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From a Group to an Individual:

Influence of Heterogeneity of Disabilities among Children with Special Education Needs on Design Processes

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Abstract

In this master thesis, I discuss some challenges in designing an app for and with a group of children with heterogeneous special needs. The original objective of the project was to design an educational app for the iPad together with children from a special education class and their teacher. Even though the class consisted of only six students, heterogeneity of stakeholder's needs and the need for increased methodological and ethical sensitivity created a complex design space. During the design process, the objective shifted from design of an educational app towards value-based design and an app that could benefit the students in their daily lives. It also signified shift of the design focus from an app to be used in a group of children towards an app that each child could use individually, either in school or occupational therapy settings. The thesis explains how the app was conceptualized, prototyped and finally, evaluated. The summative evaluation illustrates that the app has a good potential for use in both school and occupational therapy. Finally, I present the lessons learned regarding methodology, ethics, and knowledge resources and like.

Acknowledgements

First of all, I would like to thank all the children and their families for participating in this study. Without them, I would never achieve my goals. Further, I thank the leadership of the school I started to work with, and particularly Mariann Govsmark who participated in the entire design process. I also want to thank Natalia Karpova, the occupational therapist from the occupational center “NIKA” who contributed with professional advice, and warranted a bit of time in her sessions in order to test the prototype with her patients. I want to thank the leadership of the boarding school for children with speech disabilities, and particularly Alla Vengerova, who gave me the opportunity to conduct the final evaluation of the prototype at the school and performed the expert evaluation of it. And at last, but not least, I would like to thank my supervisor, Alma Culén, for supporting me throughout the whole study, giving me good advices and showing the light in the end of the tunnel when I happened to be totally lost.

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1 Introduction

According to the Central Bureau of Statistics in Norway 8,6% of all elementary school students (from 1st to 7th grade) attended special education schools or groups in 2012/2013 [1]. The statistics from the last years indicate that this number will grow, which is against the approved policy of integration of children with special needs into mainstream classes [2]. It is discussed whether children with special needs perform better among their normally developing peers or not. Reports from the Ministry of Education and Research conclude that such children achieve better results when they are included into classes with normally developing children [3]. In reality, more and more children end up in classes for special education. Currently, many schools do not have such classes and adapt the mainstream education according to the individual special needs of each child when it is needed. Among the reasons for that is the fact that such classes are resource intensive. Only in cases when disabilities' severity is preventing children from participating in a mainstream class, they are transferred to special education classes that are equipped with all necessary facilities. During the research discussed in this thesis, I got to work with a special education class that consisted of six boys of different ages. All these boys had heterogeneous skills and needs, and followed individual learning plans. For this small class of six children, there were three teachers: one main teacher and two assistants. Not all schools have ability to provide that.

Among non-human resources, technology is considered as capable of providing assistance in special education classes. Assistive technologies are of enormous interest for schools, parents and educators of such children. I consider any technology that may support children in their daily life or in education as assistive technology. Since the appearance of tablet computers, and in particular the iPad, they have been adopted by many schools worldwide as supportive technology in education for both the normally developing children and children with special needs (e.g. [4], [5], [6]). Despite the obvious coolness and usefulness of the iPad and other tablet PCs, several researches indicate that this is not enough ([7], [8]). In order to adapt the technology in education, a proper design considering the skills levels and needs of the target population, as well as the context in which the technology is supposed to be used, is necessary.

