it will find the thing" - Tor "How could you have used it in a game?" -Sofie (Facilitator)*
> *"It was mostly practical" - Tor*
> *(Conversation with Tor in group 2)*

As to how these different functionality imaginations should be managed and benefited from is up to the designers. However, we believe that for the purpose of collaboration and playfulness this is an important dimension to consider and draw inspiration from when designing gesture-controlled toy drones. With that said, while considering this the design should not be in such a way that could be perceived as deceiving to the children. Meaning that the children should not falsely be made to believe that they can control the drone with their eyes and mind. But instead should be seen as sources of inspiration when trying to design for collaboration and playfulness.

8.1.6 Previous Experience

By getting to know the children as well as we could during our time together, it helped us deepen our understanding of our results. This resulted in us noticing that previous experience with technology could have had an impact on the preference of control and what they would like to use it for. It would be fair to say that previous experience could be worth considering when designing for particular user groups. With this said, we cannot say that this is the cause behind the observed differences in the groups, but something that is worth exploring regarding the users. This will be presented through observed individual differences and on a group level.

8.1.6.1 Individual Level

It could be observed that the less experience they had with remote-controlled drones the more they preferred the idea of controlling them with their hands. However, two children from group 1 expressed a change of control preference after having a successful experience with a remote-controlled drone in one of the sessions. At the beginning of our studies, before testing the remote-controlled drone, the children responded as follows:

> *"How does it feel to control a drone this way, how does it feel?" - Sofie (Facilitator)*

"Very good" - Adam
"More fun" - Lisa
"More fun without remote" - Adam
"Because you can hold it like...you can steer with only your hands" - Lisa
"What is it about a remote that is worse?" - Sofie (Facilitator)
"It is very difficult technique you've to use" - Lisa
(Conversation from group 1 in study 1)

All of the children in group 1, apart from one child, had the opportunity to try out a remote-controlled drone during our studies. However, it was only the children who had been successful in controlling a remote-controlled drone that said they liked it better. One child had more difficulties in controlling the remote controlled, and one never got to try. These children both said they preferred the idea of controlling a drone with their hands or through other means besides a remote in the end. This is what their answers looked like after completion of all studies:

"You thought control, why?" - Sofie asks Lisa
"Because it's easier to like uh, what's it called, have control over to like you have to press some buttons, then it does what you want" - Lisa
(Conversation with Lisa in group 1 during study 3)

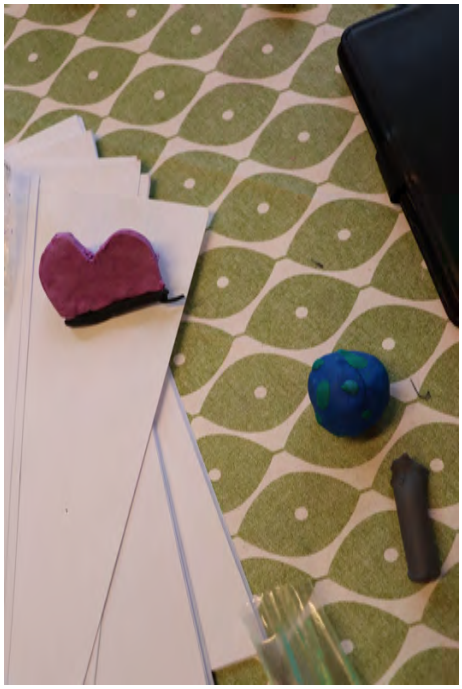
"Which way [of control] is the most natural way?" - Sofie (Facilitator)
"To like have, like, I have two ways, that like you point over there it goes there, you point over there it goes there, when you point over there it goes up. Then the other way is kind of having eye contact, when you look over there it goes there, when you look over there it goes there" - Julia
(Conversation with Julia in study 3 regarding her preferred way of control)

"If I ask you then, how do you feel after playing with these drones now?" - Sofie (Facilitator)
"It feels good, I like playing with drones that [you] control with hand, I also like when you control with voice" - Sarah
(Conversation with Sarah in study 3 who did not succeed in controlling the remote drone)

8.1.6.2 Group Differences

Group 1 had less experience in general when it came to technology compared to group 2 which seemed to have some experience. In group 1 they never expressed that they would like to use the drone for anything practical, they were more focused on learning how to control it and aesthetic aspects. While in group 2, most of the children wanted it for practical purposes as opposed to just for play. This could be observed in the workshop with group 2, as two out of the three prototypes created were of mechanical nature with remote controls (as can be seen in figures 8.2 and 8.3). While group 1 made prototypes relating to flying objects and animals (as can

be seen in figure 8.5).



(a) A planet prototype

(b) A butterfly prototype

Figure 8.5: Two drones created during the workshop in group 1, depicting a planet and a butterfly.

Group 1 was also the group more prone to suggest imaginary ways to control the drones, such as with their eyes and signage. Here we present a dense list of the most important difference between the two groups:

- Group 1
  - Ages between ten and twelve
  - Terms such as programming was explained
  - No first hand experience with drones
  - Two out of the five children had experience with a robot in school
- Group 2
  - Ages between nine and ten
  - Terms such as programming and robots needed no explaining
  - Everyone had first hand experience with robots
  - Everyone had first hand experience with drone

8.1.7 Ethical Dilemmas and Safety

As safety risk is a separate research question, we will limit this section to presenting a summarized version of these together with ethical dilemmas. We will explain why they are important to consider when designing gesture-controlled toy drones. For a more detailed report and understanding of the different types of safety risks, we refer to the next research question in this chapter.

8.1.7.1 Safety Risks

We have identified 3 types safety risk which are *Physical Safety Risks*, *Emotional Safety Risks* and *Social Safety Risks*.

- Physical Safety Risks
  These risks refer to the importance of considering a protective casing when designing gesture-controlled toy drones to inhibit the chance of getting hurt by the propellers. As the shells are today, they are not enough to protect the children completely from physical injury. This should be a central matter of safety when designing interactions that promote certain proximity to the technology, especially when the user group is children.

- Emotional Safety Risks
  Emotional safety risks refer to the negative emotional states such as frustration and aggressive tendencies, that these drones can trigger in the user, as they are today. These are, as we have noticed, often a result of turn-taking and interruptions in achieving a goal, i.e. controlling the drone. This circles back to the importance of actually designing for collaboration. What is important here is to consider how the design will promote a successful turn-taking system and/or how to avoid interruptions from other participants.

- Social Safety Risks
  Social safety risks refer to being affected by such areas as peer pressure and exclusion. These risks were, as we observed, a result of the children not being able to play more than two people at once. Which caused one or more children to withdraw from playing, if more than two children were playing simultaneously. Important to consider here is to design drones so that multiplayer play is actually possible. Other topics regarding this are loss of privacy and integrity which the designer needs to be aware of when incorporating cameras in these toy drones.

8.1.7.2 Ethical Dilemmas Stemming From Incorporation of Cameras

In order to have gesture control, it is assumed that a camera has to be used for the drone to read the gesture commands given by the user. The use of a camera opens up both ethical dilemmas and safety concerns. These include, but are not limited to, the need for security of the drone's internal system to hinder someone from taking over controls of the drone and starting to film the users.

As previously mentioned, when designing the drone there should be some consideration of input modality for external devices such as mobile phones for remote control, and a microphone for voice commands. These input modals would also need extra security to hinder someone from using these inputs for malicious intent such as espionage.

Our results have shown the importance of consideration for possible misuse in the hands of the user. Such considerations could be to address for the targeted age group, how to design for prohibiting misuse and handling of such, and maybe also consider parental control of the system.

8.2 RQ2: Types of Safety Risks

The second research question is centered on understanding the possible safety risks that may arise in the interaction between gesture-driven drones and children. To answer this question, we have conducted observational studies with commercial drones. The data was gathered in the form of observations and direct quotes, documented through notes, video, and audio recordings. These observations were either implicit or explicit responses from the children. Implicit responses were non-verbal behaviors indicating specific emotions and explicit were events that could be directly seen as a safety risk such as verbal expression of a specific emotion or body movements.

The analysis, conducted through thematic analysis, resulted in a collection of types of safety risks to be considered when designing drones in this context. We have categorized these risks as: *Physical Safety Risks*, *Emotional Safety Risks* and *Social Safety Risks*.

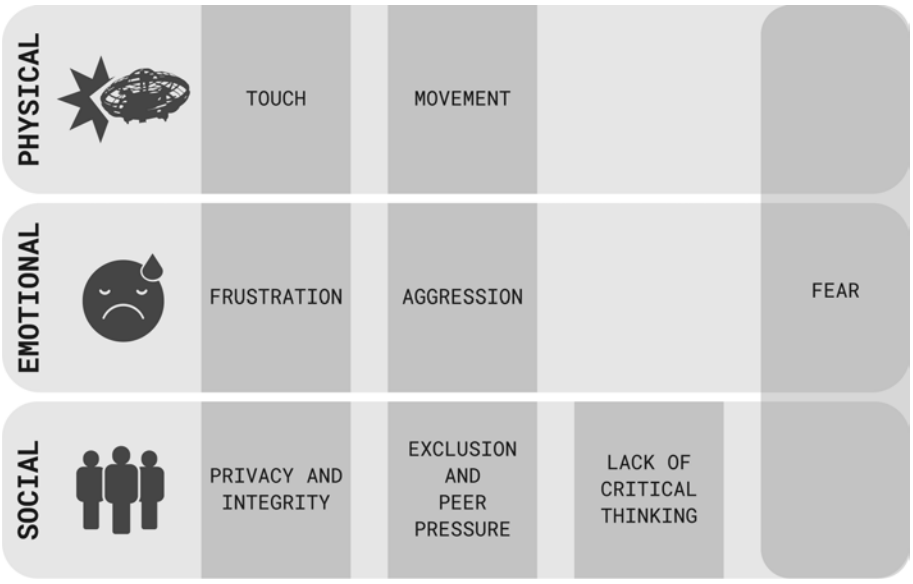


Figure 8.6: Overview for the safety risks.

8.2.1 Physical Safety Risks

We observed several safety risks stemming from both the behavior of the drone and interaction with it, many of them related to, for example, the reduced number of sensors on the drone. All drones tested had either two or four sensors on the sides and one sensor at the bottom of the drone, however, the drones lacked a sensor on top. It can be argued that because of this sensor shortage, it caused a domino effect of behaviors. When the children would play with the drones, mainly when playing collectively, they would often place their hands underneath the drone at once. This would trigger the bottom sensor and due to the sensor shortage on top, this resulted in the drone flying upwards towards the ceiling. The responses from the children were often to hold up their arms towards the drone and try to reach it, which would only trigger the bottom sensors further causing the drone to get 'stuck' to the ceiling. We have identified and described below some of the observed risks which fall under this category.

8.2.1.1 Through Touch

Here we describe the safety risks coming from children touching the drone in active mode, i.e. when the propellers were spinning. There were several occasions when this occurred, such moments included them grabbing it impulsively when the drone was near, when they wanted to move it to a more open space due to lack of sense of control, or when climbing on objects to grab it when it was stuck in the ceiling. Unfortunately, we did have one physical injury residing from direct interaction with the drone. This occurred in the second group during the first study, where they got to try out one of the drones for the first time (see figure 8.7 and the following quote).

Figure 8.7: Artwork depicting the moment before the physical injury occurred.

Abdi grabs the drone with a claw grip and brings it down
"Watch your fingers" - Matilda (Facilitator)
Peter also grabs the drone and tilts it a bit, causing Abdi's finger to end up getting struck by the propeller and he gets hurt
(Observation and quote from an accident in group 2)

They were also forced sometimes to physically push the drone when it was unresponsive as the following reflection from one of the participants will show :

"Was there some part that felt like it could be better?" - Sofie (Facilitator)
"Yeah" - Abdi
"You said that the drones would like listen to you hand, so like if you put it here it would go down but it didn't go down, I had to go like this and this [Shows how you need to push it]. But why?" - Peter
"So you want like a sensor up here as well?" - Matilda (facilitator)
"Yeah" - Peter
(Conversation from group 1)

8.2.1.2 Through Movement

The lack of control and the way of interacting, i.e. controlling with your hands, caused the children to do different movements that constitute different physical risks as well. These movements were observed in both groups on several occasions. One of these was when the children collectively gathered around the drone wanting to interact with it. Here we identified risks such as running into each other, stepping on toes, accidentally hitting one another, etc. Furthermore, when the drone would not come back down from the ceiling the children would often start to problem solve by climbing on different nearby objects such as chairs or tables to reach the drone (see figure 8.8).

Figure 8.8: Artwork depicting a child climbing on a chair to reach the drone.

This could lead to falling accidents. In one situation this almost caused such an accident when a child began climbing on the backrest of a chair, trying to reach the drone, causing the chair to wobble slightly because of the weight shift. However, one of us intervened before the chair toppled over.

8.2.2 Emotional Safety Risks

This section describes emotional risks that could occur while interacting with the drone. Our results show different types of emotional states, for example *fear*, *frustration*, and *aggressive tendencies*. We have chosen to define these types of emotional states and their corresponding reactions by following the definition given by the Swedish National Encyclopedia [77]:

> *"Frustration, psychological term referring to the emotions and reactions aroused when the path to a desired goal is blocked. Sometimes the term is used to denote the obstructing circumstances. Frustration thus implies both a goal-oriented desire (a motivation) and the thwarting of hopes of achieving the goal (e.g. by another person, an internal conflict or an external circumstance). According to an influential psychological hypothesis, frustration regularly leads to aggression [...]"*

> *"Aggression (Latin aggre'ssio 'attack', 'attack', from aggre'dior 'to attack', 'to attack'), in psychology: behaviour or reaction intended to inflict harm or discomfort on another individual. A distinction is made between aggression or aggressive reaction and aggressive tendencies. Aggressive tendencies are the tendency of an individual to respond with aggression under certain conditions. Even if aggressive tendencies are triggered, this does not necessarily translate into aggressive behaviour.[...]"*

> *"Fear, a feeling of discomfort that can vary in intensity from mild anxiety to terror, and that is triggered by a threat that may be immediate and concrete or consist of the apprehension that something or someone may harm one (compare phobia)."*

Frustration was one of the most common patterns in both groups and was often the root to the subsequent aggressive tendencies observed. The negative emotional states of frustration and aggressive tendencies were observed to be directed either towards each other or at the drone itself.

8.2.2.1 Implicit and Explicit Fear of Physical Injuries

Fear was one of the larger themes. The fear was both implicit and explicit which covered both risks from interaction and risks from drone behavior. The implicit fear was observed when the drone flew in near proximity at a high speed and/or towards the participant. Which caused a sudden bodily reaction to avoid it, as can be expected. We also noticed one participant doing such a bodily reaction when hearing the sound of the drone (see figure 8.9). The explicit fear was observed when

they expressed their fear to us directly, voiced it to each other, or after getting physically hurt by the propellers.

Figure 8.9: Artwork depicting observed fear of one participant.

Some of the children, from both groups, did explicitly express their fear of getting hurt in different ways when interacting with the drone. One child, from group 1, expressed his fear of the propellers:

> *"The thing that makes me afraid of drones are that when you hold it I'm scared of that ehh..." - Adam*
> *"The propellers?" - Matilda (facilitator)*
> *"Will come and cut me" - Adam*
> *(Conversation from group 1)*

Another child in group 2 explicitly said that he did not want to touch it and requested safety glasses because he feared the drone would poke his eye:

> *"I don't want to touch it" - says Abdi*
> *He then takes off his gloves, he also asks to get a pair of glasses before we have had a chance to give them out*
> *"I want one, I don't want it to poke my eye" - Abdi*
> *(Quotes and observation from one child in group 2)*

We also had one incident where the drone came in near proximity at a high speed towards a child in group 1, he reacted by whacking it down. This is what he told us after the incident:

"How are you?" - Sofie (facilitator)
"were you scared?" - Sofie (facilitator)
"Yeees" - Adam
Adam backs off and pant a little and seems a little dizzy from the incident
"Was it scary because it came at you [interrupted] ...." - Matilda (facilitator)
"I did not want it to poke me in the face" - Adam
"Would it have been scary if it poked you in the face?" - Matilda (facilitator)
"Yeah" - Adam
(Conversation and observation from one child in group 1)

This excerpt is of an observation and transcript which will show an example of how one child seemed to be afraid of touching it and she avoided touching it by different movements:

"When it's down you can't just pick it up [showing how it will hurt your hand and how you have to crouch down and make movements under it] so you have to go down like this" - Lisa
(Quote and observation from one child in group 1)

Last but not least is an example of how one child did not want to touch it due to prior injury:

"You don't want to touch it, why not?" - Sofie (Facilitator)
"I got hurt already" - Abdi
"I don't want to touch it" - Abdi
Abdi walks away from the group and says:
"I am way too scared" - Abdi
(Conversation with one child from group 2)

8.2.2.2 Frustration and Aggression Towards each Other

Frustration and aggression towards each other were often due to them being interrupted while playing with the drone or through arguments during turn-taking. During play with the drones, the children incorporated turn-taking of their own volition, and the success rate of the turn-taking was dependent on the group. The frustration in-between participants were externalized through arguments and also occasionally through name-calling, and would often end at this stage as well. However, sometimes the frustration would advance to physical aggression, which in this context took form in them shoving each other when arguing, pushing each other's hands away from the drones, or pushing through a group of other participants by force.

Situations, where a child would be interrupted, were either caused by another child grabbing it impulsively when the drone came near or having their arms stretched out towards the drone while in the air. In the following two excerpts we demonstrate

the impulsive behavior and the triggered frustration:

> *Peter is playing with the drone but it is too high up for him to grab it so he jumps to try and reach it, Sabina walks up and grabs the drone with his hands away from Peter, which causes it to crash.*
> *"My turn!" - Peter*
> *Peter gets very angry and stomps his foot and yells at Sabina while trying to hit her.*
> *Sabina walks away.*
> *(Observation and quote from group 2* (This can be seen in figure 8.10)*)*

Figure 8.10: Artwork depicting frustration triggered by impulsive behaviour.

> *Julia tries to grab the drone while Lisa thinks she can control it.*
> *"Stop it" - Lisa, she gets angry and stomps her foot.*
> *(Observation and quote from group 1)*

In group 1 we observed a lot more simultaneous interaction, i.e. several participants trying to interact with it at the same time having their arms outstretched in the air directed towards the drone. This would cause more frustration between participants, which in turn led to smaller physical and verbal aggression. While in group 2 they managed to agree on systematic turn-taking. Which led to less physical aggression but with frustration and aggressive tendencies still prominent. In the following two excerpts we demonstrate the name calling and a typical argument that could occur between participants:

> *The drone has crashed.*
> *"Die man die" - Abdi*
> *Sofie (facilitator) takes out the backup drone, and Ira is going to throw it up but it gets wild and starts flying from her hand, she gets frustrated when Sabina says*
> *"Ira!" - Sabina*
> *"I didn't even drop it" - Ira*
> *"It's my turn" - Peter*
> *"Take it though" - Ira*

(Argumentative - group 2)

"But stop!" - Lisa
"You have problems for real, you are cp injured walla" - Lisa towards another participant
(Name calling - group 1)

8.2.2.3 Frustration and Aggression Towards the drone

The frustration and aggressive tendencies toward the drone were most often due to lack of sense of control. Aspects such as sound were also triggering behavior, which they expressed negative feelings towards. It should be noted that we never observed any physical aggression towards the drone. Although, we did observe the drone trigger violent imaginary games in which two participants joined together and pretended to shoot down the drone, as showed by the following dialog and observation:

"Hey everybody, I just created a game" - Peter
Peter throws it up, Abdi screams a bit and backs away while walking towards it and Abdi and Peter pretend they have guns and shoot at the drone to make it go around, it is just the two of them playing while the others observe.
"Peter has played with the drone three times now" - Ira
Peter and Abdi continue with their shooting game
"No" - Sabina
(Observation and conversation from group 2 (This can be seen in figure 8.11)*)*

Figure 8.11: The game, that Peter created, being played while another child also tries to play with the drone.

This game was repeated amongst the same two children throughout the session where we tested the commercial drones (see fig 8.11). Two other children in group 1 were also observed pretending to have a boxing fight with the drone, which also could be termed as a violent imaginary game or play.

The aggressive tendencies toward the drone were most often expressed verbally as exemplified in the two following quotes:

> *"When you feel you can't control it, what do you want to be able to do?" - Sofie (facilitator)*
> *"I want to [grrr] smash it" - says Sarah, clenching her fists as she holds them up in the air*
> *(Quote from one participant in group 1)*

> *"You may say one positive thing and one negative thing about our meeting here?" - Sofie (Facilitator) "I'll start with negative, so the drones, it was more the drones so they came towards you [showing with a gesture towards the face] and you got aggressive because it didn't listen to you, it didn't do your orders. It made me angry- [...]" - Lisa*

8.2.3 Social Risks

We also observed risks of a social nature, stemming from the interactions between people. Below we present this in sub-themes as *Exclusion and peer-pressure*, *Loss of Privacy and Integrity*, and *Lack of Critical Thinking*.

8.2.3.1 Exclusion and Peer Pressure

During play with the drones, a theme of exclusion appeared. This often originated from the children's inability and/or difficulties in finding ways to collaborate and play as a group. One contributing factor to these difficulties was the behavior of the drone caused by the shortage of sensors. As previously explained in the sub-sub section Physical Safety Risks through Movement (8.2.1.2), when the children were more than two playing with the drone at once, the sensors of the drone would start to react to the children's movements and get 'stuck'. This triggered different responses, most often a problem-solving response described in said sub-sub section, however sometimes this triggered the children to express verbal frustration and/or them withdrawing from the play and simply observe.