Today, there is a large body of research addressing design of interactive products and technology for and with children (e.g. [9], [10], [11]). A body of research on design for and with children with special needs is also growing. A central principle of participatory approach to design, including the user-centered design, is that no design fits all, but should rather be driven by understanding of needs of the target user group, as well as the context in which the designed product or a piece of technology is going to be used. There is a growing interest in inclusive design and universal accessibility, which has brought to front line considerations related to differences among target user groups, e.g. abilities and disabilities, and different cultures. Even though these considerations can also be applied to children with special needs as a user group, they may still be underserved by technology. The reasons for that are many,

but the most important ones for this thesis are recruitment of children who would participate in the process, increased number and gravity of ethical issues, and methods for including children with special needs into the design process. In addition, the way children with special needs make sense of their surroundings and share their experiences differ from those of the normally developing children. Moreover, many cognitive, motor and sensory impairments are related to the thought process and communication skills, including memory, imagination, ability to interpret abstract objects, and interpreting social cues. These are exactly the processes that many participatory techniques are based on. As a result, such techniques might not be adequate for the children with special needs and need to be adapted. A critical issue in adapting participatory methods and techniques is that specific adjustments have to be made for each user group, while the main principles behind those adjustments are not always clear. In this master thesis, I address these and some other challenges in designing an app for and with a group of children with heterogeneous special needs.

The original objective of the project was to design an educational app for the iPad together with children from a special education class and their teacher. Even though the class consisted of only six students, heterogeneity of stakeholder's needs and the need for increased methodological and ethical sensitivity created a complex design space. During the design process, the objective shifted from design of an educational app towards value-based design and an app that could benefit the students in their daily lives. Our goal was inspired by the wish from the main teacher of the class – make something that all of the children could use together in a school activity. However, the heterogeneity in skills among the children made it impossible to create an educational app that could benefit all children. Ultimately, we felt that a better direction would be to concentrate on a more therapeutic approach related to a common condition among all boys, such as concentration difficulties or social isolation.

The shutdown of the special education class, and the followed increased complexity in accessing the children forced us to explore other options of involving children into the design process. An opportunity to continue the research in operational therapy settings arose, and we happily grabbed this chance. The shift of the design setting caused the shift in the design focus; it went from an app to be used in a group of children towards an app that each child could use individually, either in school or occupational therapy settings.

The thesis explains how the app was conceptualized, prototyped and finally, evaluated. The conceptualization of the app started at the original special education class involving children and the main teacher. After the class was closed down, the concept was further discussed and scenario played with external interaction designers. Based on the data collected during the iPad assessment at the special education class and the workshop with the interaction designers, a paper prototype was created. A formative evaluation of this low-fidelity prototype, and the subsequent high-fidelity prototype, was conducted at an occupational therapy center involving children with similar issues as the boys from the original special education class. The feedbacks from the children, as well as feedbacks from the occupational

therapist were considered in the final version of the app, which was tested at the same occupational therapy center and a boarding school for children with speech disabilities.

During the summative evaluation, we were looking at three factors: usability, enjoyment and behavior learning. All of these factors make a foundation for achieving the main goals of the game: concentration development and behavior learning. Through fun and play, the app is intended to teach children what is appropriate behavior and what is not. In addition, by including gamification elements such as scores, different levels of difficulty and awards, we aim to increase the engagement of children, and thus prolong the time they concentrate on the game, and to make them want to come back to the game and play it again. The results of the summative evaluation confirm that the app has a good potential for use in both school and occupational therapy.

Involving children with special needs into the design process has been challenging, but very rewarding. In this thesis, the lessons learned regarding methodology, ethics, and knowledge resources and like are presented and discussed. I address challenges that were met during the design process and how these shaped the outcome of this research.

1.1 Motivation

Before I came to Norway and started studying Human-Computer Interaction at the University of Oslo, I studied occupational therapy and speech-language pathology in the Karelian State Pedagogical University in Russia for two years. I never finished this study, nor got a chance to practice my knowledge in real settings. However, I always felt that the field of occupational therapy is exciting and wanted to do something related to it. My mother is an occupational therapist and I grew up very close to this context, often helping her to make tools for her therapy sessions, see Figure 1, of something I made at the time. Back in these days, the tools were made of paper using glue, paints or other low-tech materials.