This left some children feeling excluded and that they never got to play with it, as the following excerpt shows:

> *"Okay but if we ask you then, Julia, how do you feel about today, it is your first time [playing with gestured drones]?" - Sofie (facilitator)*
> *"It feels good" - Julia*
> *"Does it feel good?" - Sofie (facilitator)*
> *"It was fun, but a bit unfair I think to myself, because Adam and Lisa were playing with it a lot [people come into the room and interrupt her*

in the sentence] and I didn't get to play with it" - Julia
(Conversation in the end of study 3 in group 1)

Or them requesting during the session to play with the rest of the drones so everybody played with one simultaneously by themselves:

"Everyone can take their own so they don't argue!" - Julia

We also had one behavior of withdrawal from group 2 that one participant expressed to be out of fear of the drone, which could either be due to him expressing fear prior to our testing the drones or due the accident he had early in the testing process:

"Are you afraid of drones?" - Sofie (Facilitator)
"No" - Peter
"I mean, I am afraid of them a little bit" - Abdi
(Conversation from our first study with group 2)

He explicitly and repeatedly expressed that he did not want to play with it or be near it, as can be seen in the following quotes:

"You don't want to touch it, why not?" - Sofie (facilitator)
"I got hurt already" - Abdi
"I don't want to touch it" - Abdi
Abdi walks away from the group and says:
"I am way too scared"

Abdi runs past Sabina to the other side of the room as she plays with it and says
"Don't bring the drone near to me"
(Conversation and observation from group 2 during the last study)

Every time he expressed such fear, we reminded the child that he was free to leave and join the rest of the class who were doing other activities nearby, but he repeatedly declined this. This particular child could also be expressing this fear because he got his finger inside the shell of one drones and got struck by one of the propellers early on in the first study. This was unfortunately during a time when we had not yet provided them with safety gear, such as gloves. At the same time, he wanted to be a part of the group and during the group's attempts at turn-taking with the drones, one of the participants confronted him on his refusal to play with it after being asked several times as can be demonstrated with the following dialog:

Ira says the order of how they should play: Tor, Ira, Sabina
"I don't play" - Abdi
"And then me!" - Peter
"No, you're last" - Ira about Peter
"I don't want to" - Abdi
"I don't want to!!!" - Abdi says hand raises his voice and tells her firmly
"He doesn't want to, I'm last then" - Peter

"But you said you don't want to, to all the drones" - Ira to Abdi (Conversation from group 2 during the last study)

This type of behavior shows another social risk, however not necessarily connected to the theme of exclusion. This could be categorized as peer pressure and the possible effects that come with it when emerged in play with drones as a medium.

8.2.3.2 Loss of Privacy and Integrity

Some of the children, especially expressed in group 2, showed an interest in the usage of cameras as a functionality. Their first and foremost intention with the camera was for espionage on families and friends. They also showed a lack of critical thinking, both towards third parties using it and their own intention of usage. As this is an input modality that would be needed to interpret more complex gestures this creates a risk of loss of privacy and integrity.

In group 2 all of the five children showed a clear interest in incorporating cameras in their drones. For three out of the five participating children, this was a recurring theme throughout our study with them being very insistent on using cameras, up to a point where it almost occupied their whole imagination. The usage of cameras could range from simple practical reasons, such as being able to pick up objects or taking pictures on a skiing trip with the family, to malicious intent such as espionage. It should be noted that the most dominant use case for having a camera in the drone, according to the children, was for espionage. This could involve either spying on their friends or family members. The following transcript shows the three children's initial response to what they would use a drone for and one child describing what they would use a drone with a camera for:

"Could you see yourself use [a drone] for something special?" - Sofie
"Camera" - Peter
"Camera" - Abdi
"Tag" - Sabina
"I would like to have one of these with a camera and so would I, if my brother and, for example, his friend were playing. Because his friend lives very close, so I would have taken it out the window, I would have wanted a camera to see what they were doing. If it was something fun, I would have gone and asked them if I could join" - Ira

One child described how he wanted to sneak on his little sister and scare her:

"In which situation would it need to be quiet?" - Sofie (Facilitator)
"When you're going to scare your sister, you can film what she's doing so you know exactly where she is, so you can plan beforehand how to go into her room and then you check the drone and it's in the corner and you see that she's looking away... then you jump and you throw her down on the floor" - Tor

(Conversation from group 2)

One child reasoned on how a drone could use personal data of his to help him find things that he had lost:

"Finding things you've lost?" - Sofie (Facilitator) "But I think, if you've lost something, like there's something in the dresser, the drone has x-ray cameras and it kind of knows what you have because it's checked it out before and then it also has a sense of smell so it recognizes my smell, so if there's something in the dresser, it can sense it" - Tor
"And that you can also draw the thing and upload it and it will find the thing" - Tor
"How could you have used it in a game?" - Sofie (Facilitator)
"It was most practical" - Tor
(Conversation from group 2)

During the co-design, the majority of children from group 2 were keen on incorporating cameras in their drones. When asked specifically if it is important to have cameras in drones, one child answered vaguely:

Sabina shows the facilitators that she has made wheels for her drone.
"So that it can walk" - Sabina
"So that it can both walk and fly" - Sabina
"Is is important that it does this?" - Sofie (Facilitator)
"If it walks, it can film from underneath and it can also go up so" - Sabina
"It is important to film?" - Sofie (Facilitator)
"Yeah" - Sabina
"Why is that?" - Sofie (Facilitator)
"Because, I don't know... It is good" - Sabina
(Conversation with a child from group 2 regarding her drone design)

It should be mentioned that group 1 was aware that drones could have cameras. One child described seeing police drones that had a camera, and another described having seen others use a drone with a camera. However, cameras were not something they explicitly requested during any session or tried to incorporate in the co-design workshop.

8.2.3.3 Lack of Critical Thinking

Furthermore, we noticed a lack of critical thinking when it came to the use of cameras both in the hands of third parties and their own. This was shown through a certain trust in authorities using cameras, how they reasoned about other areas in life where cameras are used and ambivalence in their attitudes towards being filmed or filming others.

For example, the following conversation shows how they believe that the cameras used in the tolls only capture important features of the situation and exclude those

who are not:

> *[Talking about traffic enforcement cameras and pay tolls] "But how does it feel, that there are drones filming?"- Sofie (Facilitator)*
> *"Well, the only thing they will see is the car and possibly the registration number"- Ira*
> *"And the people sitting in it, but on speed cameras you only blur the passenger"- Tor*
> *"You know those signs that are on the highways that say like 20 kr and stuff, there are cameras so they can see the registration number to be able to send the bill" - Ira*
> *(Conversation from group 2)*

Another example is how a child tells us that she believes that those who have drones are professionals:

> *"How do you feel about a big drone?" - Sofie (Facilitator)*
> *"more fun kind of" - Lisa*
> *"Okay it doesn't feel like...another one of those" - Sofie (Facilitator)*
> *"Well, it's not like I'm like for big drones" - Lisa*
> *"I know that most people who have drones are kind of professional" - Lisa*
> *"So it's not like everyone has bought drones just to [inaudible], there are some who buy big drones for filming and stuff, there are some who buy drones to like just have fun with them. I think I would have more [usage with] a big [drone] like" - Lisa*
> *(Conversation from group 1)*

Finally, here are an example of one child being positive to authorities using it for legal purposes:

> *"The police who follow a car that has driven wrong or needs to pay" - Sabina*
> *"Do you think that is the best thing to have the drone for?" - Sofie (Facilitator)*
> *Sabina nods in agreement*
> *(Conversation from group 2)*

A feeling of ambivalence towards the usage of cameras on drones could be noticed in group 2, where they did want to use cameras but when asked how they would feel being filmed by drones some responded with some skepticism.

> *"How would you feel if there was a drone flying around during this time [when they have a break in the schoolyard]?" - Sofie (Facilitator)*

"It's a little fun because you do not really know what it does" - Tor
"So you mean like you would be suspicious, or?" - Sofie (Facilitator)
"No, but it's to see what it thinks it should, [or] can do" - Tor
(Conversation from group 2)

"How would you feel if there was a lot of drones around you and filming you?" - Sofie (Facilitator)
"Not so good... But I would only want to see if there was someone there" - Ira
(Conversation from group 2 - after explaining what they would a use drone with a camera for)

"How would you feel if there was a drone flying around during this time [when they have break in the schoolyard]?" - Sofie (Facilitator)
"But at the same time it's really scary because it's filming. Because you don't know everything" - Sabina
(Conversation from group 2 - after saying that they would like a camera)

While in group 1 they never reflected on this subject in more then one situation and the child did not show any critical thinking towards being filmed by drones:

"How do you feel about being filmed by drones?" - Sofie (Facilitator)
"Very cool, you'll become a celebrity" - Sarah
(Quote from participant in group 1)

9

Discussion

The following chapter presents a discussion surrounding our RfD approach and its accompanying methodology. Our Methodology will be primarily discussed in relation to working with children. We also connect back to our research questions to see how well we have succeeded in answering them or not. In addition, we relate back to the literature and present what we have learned while working with children. Finally, we discuss future research in the area of CDI.

9.1 Research Question 1: Design Considerations

In this first part, we discuss our results in relation to our first research question. This includes topics about to what degree we have been able to answer it, shortcomings, and how it stands in relation to the background and theoretical underpinnings of our project.

What can be said about the design of gestured controlled toy drones for collaboration and playfulness? According to our work when evaluating current designs, available drones do not promote collaboration amongst children. They do however have an appeal to the individual and most of the children said that they thought it was fun to try to control it with their hands. Furthermore, most of the children said that they could see themselves buying a similar toy drone. Our design considerations provide good insights for the design of these toy drones in numerous dimensions to make them more collaborative and therefore playful amongst children. Some of the provided considerations are rather broad and lack some depth, but in an unexplored area such as this, it is necessary to provide the broad strokes first. We have not only provided design considerations for toy drones but also helped define an initial scope for further research within CDI.

9.1.1 Defining Gestures for Children

It turned out to be difficult to investigate and define specific types of gestures for different actions due to the children using their whole bodies. Initially, we thought that specific gestures would be a natural outcome of our work. However, these gestured interactions proved to be too difficult for the children to define. This instead turned into interesting insights into the field of Natural User Interfaces (NUI), in

relation to gestures within CDI. Meaning, as our results have shown, we question using gestures as an interaction form in CDI, and whether gestures really are to be considered as an NUI. Most children liked the idea of being able to control with their hands initially and one explicitly told us that using a remote is difficult. Although, after they had succeeded in testing a remote-controlled drone, they preferred to control it this way. This could also have been affected by the other gestured drones being very hard to control, and in comparison, the remote was better or more precise. But there was still a natural preference towards the concept of having an external device controlling, as could be seen in group 2 where they never tested remote-controlled drones. We speculate that it may be difficult for children to make sense of these interaction types as they initially may not understand the technology behind them. This makes them desperately try to seek something they can relate to, as a way to make sense of what is controlling it. As adults may not either always understand the technology behind things, they are different in the sense of their perceptions of the world's capabilities than for example children, i.e. a lot bigger framework to relate to or draw knowledge from. For example, how do children reason about novel technology with new types of interaction, can we see a pattern in their sense-making? We believe that it is crucial to understand more about children's perceptions of different technology and the reasons behind them to get a deeper understanding of how and why we should design differently for this complex user group.

As we still believe that NUI is a good way to make the products more inclusive, being able to span over a broader age group, other interaction types should perhaps be considered in this area. We have instead suggested many other different interactions that could be worth considering in this regard, such as body movements or voice control.

One of our findings suggests that it should be considered making a distinction between gesture-controlled toy drones, and sensor-based toy drones and their corresponding interaction type. The toys tested in this study were mainly sensor-based which resulted in the children eventually using coordinated two-hand movements to be able to control them, otherwise, they would fly up in the air and get stuck against the ceiling. This would in turn often result in them climbing on nearby objects to get them down. Although, some of the toy drones did include a set of gestures that would, for example, make the drone do a flip or circle around you. This was included in the technical instruction which the children did not have access to. In a natural setting, the children would have access to the instructions and could try this out. However, we wanted to explore what natural interactions occurred during play with others when using gestured-controlled toy drones. Although, one of the children told us that she rarely read the technical instructions and if she would do it they would need to be fun and not boring. In complement to this, even if they had the opportunity to read the manual they would need to have the drone in proximity to perform the different gestures, due to the drone being sensor-based.

Interestingly, these coordinated two hand gestures in solo play did portray a certain level of calm behavior but were counteracted by the number of participants wanting

to interact with it at the same time. We also observed changes in behavior towards the drone, one of the children stopped completely interacting with her hands or made slow and careful waves with her hand close to her body. During this time she believed that she was controlling it with her eyes:

> ***"I can control it, I can control it" - says Lisa and makes some joyful jumps Thinking she can control it with her eyes"***

. This constitutes another interesting area for further investigation. As this interaction involved two-hand gestures and a certain degree of focus and restraint it opens up a door to explore how the erratic behavior of drones can affect children's behavior and what it could be used for. What is compelling here is that the drones' erratic behavior seems to be the source of their engagement.

9.1.1.1 Multiplayer interaction

When discussing the setup of the different studies, we contemplated on how to encourage collaborative and multiplayer interactions. However, we decided to not encourage this as we are conducting ethnographic research and if these drones actually are multiplayer friendly, as they claimed, this would almost come naturally and would not need interfering. Although we did not observe collaborative play truly happening in the primary studies, as we only saw the children attempting at collaborative play with one-on-one interactions, it never led anywhere. Compared to the pilot study, where collaborative play came almost instantly with them creating a game. This difference could be due to many factors. For example, when the drones claim to be multiplayer they might only regard two people as multiplayer. As we saw collaborative play sort of working when only two children were playing with the drone. It could also be due to the pilot study only having two participants, who were siblings, so they might have felt comfortable enough with each other to create games. There was also a discussion about how the structure of our studies affected the outcome. For example, could a study with solo play before collaboration have yielded a different result? We believe that this would maybe have added confidence and self-esteem within the individual in terms of control, where every individual would have gotten the chance to learn it beforehand. We believe that this would not have changed the fact that everyone wanted to interact with it at the same time and how the sensor reacted to a multiplayer set-up. It should also be noted that if someone bought one drone for the specific purpose of playing with a friend, they would only have one, and then in a natural setting that would not have been possible. Although we believed that creating a stronger sense of control while interacting with the drone is important with respect to the emotional aspect.

The drone's behavior, sound, movements, etc., did have an effect and triggered impulsive behavior within the children. With that aspect in mind, it could be said that several different opposing forces are working against each other. One where the children want to collaborate and not fight, one concerned with their own best interests, and the behaviors the drones trigger. Saying it like that, it does not seem odd that there would be difficulties in the collaboration. This makes it more clear

that designers need to understand the effect of the drones' behavior to be able to find ways to use this in a creative manner to motivate collaboration. This becomes especially important in cases where claims that the product is multiplayer friendly are made.

9.1.1.2 Anthropomorphism and Child-Drone Interaction

One thing we noticed in our studies is that the children liked to apply personal traits to the drones. They also liked to talk to it in general as if it was a person or a pet. One even explicitly described she would like to control the drone similar to how you give dogs commands. Furthermore, when they did not succeed in controlling the drone, they assigned negative qualities and addressed it as if it were a human, such as *"stubborn kid"* or it being stupid. This goes in line with prior work within HDI presented in our theory, such as Cauchard et al. who discovered that people seem to interact with drones as they do with a person or a pet[18, 107]. We also observed the children sometimes applied a parental role toward the drones. For example, one child called it a baby and another child referred to himself as the drone's mother, as can be seen in the quotes in our results. There was also one time when a child said that they did not feel as if it were a drone because it was much more autonomous than he expected:

> *"It didn't feel as much like a drone, it was more automatic than what you're used to" - Tor*
> *(Conversation with Tor in group 2)*

These observations entail a compelling topic for discussion, in relation to this area, in terms of trying to understand the natural interaction between children and drones. For example, it would be valuable to know how much the size affected their way of speaking to the drone. It would also be interesting to look into how much sense of control plays a part in them applying agency to a drone.

9.1.1.3 Play for Play's Sake with Drones

Conducting studies with a mindset of designing play for play's sake with drones is, as shown by our work, a challenge in itself. We struggled with getting the children to view the drones as a means for play with their friends, especially with group 2. This was the group that exhibited the most general knowledge of technology. As a result of our attempts of actively trying to get them to view it in a playful context they often referred to already existing gameplay, which Caillois would term a more "Ludus" form of play. The "Paida" play, i.e. "wild, free-form, improvisation play", that we set out to investigate appeared mostly in one-on-one situations [17]. During these times they mostly exhibited passing games, where they compared it to either a basketball or something to be passed between each other. We believe that previous experience and expectations of drones could possibly affect this, as many of them initially saw it as something practical such as for filming and photography.

Another topic for discussion is to consider how most novel technology initially is

introduced to children. As we stated in our background there is an extensive collection of studies within the field of CRI with a focus on edutainment and playful learning within education or development. In our studies, we could see that if the children had some experience with robots, it was related either to programming or something they had done in school. We argue that there should be more weight put into exploring new digital spaces for children in play where it is viewed as an occupation, i.e. as an aim, a right, and participation that contributes to the children's well-being. In a digitized world where technology becomes more and more inevitable in children's daily play, this becomes even more important for the sake of not losing the nature of children's play.

9.1.1.4 Toy Drones and Sustainability

A discussion about sustainability arises in relation to repair-ability. We discussed if making the drones repairable would make them more sustainable and how this relates to our design considerations. In terms of aesthetics, we recommended considering the possibility of having changeable shells with different forms. Here you could claim that this makes the drones more sustainable by making them re-usable but you also need to think about the manufacturing of the parts. It is still plastic and they still need to manufacture all of the replaceable parts. On the other side, this is maybe better than people tossing it after a short time and buying a completely new one. Therefore, we agreed on the fact that making these drones repairable is a step toward having a sustainable mindset while you still need to consider a lot of other parts of the production to claim that they are sustainable.

9.2 Research Question 2: Types of Safety Risks

This section provides a discussion circled around our result from our second research question which provided three different types of safety risks.

By exploring existing gestured controlled toy drones we got an opportunity to explore what types of safety risks may arise from these. At first glance, we were inclined to believe that the biggest issue would be the propellers and the risk of physical injury. Our work has been able to show that there are more than just the propellers that pose a threat to the children. We found three different types of safety risks, *Physical Safety Risks*, *Emotional Safety Risks* and *Social Safety Risks*. In this, the risk of getting physically injured, through direct contact with the drone, is actually just a sub-part of physical risks. There is a lot more than meets the eye and the behavior of drones seems to have a lot of impact on said safety risks. This has opened up for different lenses to approach the area of safety.

9.2.1 Social Drones and Children

In terms of social drones, we deem these toy drones to not be autonomous enough to be included in this category [10]. But what is interesting, relating to our work and result, is the challenges and risks that these social drones may bring in the

light of children. Aspects corresponding to the inherent mechanical workings of the drones, such as sound and propellers together with children's lack of critical thinking constitute a risk. If we are to believe what Baytas et al. says about autonomous flying drones becoming ubiquitous in the future, as well as a possible major HCI paradigm you will need to take this aspect of children into consideration. How do children react to drones, and how does it contribute to their well-being and mental state? What more than physical safety can be expected to occur? If you are considering a future where drones are to inhabit our daily environment there is no doubt of the importance of further exploration into the different challenges and risks that we have pinpointed with our work in relation to CDI [10].

9.2.2 The Future of Toy Drones

All of our results together naturally culminate in a discussion about the appropriateness of these drones as toys for children. When trying to come up with a suitable design for the new drone, we looked at blade-less propellers as this would remove the entire risk of the propellers used today. However, this was deemed to be too speculative, because even though the technology exists today it would be too expensive to incorporate into today's design of toy drones. This has made us reflect on if the technology today is mature enough for being used in the production of commercial toy drones. If so, careful considerations regarding design should be made to try to minimize any and all safety risks that come with it. This entails further exploration in different directions, such as how to encourage collaboration between children with drones as a play media. How to make sure that the children can control the drone well enough so that it does not cause frustration and aggression towards each other. How to make sure everyone feels included in the experience, not only considering collaboration but also included as a whole. How to handle the sound, which we have observed as a significantly stressing characteristic and negative in that sense. Several of the children also stated that they would rather like it to be quiet or as quiet as possible.

9.3 Ethical Considerations

Throughout this master thesis we have tried to follow the UNICEF framework and guidelines [47]. These guidelines, also known as the ERIC guidelines, are as follows:

- Ethics in research involving children is everyone's responsibility.
- Respecting the dignity of children is core to ethical research.
- Research involving children must be just and equitable.
- Ethical research benefits children.
- Children should never be harmed by their participation in research.
- Research must always obtain children's informed and ongoing consent.

- Ethical research required ongoing reflection.

To try and follow these guidelines we conducted expert interviews to get a better understanding of the complexity of conducting research with children. These experts also gave their insights with their experiences when conducting research with children. When actually conducting the studies we tried to be as systematic as possible, trying to avoid leading questions, and favoritism, emphasizing that these studies were completely voluntary, and having general patience with the children. While we did, unfortunately, have an incident of injury with one child during our studies. When this incident happened, it was very important to us that the injury did not cause any physical or emotional harm. We did our best to handle the situation and kept an extra eye on the child during the rest of the studies.

When handling the data we had collected during our expert interviews and during our studies, we followed GDPR and after the analysis is concluded we will delete all recordings before publishing this master thesis.

9.4 Methodology

Here we will discuss how well our methodology worked out and possible limitations.

9.4.1 Result from The Planning of Our Project

In addition to our literature study, which produced a good base for our understanding of both HDI and the lack of research regarding CDI, we also found our expert interviews and pilot study to be incredibly helpful. We think that they can not only work as a support for other students who are considering going down the same path. But also for ourselves as the interviews and pilot study really gave us insights into different aspects which we would not have thought about ourselves.

9.4.2 Research For Design as an approach

By approaching this through the lenses of RfD, we believe that we had more time to produce qualitative results with the children as our primary source of information. Compared to a RtD approach, we could focus on the actual process of gathering information and getting to know the children instead of mainly focusing on the design. Another reason as to why we chose the RfD approach is that, in our opinion, there needs to be more research conducted within the CDI area before using a RtD approach. Meaning that, with the work that we have done, we can hopefully contribute to a future successful RtD approach.