Figure 1 - A cube I made from a box, self-adhesive paper and caps. This tool was used in therapy with children, for memory development and color recognition. Photo: N.Karpova

When I started the master program at the University of Oslo, I got an opportunity to assess use of the iPad at a special education class. I did not hesitate a minute and grabbed this opportunity. When the opportunity of assessment became an opportunity to design something for the children as part of my master thesis, I did not think that I could get better topic at all! This time, rather than using low-tech props, I had the possibility to study the potential that modern high-tech offers for children with special needs, first in educational setting and then in occupational therapy setting. My vision was to make something that could help both the children and their teachers to improve the quality of learning through fun, and thus help improve the quality of life for this heterogeneous group of children with various difficulties.

1.2 Research questions

The research for this thesis was carried out in two phases:

- First, an assessment of the iPad as an educational tool in a special education class was conducted;
- Second, design of an app for children with heterogeneous skills and needs was performed involving the target user group into the design process.

During the first phase, we were answering the following sub-questions:

- What are the children's abilities in regards of using the iPad as a tool?
- What are the children's abilities in regards of academic skills?
- What are the children's individual skills when using iPad apps based on gamification concepts?

The results of the first phase showed that all children were capable of using the iPad; they could turn it on, open and close apps, switch between apps and like. Children's excitement about the iPad and the easiness of using it appended to the potential benefit of using this technology in classroom education settings. Unfortunately, no apps that could fit all the children at the same time were found due the heterogeneity of skills needs. This led us to the decision of making such app together with the children and the main teacher. In order to do that the following question was addressed:

- How to design with children with special needs in a heterogeneous setting such as the classroom?

The sub questions that were looked at in order to find some partial answers to the above questions were:

- Which methods techniques, developed for designing with normally developing children work in the setting with children with special needs?
- What are the added ethical considerations in this situation?

1.3 Chapter guide

Before starting on the next part of this thesis, I would like to give a brief overview of the upcoming chapters:

Chapter 2 Literature Review: In this chapter, I present an overview of previous and current research and design related to designing assistive technology for and with children with special needs. I also present research that is not directly related to technology design but is still relevant to the topic of this thesis.

Chapter 3 Theoretical Framework and Ethics: This chapter introduces my philosophical stance, phenomenology, in relation to the participatory approach adapted in this project. This approach lays the ground for the methodological procedures in this research for both data collection and data analysis. Further, the FACIT PD framework is used to describe the main principles underlying the choice of methods in this research. At last, I present the ethical guidelines that helped us to face ethical challenges throughout the research.

Chapter 4 Methods: In the chapter I introduce the methods and techniques used during data gathering, technology design and data analysis.

Chapter 5 The iPad Assessment: In this chapter, I answer the questions related to the iPad assessment in the special education class. I will demonstrate how some of the methods described in chapter 4 were applied and how the results influenced the future research.

Chapter 6 Design and Prototyping: In this chapter, I address the process of concept creation and app design involving the main teacher from the special education class and other interaction designers. Further, I talk about the formative evaluation of the low-fidelity and the high-fidelity prototypes and present the results from these evaluations. The final version of the prototype is also described in this chapter. Finally, I present the final evaluation of the prototype with detailed description of the results for each child. At the end, I present the expert evaluation of the game from an external occupational therapist who was not involved into the design process.

Chapter 7 Analysis and Discussion: In this chapter, the results from the summative evaluation are analyzed and discussed. The analysis of results is divided into three groups according to the evaluation metrics that are defined in the Summative Evaluation chapter: usability, enjoyment and behavior learning. Finally a discussion on the methodological and ethical differences in implementing HCI research methods, originally designed for using with normally developing children, in the context of technology design with children with special needs is given, answering the last question in this research.

Chapter 8 Conclusion: In this concluding chapter, I aim to provide a summary of the work presented in this thesis. I will also take the opportunity to present some implications for the future work regarding the design with children with special needs.