9.4.3 Elicitation through Enactments

During the planning of this project, we considered doing an elicitation study with the children including techniques such as Wizard of Oz. We chose not to do this in the end and instead did an elicitation study involving the technique of enactment,

due to convenience and ethical considerations. In this, we also incorporated design probes in the form of cards. During elicitation, it became apparent that the children seemed to have a hard time mapping the action cards to gestures. They instead started different role-playing where they acted out as the drone and the other child would guess what they did.

Because of this confusion, we wonder if the cards perhaps were a factor or the study in itself. If we were to redo this enactment study, we would have focused on a pure enactment study as this would have possibly decreased said confusion.

9.4.4 The Complexity of Research Involving Children

Even though we were well informed and well read on research with children, there is still a certain unpredictability that cannot be prepared for. There are a lot of things that could go wrong, or rather will go wrong, which could have significant effects on both the process and the end results. This calls for a certain skill as a researcher where flexibility to changes and behaviors is important and how to adapt to these in a rapid manner. How do you handle social exclusion? How do you tackle verbal and physical abuse between participants? How do you prevent yourself from not unconsciously promoting exclusion? While at the same time trying to break down the barriers of power structures between you and the children. All of these and more are things that we had to face, in the moment, in our studies. These are matters that we, as beginners, could not have prepared for. These are things that are dependent on the individual, group dynamic, environment, and current emotional state. This can be related back to the work of Spiel et al. regarding Micro-ethics [100].

Regardless, we really enjoyed working with these children, getting to know them, and just getting their insights has been a very fun process thanks to them. It should also be said that we found it very interesting to have one group that did not have as much experience with drones as the other group. In conclusion, it is incredibly complex to research with children as participants. It is a demographic who are unpredictable and this cannot be prepared for. However, in our experience, they are very fun to work with and always have interesting remarks.

9.4.5 Design For and With Children

Summarizing our own experience working with children in different age groups in relation to the prior work of Druin and Shahid, Krahmer, and Swerts [31, 96], we could see similar happenings in our findings. In general, we could see that the age group between nine to ten were somewhat more expressive in terms of concrete contribution relating to play and functionality as opposed to the children between the age of ten to twelve. Although, the older age group was much more manageable, meaning we did not need to intervene as the adults in charge as much as we perhaps needed in the other.

As to the choice of material in our co-design workshop, we did notice that the older children were not as thrilled about the activity as the younger ones. The younger

ones did perform the activity somewhat longer and were much more thorough in their designs. They also made use of and mixed more materials, such as cardboard, tape, and clay. Although, they did complain about how the two materials did not seem to mix well together when trying to assemble their designs. In the older age group, there were two fully completed minor prototypes with fewer details, one incomplete and another did not show any interest in contributing to the assignment given. They had a hard time getting started and needed more active encouragement and inspiration to get started. They only used clay as a material and declined cardboard.

In conclusion, we agree with Obaid et al. that it is important to consider the age-appropriateness in the choice of materials, even if the age groups in this study were closer in age we could still see a difference supporting this. Naturally, we also see that it would have been fitting to look closer into alternative materials than cardboard that mixed better. Changes surrounding the management of the workshop could have benefited us as well, for example, one child said that she had limited her amount of clay so that she would make sure that the rest of the children would get the same amount. In the future, we would instead try to provide each child with their own workshop kit. All of this supports the importance of dimensions such as content and management in design activities with children [69].

9.4.6 Handling of unexpected events

As a researcher, you always need to be prepared for unexpected events because it is not likely that everything will go according to plan. We would like to argue that this is more prominent when working with children, where they seldom do exactly what you tell them. This could be connected back to what John, one of the experts, stated in his interview:

> ***"Now children, which is that, of course, that's their nature, they like to play and they like to discover and explore. They would, of course, listen to your command but they would do something a bit more. Like you always do something different, like they always do the extra- extra thing. And the technical side of it does not support that. Like, for example, we use [certain technology], which was expected someone to raise their hands. Now, if the child jumps, the system would not recognize it."***

This would in turn logically increase the number of unexpected events. For us, this manifested in different things such as illness, collisions with leisure activities, replacement of participants in the middle of the study, methodological confusion, etc. Although we successfully completed studies with both of our groups we had to handle certain in-the-moment events. One of these was the addition of new participants in different stages of our studies with the children. Children that needed to leave because their parents came and pick them up, leisure leaders interfering and removing some kids temporarily to speak with them due to bad behavior, and more.

While it is hard to prepare yourself for everything, it is always good to try to have the roles of the facilitator and the other adults involved clearly stated. Meaning, having clear communication with the other responsible adults and discussing this in advance. This was something one of our experts, Henry, also spoke about in his interview. We did discuss with our advisor whether we should have the leisure leaders in the room while performing the studies or not and were advised that, for our own sake, we should. This failed to be communicated by us to the leisure leaders in advance, which collided with their expectations of the studies. So, therefore an important step in decreasing the chance of having unexpected events having too much impact would be to always have a plan B and try to have each role and expectations clearly defined in advance.

9.4.7 Group dynamics

Group 1 was a more united group as a whole. The leisure center they were connected to had a very well-working organization with motivated and passionate leisure leaders. They also had previous experience in collaborating with external sources on different projects, where the children had a central role. One of these was together with one of our experts within child-culture design. The children were there in their free time, which naturally alters the whole game plan for that particular group. The other group was gathered in a school environment, although as a part outside of typical school activities. Which would, as expected, result in a more formal environment that might have led to the children acting differently. These two very different group dynamics and their environment gave us insights and perspective on the effect they could have. We had problems and challenges of different types in each group, meaning that one way of dealing with issues did not necessarily apply to the other group. The takeaway from this is to consider group dynamics as it could have an effect on the results, both regarding their answers and their overall behavior.

9.4.7.1 Division of groups

In group 2 we noticed a division of groups between the English and Swedish-speaking children. We observed the English-speaking children more or less removing themselves because the conversation did not include them directly. During these times they often engaged in conversation and play with each other outside the scope of the assignment. There were a few times when they engaged and listened to the conversation with the rest of the children. Our choice to let the Swedish children communicate in their native language did probably contribute a great deal to this. This was an effect that we failed to foresee and take into consideration when deciding on this. Our aim, to make the children as comfortable as possible and the chance to express themselves freely should in the future be weighed against the possible negative effects more carefully. Meaning that this should not try to be achieved at any cost. Although relating this to what this meant for our final result, it is fair to say that it did not have significant effects. It should also be mentioned that this division is most likely something common within these types of school environments, meaning that this would maybe be something already present despite

our attempts to counteract this. We noticed that the English-speaking children did have a relationship beforehand and said that they used to play with each other in their free time. This could have affected our results as they would often copy each other's answers when asked questions about why they liked certain drones and they might have also exaggerated their answers to try and impress their friend. To try and counteract this, we could have limited the language to only English, as this is something they should be used to when going to an international school.

9.4.7.2 Research with children in a group setting

It is a well-known phenomenon that what people say is not necessarily how they act, which is of course true for children as well [95]. The additional problem that can reside amongst children is that they could actually lie about, or exaggerate different answers. This behavior could also be heightened in a group setting like the ones we conducted. There were several times we felt that it was hard to determine when to take them for their word and when to not. For example, there was one child changing his answer multiple times when it came to his previous experience with drones, which made us skeptical. We did an active choice of not doing one-on-one sit-downs with the children. This was both due to convenience, prohibiting the sense of being singled out, but also to create an informal environment as a way of breaking down barriers of power structures. The context surrounding our research questions was collaboration and playfulness, which we felt would be best explored in a group setting. Although, retrospectively it would perhaps be good to consider two-and-two interviews at least, which is something our expert Noah also recommended. In this way we would have been both convenient and a way of controlling certain answers and claims made by the children.

9.4.8 The Storyboards

We found that using storyboards, especially using a storyboard that contained cartoon-like figures, was an age-appropriate way of presenting a prototype to the children. Both groups liked their storyboards and said that they wished it was longer. The children talked about who was who in the storyboards and quickly recognized themselves. We also think that using a storyboard can be a fun way to resonate with children regarding a prototype, compared to such prototyping tools as wireframes which often do not say much. With storyboards, the children get a story about what the prototype is, what it can do, and what it can be used for.

During the creation of our storyboard, we also discussed our intentions of these. We decided, through council, that our intentions would be to create something that could actually be done today. This included us excluding different requirements, or altering them, in a manner we as designers saw fit. We also decided to create two different storyboards because the requirements from the two groups deviated a great deal. For example, with group 2 they were very insistent on having cameras in their drones, mainly for espionage. Instead of ignoring their insistent requests, as it is not really within our scope, we decided to add cameras to our storyboard and use this as an opportunity to prime the children for critical reflections. We did this

in the hopes of giving them other perspectives and the potential consequences of using cameras, especially for espionage. So when showing them the storyboard we also told them a story that provoked a critical reflection within the group regarding cameras, privacy, and the consequences of using cameras.

9.5 Evaluation

We saw this evaluation mainly as an opportunity to connect back with the children after a period of time. This was the last time we got to meet them, so we wanted it to be a fun reunion and, to get the chance to talk to them more regarding their experiences with us, and what they felt they got out of it, as well as let them see what we produced with their help. As they did not provide too many thoughts on our prototype, they did seem to withhold the same thing they stated since the last time we saw them. When conducting the evaluation with group 1, It was very positive for them which was nice, and we also feel that we got to know them well. During this evaluation, they also got to play with the drones one last time, which was a fun experience both for us and for them. However, it did turn out to be somewhat of an educational moment as we learned that one of the children thought that the safety gloves, that we made the children wear, were used to control the drones and not just for safety which was very interesting.

When we visited group 2, we first showed them a storyboard that showed the drone we thought would fit them the best. The initial plan was to see if the storyboard could prime them to critical reflections without explicitly telling them our story. This was to avoid the risk of them feeling criticized or attacked by us. As we saw no reactions after presenting the storyboard we choose to tell them our story. We observed one explicitly saying that it was creepy to use cameras for espionage. The other ones got a bit more defensive saying that they only intended to use it on their families. They had a hard time seeing the risks that could come out of this getting in the hands of third parties.

The story and critical reflections were not something we initially set out to do, but instead something stemming from the requirements during our primary studies. Without time limitations in mind, this is something that would be worth giving more attention to. Meaning that, we could discuss the design of the story some more, its appropriateness, and how it was presented to them. In addition to this, we could have introduced a more generative subsequent step as opposed to only discussing it verbatim. Here it could also be considered the possibility of having one-on-one interviews with the children. In essence, we could have taken a more careful consideration of the terms of the planning and execution of this step, however, we were limited by time.

9.6 Future work

The work we have presented throughout this master thesis is exploratory and broad, preparing for a future design. As the area of CDI is lacking and in need of more, and more niched, research. We hope that more research is to be done within CDI. With more toy drones or drones in general, entering the market the need for research grows larger. For the participants, we actively choose an older age group due to the complexity and challenges of shadowing the younger ones. Leaving CDI in relation to preschool children as something still left unexplored.

Other interesting areas would be to dig deeper into the interactions these sensor-based drones provide as we did notice a certain degree of calm behavior emerge. How can we draw benefit from the mechanical natures of the drones and incorporate that into collaboration and play amongst children? What are children's most natural ways of interacting with social drones? How does behavior and aesthetics influence children's relationship with drones and what can be said of those? those are just a portion of the things that our work has outlined for future work. This entails an opportunity to tackle this problem space with the help of RtD approach in a number of different ways, e.g. combining biomimicry, design, and drones in the context of children.

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Conclusion

As toy drones have entered the market, with more probably on the way, we found a mismatch between the existing toy drones and the research area of CDI. When conducting a literature study and a market analysis, we found the area of CDI to be lacking and the toy drones to be containing possible safety risks, even though many are being sold for children on the market today.

In this work we have presented two research questions relating to gesture-controlled toy drones:

RQ1: What should be considered when designing gesture controlled toy drones for collaboration and playfulness within child-drone interaction?

RQ2: What possible safety risks can arise with these types of gesture interactions?

We answered these research questions by conducting three primary studies with children of the ages nine to eleven. However, to gain more knowledge on what it entails when researching with children we conducted expert interviews. To also find any errors with the setup we had we conducted a pilot study.

After researching the area of both CDI and how to conduct studies with children we conducted our primary studies with two groups of children, with five children in each from two leisure classes, between the ages of nine and eleven. The setup of the studies was as follows, an elicitation through enactment study, a co-design workshop, and a commercial drone testing study. Each of the studies was video and audio recorded on multiple devices to ensure information capture, with photos taken during as well. After conducting the three studies we created two low-fidelity prototypes in the form of storyboards, one specific for each group, based on the initial viewed data from the three studies. In total, we met with the children five times, where the first was a meet and greet to familiarise ourselves with the location. The second, third, and fourth meetings were the primary studies, and the last meeting was an evaluation with the children of our prototypes produced.

For **Research Question 1**, we identified seven core themes that can be considered

when designing a gesture-controlled toy drone for collaboration and playfulness. Within these seven core themes, we also identified in total 13 sub-themes that went into greater detail on these considerations. Each of the core themes described findings from the studies that suggested what, relating to the theme, should be considered, and an example of what that consideration could entail. These consideration themes, with sub-themes, were:

1. **Input modality**, here we suggest to designers to consider adding more ways to control a gestured drone because of proxemics dictating drone use. Within this topic, we focus on the sub-themes of *Gestures* and *More ways of controlling it*. We also give examples of how to solve the design problem, such as, allowing the option of external devices for the user to choose when to use.

2. **Desired functionalities and Behaviour**, where we suggest incorporating some other functionality into the drones other than flying. In this topic we focus on the sub-themes *Behaviour of drone*, *Sound*, and *Extensions*. With examples of drone functionalities stemming from different requests made from both groups.

3. **Collaboration and Playfulness**, here we suggest to designers to consider actual multiplayer interaction and promote collaborative play by taking inspiration from games. With this topic, we focus on the sub-theme of *Existing gameplay and Promote playfulness*. We also present a solution for this, by creating a game where the drone is used as a game piece or designing the drone to be applied to existing games.

4. **Aesthetics**, although this might be considered a trivial aspect, we suggest that this should still be taken into consideration. As we noticed children being drawn to certain aspects of aesthetics and connecting them with sense of control. Within this topic we focus on the sub-themes of *Shape*, *Size*, and *Color*. We also present a solution for this, by having protective shells which could be exchangeable.

5. **Imagination**, we wanted to include this as we see the potential of this aspect is easily overlooked. Here we suggested that the designer should take this into consideration, but to also be careful so as to not deceive the child.

6. **Previous experience**, we also wanted to include this as it may provide some insights as to what might be expected from users. We saw that with different technical backgrounds comes different drone expectations. Within this topic, we focus on the sub-themes of *Group differences* and *Individual level*.

7. **Ethical dilemmas and Safety**, as this theme is covered in more detail with RQ 2 we mainly suggested overall considerations. With this topic, we had two sub-themes *Safety risks* and *Ethical dilemmas stemming from the incorporation of camera*. Due to the specific consideration of safety risks when assuming a camera is incorporated for using advanced gesture control.

For **Research Question 2**, we identified three main types in terms of safety risks regarding gestured interactions. These types stemmed from implicit and explicit responses. Within these types, we identified eight sub-types, which went into greater detail on said safety risks. Each of the main types described findings from the studies that suggested a possible safety risk that could arise from gestured interactions. These types, with sub-types, were:

1. **Physical safety risks**, which involved risks stemming from both the behavior of the drone and the interaction with it. Here we focus on the interactions with the sub-themes *Through touch* and *Through movement*.

2. **Emotional safety risks**, which described emotions that could arise when interacting with the drone. Here we focus on the negative emotional safety risks with the sub-themes of *Frustration and Aggression towards each other*, *Frustration and Aggression towards the drone*, and *Implicit and Explicit fear of physical injuries*.

3. **Social risks**, which described actions and responses stemming from the interaction between people. Here we focus on the sub-themes of *Exclusion and Peer pressure*, *Loss of privacy and Integrity*, and *Lack of critical thinking*.

In general, there seems to be a mismatch between the toy drones on the market today and research conducted. We believe that this work presented can show, not only this mismatch but also give an indication on how to move forward within this area. Both to potentially solve the issues presented, but also to give some data on where the issues may lie. As there will be, most likely, more and more toy drones entering the market, we deem it vital to include the intended user group in the design process and consider the results we have presented. Since the area of CDI is still quite young, this research helps in closing that gap and we hope that more research can be done within this area to close the gap even further.

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A

Literature Study

For the literature study, a total of 45 different research papers, books, and articles were found, analysed, and documented in a Google Sheet document. Two keyword sets were used to procure the majority of the research, while some were received from a third party, and some were found through references from the research material. The keyword sets were used in Google Scholar, a database service from Google mainly for scientific research publications.

A.1 Keyword Set 1

Due to the sensitivity of the topic of conducting studies with children a first keyword set, ***children, methodology, research, CRI, CDI, ethics, child-centered***, was used to gain more knowledge on methods and frameworks which could be, or have been, used to conduct studies involving children. In total 15 research papers, books, articles, and collections were deemed useful and analysed, with the main topic being Methodology. From the research were three different sub-topic identified, Design Research [1, 5, 7, 8, 11, 12, 14], Methods & Children [3, 4, 6, 9, 10, 13, 15], and Frameworks [2], with the main proportion of the research involving design.

The research showed that while the topic of CRI is more established than CDI, there is still much to explore on the topic regarding interactions with children. The field of CRI is still quite young, which is observable through some studies trying to standardize measures and different methods [10, 15]. The most recent focus in CRI seems to be on participatory design and how to best involve children both in relation to structure and management and techniques[11, 13]. There is still a lot to take from this into this work, but there is a mismatch between the methods used for CRI in relation to learning experiences and methods used for designing play for play's sake. This calls for adjustments in methodology for this specific type of play. Only one study seemed to adopt this mindset through the development of a Playfication methodology for studying children which showed that it was superior to the other traditional methods [3].

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A.2 Keyword Set 2

The second keyword set involved ***drone, robot, play, gestures, children, HDI, HRI***. Many combinations of said keyword set were used, such as *Drone AND children AND gestures*, as to not exclude a wider area of research that could be useful. One combination, however, was omitted due to the research results it showed that was deemed unfit for the topic of this study. This was the combination of drones AND children, which produced research results involving children, military drones, and in many cases the death of children caused by military drones.

In total 31 research papers, books, and articles were deemed useful and then analysed, with the main topics of the research found being Play, Drones, and Robots. The largest proportion was on the topic of Drones that stood for almost 58%, 18 out of 31, of the research material, see figure A.1. Which can be considered to be due to the projects main topic being drones.

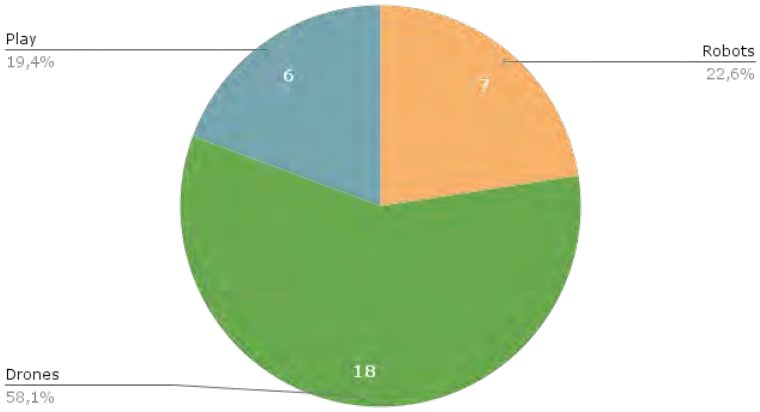

Figure A.1: Shows the main topics of the research material found.

Within the main topics of the research five different sub-topics, with the exception of some articles only centering on the main topic, were found. The sub-topics were Play, Children, Gestures, Framework, and Drones, see figure A.2. The research that had sub-topics often had a combination of two, for example, the article written by Lupetti et al., Design for Children's Playful Learning with Robots, centered on the main topic of Robots, with the sub-topics of Children and Play [17].

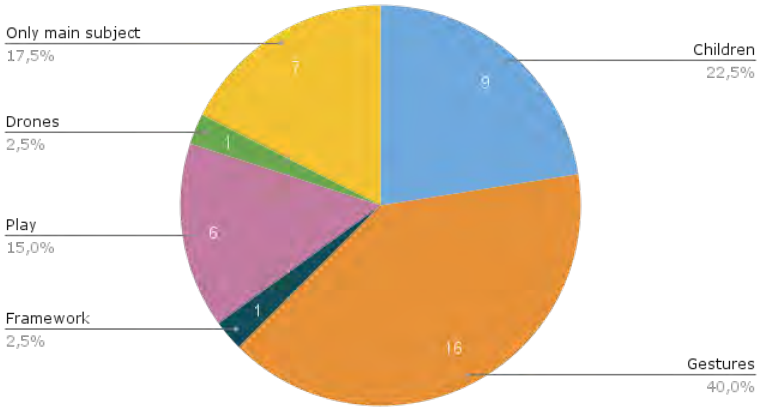

Figure A.2: Figure on how many times each sub-topic occurred in the research material, note that each sub-topic can appear in a combination with another sub-topic except for "Only main topic".

In the research material analysed, were nine on the topic of children, seven out of nine had children as participants [12, 17, 25–28, 30], and two out of nine were planning on having children as participants [18, 29]. Most of the research were with children interacting with robots, five out of nine articles [12, 17, 25, 28, 30], and only one article was found which had children interacting with drones [27].