2 Literature Review

This literature review provides an overview of previous and current research and design related to designing assistive technology for and with children with special needs. There exist a number of studies on co-designing with children in order to create technology that will be used by children. A small part of these studies that do address the children with special needs, usually aim for groups based on a particular disability, such as loss of hearing, blindness, ADHD, autism, etc. An even smaller part of them is concerned with designing assistive technology for and with children with diverse special needs. The topic of technology co-design with children with special needs is to the best of my knowledge still under-researched. Given that I could not find a very rich body of research in the field of my interest, I will present research that is most relevant for this thesis.

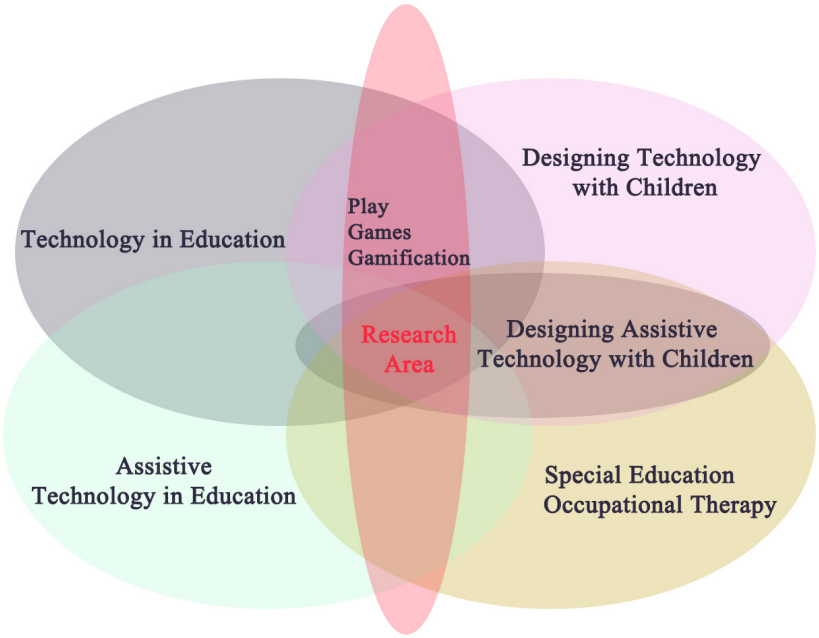

Figure 2 - Relevant research areas

The Figure 2 shows a map of research areas related to my project. The area in which I have contributed is placed in the center. The fields of occupational therapy, technology in education, assistive technology and design for and with children are all large, well-established research areas. Gamification is also a fast growing area of research. Instead of trying to review those as research fields, I have pick out only a small number of references that I have used actively in the present work.

2.1 Method used for finding relevant work

Identification of related work was done in several iterations and focused on the initiatives related to co-design of technology with children and use of iPad as assistive technology. First, I started from reading of the relevant literature suggested by my supervisor. Then broad

searches were performed on Google and Google Scholar with focus on the most cited works and authors in order to identify common keywords, acronyms and terms used in this field. The search included the phrases “designing technology with children”, “using iPad at school”, “design process with children”, “apps for children with special needs”, “gamification”, etc. The relevant publications were recorded. The bibliographies of these articles were used for spotting other relevant sources.

2.1.1 Analysis

In the end all, the literature was divided into groups according to the Figure 2. The articles that described case studies that were in some way similar to mine were analyzed closer. Frauenberger inspired the analysis of these articles. He analyzed 11 publications on projects that worked with children with disabilities and adopted a Participatory Design approach. His aim was to identify recurring challenges and possibly their solutions. He mostly focused on the role children played during the design process and the ways in which their input was reflected in the outcome [12]. I adopted this method on the literature, which concerned both normally developed children and children with disabilities in order to look after known challenges, their solutions, methods, and techniques that could be adopted in my research. More details on this analysis are available in sections 2.7 and 2.8.

2.2 Technology in education

The acquirement and use of educational technology was problematic in the past, e.g. Bromley and Apple in [13] point out that investments in technology for education are not done appropriately, they argue that right questions are not asked when purchasing new technology. Other authors mean that technology remains under-used [14]. Cuban supports his views by looking long into the past patterns of technology use at schools [15]. Many researchers, educators, and even students, see that the digital technology does not always work in the ways it was envisioned for it to work.