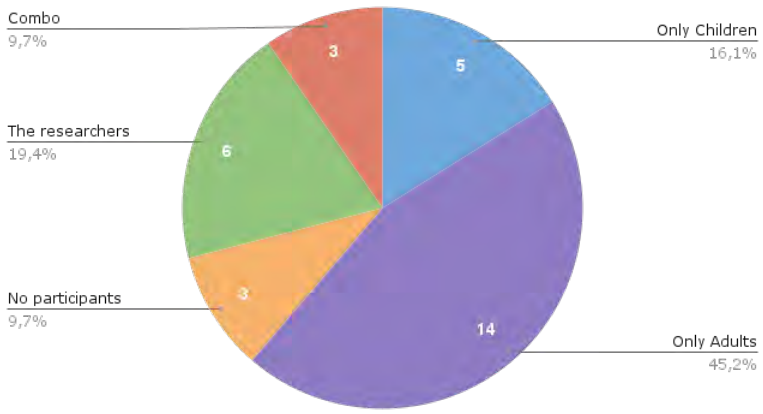

Figure A.3: The type of participants that could be found in the research material.

14 out of the 31 papers had adults as participants [1–4, 6, 9, 10, 13–16, 22, 23, 31], three papers had a combination of both children and adults [12, 17, 19], six out of the 31 had only the researchers as participants [5, 7, 8, 11, 20, 24], five out of the 31 had only children as participants [25–28, 30], and three out of the 31 had no participants [18, 21, 29] (see figure A.3). When focusing on the main-topic of drones, 10 out of 18 papers only had adults as participants [1, 2, 9, 10, 13–16, 22, 31], one out of 18 only had children as participants [27], one out 18 had adults and one child as participants [19], five out of 18 only had the researchers as participants [5, 7, 8, 11, 24], and one out of 18 had no participants [21].

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B

Market Analysis

A total of 16 drones were found online and analysed. Seven were ordered to be tested and the rest were not ordered for different reasons.

B.1 Ordered

The following drones were the ones that were ordered to be analysed more closely and tested under equal conditions. These conditions include reading the manuals before the test flight, charging the battery of the drones before the test flight, being in the same room, and being in a room with no windows.

Name	Price (kr)	Gesture Control	Order status	Rec. Age	Source
Air Hogs Super Nova	618	Hand movements	Ordered	3+	Link
Flynova Pro Ball	339	Hand movements	Ordered	-	Link
Smart Drone	249	Hand movements	Ordered	3+	Link
Litzee	289	Hand movements	Ordered	-	Link
Gadget Monster UFO	249	Hand movements	Ordered	3+	Link
Kissiqiqi	359	Hand movements	Ordered	-	Link
Gear4Play Flying Spinner	111	Hand movements	Ordered	8+	Link

Table B.1: Table of drones ordered to be tested.

B.2 Did not buy

When deciding which drones to buy, some drones were deemed unnecessary due to similarities in appearance with other drones that were bought. Other reasons for not buying the listed toy drones below was due to price, being out of stock, safety reasons, or were deemed irrelevant due to the drones having a remote.

Name	Price (kr)	Gesture Control	Order status	Rec. Age	Source
Mickcara Drone	489	Hand movements	Too similar to other drones	-	Link
Achort Mini Drone for Children	736	Hand movements and remote control	Remote control and too risky	-	Link
Denver Drone	399	-	Remote controlled	-	Link
KD Interactive Auro Drone	480	-	Remote controlled	-	Link
Air Hogs Gravitator Drone	299	Hand and Body movements	Out of Stock	3+	Link
Gear4Play Spinning Ball	249	Hand movements	Out of Stock	8+	Link
Gear4Play Space Invader	249	Hand movements	Out of Stock	-	Link
Flynova Ball	389	Hand movements	Unknown	6+	Link
UFO Drone	299	Hand movements	Unknown	5+	Link

Table B.2: Table of drones that were not ordered.

C

Expert interview questions

Before we met with our experts, we created a script with the questions we wanted to ask for each of them. For all experts we had an introduction where we presented ourselves, our research questions, and the background of our work. We then asked some personal, or guiding, questions regarding their field and some of their work that they had conducted. Below are the questions that we asked each of our experts during their interview and the script we based our interviews on. However, personal questions which could identify our experts have been removed.

C.1 Expert questions: John

C.1.1 Welcome chat & Formalities

- First of all thank you for taking the time for this, it is much appreciated. Before we begin we would like to ask you permission to record this conversation?

C.1.2 Presentation of our goal and form of study

We are as you might know doing our master thesis right now within Child-Drone Interaction with focus on play experiences. Our aim is to make a qualitative study, where we will give the children a central role, they will be treated as a design partner. Our [primary] research question is:

> *What should be considered when designing gestured controlled toy drones for collaboration and playfulness within child-drone interaction?*

with a sub-question being:

> *What possible safety risks can arise with these types of gestured interactions?*

Before moving on to describing how we intended the to our study we would like to ask you:

- What would you do if you were in our shoes?

We have planned three parts of our main study with children, namely:

- Where we test the existing product and also observe children play with them together.
- Elicitation Study through a Wizard of Oz where we will test some gestures that previous work has done but also use the result from the first study to maybe explore some new things depending on the outcome of course. (Should not be the same participants as in the first one)
- Design workshop with children where they will be a part of generating design ideas both in relation to aesthetics and features of toy drones. (These participants should be some of those that have already been a part of one of the above studies)

C.1.3 Guiding questions

- Before moving on to more topic related questions, what are your first thoughts on this?
- Can you see any immediate errors or challenges?
- Any special consideration we should make before?

C.1.4 Questions about Child-Robot Interaction / Child-Drone Interaction

- In regards to CRI, can you give us a short summary of the work that you have done in that area?
- What is the primary age group you have worked with?
- What do you wish you knew before you engaged in these studies?
- Would you mind telling us about a specific study where you learnt a lot?
- What are your thoughts about the future of Child-Drone Interaction?
- What do you feel would be the most interesting thing to investigate when it comes to CDI?

C.1.5 Questions about drones

Initial question before looking at the drones we have

- How do you see social drones being best integrated with people and the community, considering that there are quite many challenges when it comes to loudness, safety issues etc. ?

- And what do you think should be the main focus for designers and researchers?
- Do you see a difference in children's relation to drones as opposed to adults?

Now we will show you a selection of a few toy-drones that exist on the market today, with regards to children:

- When looking at these drones, what are your first impressions?
- Do you find any safety issues regarding these drones?

C.2 Expert questions: Melissa

This interview was not recorded and a script was not prepared before. So the questions asked could not be shown.

C.3 Expert questions: Anna

C.3.1 Welcome chat & Formalities

- First of all thank you for taking the time for this, it is much appreciated. Before we begin we would like to ask you permission to record this conversation?

C.3.2 Presentation of our goal and form of study

We are as you might know doing our master thesis right now within Child-Drone Interaction with focus on play experiences. Our aim is to make a qualitative study, where we will give the children a central role, they will be treated as a design partner. Our [primary] research question is:

> *What should be considered when designing gestured controlled toy drones for collaboration and playfulness within child-drone interaction?*

with a sub-question being:

> *What possible safety risks can arise with these types of gestured interactions?*

Before moving on to describing how we intended the to our study we would like to ask you:

- What would you do if you were in our shoes?

We have planned three parts of our main study with children, namely:

- Where we test the existing product and also observe children play with them together.

- Elicitation Study through a Wizard of Oz where we will test some gestures that previous work has done but also use the result from the first study to maybe explore some new things depending on the outcome of course.
- Design workshop with children where they will be a part of generating design ideas both in relation to aesthetics and features of toy drones.

We will work with the same child in each study and hopefully two different groups in parallel of which one group will be children between the ages of ten to 13 years and the other is between eight to ten years old.

C.3.3 Guiding questions

- Before moving on to more topic related questions, what are your first thoughts on this?
- Can you see any immediate errors or challenges?
- Any special consideration we should make before?

C.3.4 General questions about the expert

- What are you working on today?
- How much experience do you have working with children?
- and what ages have you worked with?
- and it what area?
- What do you wish you knew before you engaged in these studies?
- What are your thoughts about the future of CDI?
- What do you feel would be the most interesting thing to investigate when it comes to CDI?

C.3.5 Questions about Child-Robot Interaction / Child-Drone Interaction

- In regards to CRI, can you give us a short summary of the work that you have done in that area?
- What is the primary age group you have worked with?
- What do you wish you knew before you engaged in these studies?
- Would you mind telling us about a specific study where you learnt a lot?

- What are your thoughts about the future of Child-Drone Interaction?
- What do you feel would be the most interesting thing to investigate when it comes to CDI?
- What do you think is the biggest difference between participatory design within CRI compared to CDI?
- Do you think there are any obvious challenges to where is can differ?

C.4 Expert questions: Noah

C.4.1 Welcome chat & Formalities

- First of all thank you for taking the time for this, it is much appreciated. Before we begin we would like to ask you permission to record this conversation?

C.4.2 Presentation of our goal and form of study

We are as you might know doing our master thesis right now within Child-Drone Interaction with focus on play experiences. Our aim is to make a qualitative study, where we will give the children a central role, they will be treated as a design partner. Our [primary] research question is:

> *What should be considered when designing gestured controlled toy drones for collaboration and playfulness within child-drone interaction?*

with a sub-question being:

> *What possible safety risks can arise with these types of gestured interactions?*

Before moving on to describing how we intended the to our study we would like to ask you:

- What would you do if you were in our shoes?

We have planned three parts of our main study with children, namely:

- Where we test the existing product and also observe children play with them together.
- Elicitation Study through a Wizard of Oz where we will test some gestures that previous work has done but also use the result from the first study to maybe explore some new things depending on the outcome of course. (Should not be the same participants as in the first one)
- Design workshop with children where they will be a part of generating design

ideas both in relation to aesthetics and features of toy drones. (These participants should be some of those that have already been a part of one of the above studies)

C.4.3 General questions about the expert

- What are you working on today?
- How much experience do you have working with children?
- and what ages have you worked with?
- and it what area?
- What do you wish you knew before you engaged in these studies?
- What are your thoughts about the future of CDI?
- What do you feel would be the most interesting thing to investigate when it comes to CDI?
- Your were in our shoes not so long ago, what would you say be the number one advice for us?

C.5 Expert questions: Henry

C.5.1 Welcome chat & Formalities

- First of all thank you for taking the time for this, it is much appreciated. Before we begin we would like to ask you permission to record this conversation?

C.5.2 Presentation of our goal and form of study

We are as you might know doing our master thesis right now within Child-Drone Interaction with focus on play experiences. Our aim is to make a qualitative study, where we will give the children a central role, they will be treated as a design partner. Our [primary] research question is:

> *What should be considered when designing gestured controlled toy drones for collaboration and playfulness within child-drone interaction?*

with a sub-question being:

> *What possible safety risks can arise with these types of gestured interactions?*

Before moving on to describing how we intended the to our study we would like to ask you:

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- Elicitation Study through a Wizard of Oz where we will test some gestures that previous work has done but also use the result from the first study to maybe explore some new things depending on the outcome of course. (Should not be the same participants as in the first one)
- Design workshop with children where they will be a part of generating design ideas both in relation to aesthetics and features of toy drones. (These participants should be some of those that have already been a part of one of the above studies)

C.5.3 Guiding questions

- Before moving on to more topic related questions, what are your first thoughts on this?
- Can you see any immediate errors or challenges?
- Any special consideration we should make before?

C.5.4 General questions about the expert

- What are you working on today?
- How much experience do you have working with children?
- and what ages have you worked with?
- and it what area?
- What do you wish you knew before you engaged in these studies?
- What are your thoughts about the future of CDI?
- What do you feel would be the most interesting thing to investigate when it comes to CDI?

D

Timeline

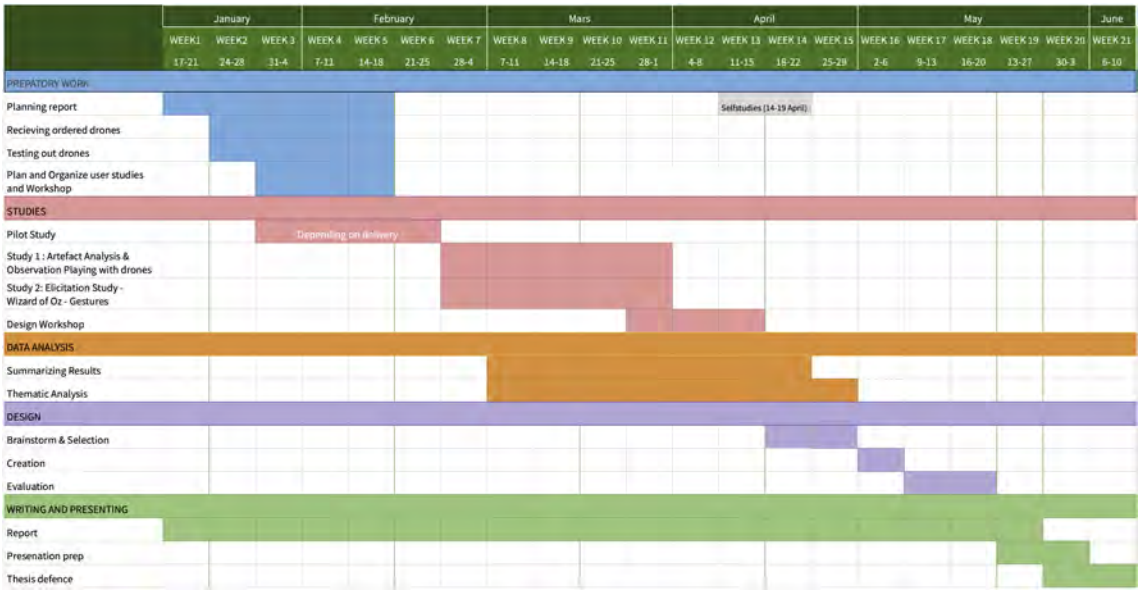


Figure D.1: GANTT schedule of the master thesis.

E

Storyboards

In the following two pages are the storyboards for the groups, the first page was created for group 1 and the second for group 2.

This is the journey of a

Toy drone - Group 1

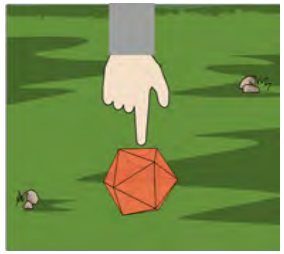
The children at a leisure center wants a colourful drone which they can do several different games with, using different types of shells, and they can control it however they want.

1

Lisa and Sarah say that they want to play with drones. They decide to play Capture the drone!
They ask Adam, Julia, Steven and Oliver if they want to join because they need more participants for the game.

2

Everyone chooses different colorful round shell for their drones. They also each take a bracelet to control the drones.



3

Adam puts on his bracelet first and starts the drone by pressing a touch button on top of the drone.

4

It spins and floats in front of Adam until he gets the drone's attention by making a certain move slowly. The drone emits a sound and glows green to indicate that it is fully calibrated.

5

Everyone's drones flies up over their heads, now everyone is ready to play, and they all start chasing each other. Julia starts chasing Sarah.

6

When she's close enough, she makes a whipping gesture towards Sarah. This causes Julia's drone to go towards and around Sarah's drone.

7

This makes Sarah's drone "free" and now shines white, this starts a minigame with the drone.
Both make a certain move towards the drone for 10 seconds, the one who does it the fastest and with most rotations gets the drone's attention and wins the minigame.

8

Sarah manages to get her drone's attention back and it flies back over her head, Sarah quickly runs away because she has 10 seconds before Julia or anyone else can chase her again.

9

But Oliver is not so lucky, Steven wins Oliver's drone and the drone flies over Stevens' head and only listens to Steven now.
Oliver is now out of the game.

10

After a while, Steven has managed to capture the others' drones. Which is seen by all the drones hovering over his head. The game is now over.

11

To land the drones, everyone holds out their palm and waves upwards, the drone lands in the hand and stops. Lisa, Sarah, Adam and Julia feel that they want revenge and Lisa suggests that they reprogram the drones to race against each other with the phones as controls instead.

12

Everyone agrees and runs back to the leisure center to start programming!

This is the journey of a

Toy drone - Group 2

The children in a leisure class wants a small drone which they can programme to do what ever they want and they want to control it using different platforms.

1

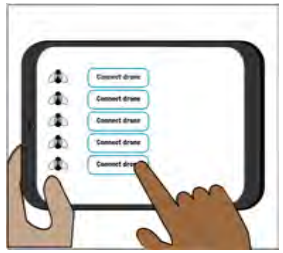
Ira and Sabina get the idea that they want to play with drones. They decide to play hide and seek! They ask Peter, Abdi, and Tor if they want to join in.

2

Everyone takes a fly drone.

3

And presses a button on their stomach to turn it on.



4

Tor connects all drones to the app on his iPad.

5

Then everyone throws their flies in the air and they start flying.

6

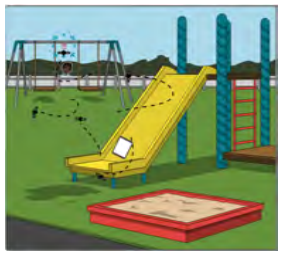
The flies hover in front of everyone, waiting for a command, Abdi presses the pre-programmed game of hide and seek and enters 50 seconds for the drones to wait before they start looking.

7

Everyone runs and hides quickly while the drones count down, when they have finished counting the iPad makes a pling ing sound to show that they have finished counting.

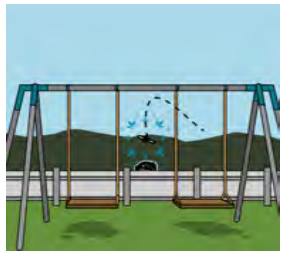
8

When they have finished counting the iPad makes a plinging sound to show that they have finished counting.



9

Peter looks over to see where the flies are. A fly sees that Peter has peeked out and quickly goes to his hiding place.

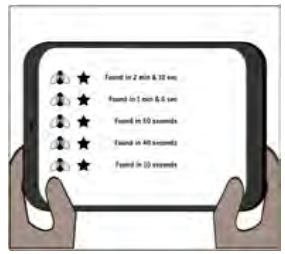


10

When the fly is there, it makes a siren sound and hovers over Peter's head, Peter is found and has to go back to where the iPad is to silence the fly.

11

Once at the iPad, he presses a button "I'm found" and the fly is happy and lands in Peter's hand.



12

After a while everyone is found and the game ends with a message appearing on the iPad with statistics on how long everyone was hidden, Ira did the best hiding and was not found for several minutes.

13

Sabina was the second to be found and thinks they should play something else, Tor then suggests they spy on them in the playground. Everyone agrees and takes out their mobile phones to control their own drones.

F

Consent form and Informational sheet

The following two pages show the consent form which were sent out to the guardian of the child participating, and the consent form which were given to each child.

Child-Drone Interaction Study –
Information sheet and Consent form

We would like to invite your child to participate in an explorative research study on "Child-Drone Interaction". The aim of this study is to investigate how toy drones should be designed to best accommodate their needs and safety in the future. This will be done by observing how children interact with gesture-controlled drones in a playful context amongst each other. They will do this on three different occasions during [REDACTED] and one in [REDACTED]:

1. [REDACTED] - Investigate gestures with a drone amongst each other
2. [REDACTED] - Workshop where the children design drones
3. [REDACTED] - Testing existing toy drones on the market today
4. [REDACTED] - Evaluation of concept

We are students from Chalmers University of Technology (Sofie Åkesson & Matilda Falkenby) who would like to ask for your permission to take video, pictures, and audio recordings of your child/children during the 2 studies, 1 workshop, and 1 evaluation organized at [REDACTED] at the specific dates provided above.

The studies will approximately take 60 minutes per study and you and your child/children's participation in this study is voluntary. They are free to choose whether or not they will take part in the study. Your child has the right to withdraw from the study at any time, including withdrawal of any information provided. The information in this consent form will be given to your child before every study in which they will get the opportunity to give their own consent. This consent form will be made accessible to your child, meaning the information given here will be given to them in a child-friendly way in which they are given the right to understand the aim of our research before consent and the risks and benefits. We have provided this information sheet together with this consent form so that you as a parent, or guardian, can review it beforehand.

The following material will be collected during the study for further analysis:

1. Video Recordings
2. Pictures
3. Audio Recordings
4. Interviews
5. Observations/notes

We will be recording your child on video and audiotape. We will also interview your child/children and take notes. Videos will be used by the researchers conducting the study to analyze your child's interaction with gesture-controlled drones in a playful context amongst other children. Participants cannot take part without being video-recorded if they want to withdraw, any actions of the child within the footage will not be used for further analysis. All collected data will be treated as confidential and stored on a drive which only we researchers have access to. After analysis, the recordings will be destroyed. We may

Consent and information

Presentation and explanation
We are two students from Chalmers University of Technology who want to investigate how you play with toy drones. We are doing this to develop how toy drones should be designed in the future. We are so called interaction designers or also called usability experts, who work with designing different technological products so that we humans who use them get the best experience possible. These products can be anything from an app on your phone or a game to a toy drone like in this case.

What is a drone?

Drones are something that fly in the air and can either be controlled using a remote control such as when playing video games or you can also control them with your hands through different movements and it is these types of drones that we wish to study. What we want to know more about is how you actually wish to play with these drones as there are not many who have done this before yet these types of drones are sold as toys today.

What do we want to accomplish/achieve with our research?

We hope to, with your help, bring out important things to consider for those who manufacture and design these drones so that you can have the best experience possible once you play with them. We think it's important that you children have a central part in this research as you actually know best about how you want it and these are toys that are entirely just for you. It is also your legal right to have your say on matters that affect you.

Information about your participation
This sheet contains all the information we will now give you orally as a group and you will each get a copy if you feel you would like to read through it later or perhaps ask someone else to read it to you afterwards. If you have any questions in the meantime, please do not hesitate to interrupt us, or raise your hand and we will do our best to answer them. If you choose to participate in these studies, we will remind you of this information at every opportunity, so it is great if you keep it, but otherwise we will always have copies with us in case it gets lost.