On the other hand, mobile technologies are broadly considered to be better suited for educational purposes (e.g. [9], [16], [17]), opening ways to mobile learning. However, in the light of opportunities that mobile learning offers, some researchers are becoming concerned that the new technology requires a different model of education, pointing out that schooling and learning are not the same [18]. In Rethinking Education in the Age of Technology, Allan Collins and Richard Halverson argue that the knowledge revolution has made an impact on our jobs, our homes, on the way we live, and therefore must influenced our schools. To keep up with a globalized technological culture, it is necessary to rethink how we educate the next generation. This book offers a vision for the future of American education that goes beyond the walls of the classroom to include online social networks, distance learning with "anytime, anywhere" access, digital home schooling models, video-game learning environments, and so on.

It is generally agreed that iPad and iPhone were cool and innovative products that permanently changes something about mobile technology and finally made a way for tablets into the market [7]. Even though iPad was not designed particularly for education, it obviously could be used to support it. A lot of media attention was gathered around the iPad-centered education (e.g. [19] [20] [21]). Some educational institutions have adopted iPad into their daily life [22]. It is possible to connect with these institutions through iPads in Education [6] and [5], follow iPad education on Twitter (#iPadEd), participate in the social media, etc. The producer, Apple, has noticed this enormous interest and broadened services in order to satisfy the need of this user group. Series of products among them racks, or as Apple name them "labs", that can hold multiple devices that in this manner can easily be taken into a classroom [23].

Despite the innovation and coolness of the modern devices such as tablet PC's and iPad there have been some issues in adapting them in the educational setting. Da Silva mentions in his article [8] that it is difficult to find software for Tablet PC that offer functions to support the broad of student's activities. Culén supports this view arguing that being "cool" is not enough when the overall aim is to adapt a device as a learning tool. It is necessary to understand the context of use and carefully design for it [7].

2.3 Assistive technology in education

When it comes to students with special needs, there is broad spread optimism regarding possibilities mobile technologies could offer [24]. But the situation is more complicated with assistive technologies (AT), where additional factors play an important role e.g. the perception of the self and adoption of AT [25], competence and knowledge on the side of providers of such technology and prohibitive costs ([26], [27]) and recommending AT for children with multiple disabilities [28].

A review of AT in education, focusing on type of devices used and their impact on students, is reported in [29]. The variety of technologies reviewed in this study is quite large and it is difficult to say what technology worked best. The majority of articles reviewed in this study indicated that AT was beneficial in increasing the literacy and speech abilities. In almost all studies the students increased their level in the skill that was tested [29]. After the launch of the iPad, Culén and Gasparini studied its use at different levels of education, from elementary school to postgraduate education, see [30], [7], [31]. Gasparini and Culén [4] discuss two pilot studies involving dyslexic students and the use of the iPad. One of the cases involved a university student, the other, two 4th grade students in an elementary school. In both cases, the students had reading difficulties and happily adapted the iPad in their learning routines. In the case with the university student the research was conducted over two semesters where the researchers had possibility to observe the student using iPad and help to adapt the technology for the student's needs. The process of acceptance was not easy but by the end of the study, the student seemed very happy with the technology and used it freely. In the case with

elementary school children, the study lasted one semester in a class where two children had reading difficulties but they were not diagnosed. A reading experiment was conducted with and without the iPad. In the experiment without iPad both kids who had reading difficulties could not answer control questions at the end, while iPad facilitated reading and made it possible for children to answer them. However, while working with the iPad was facilitated, nothing was designed for students.

2.4 Education for children with special needs

In [32] the authors define the term children with special needs:

Children with special health care needs are those who have or are at increased risk for a chronic physical, developmental, behavioral, or emotional condition and who also require health and related services of a type or amount beyond that required by children generally. [32]

This definition includes several concepts that need further explanation. *Children at increased risk* are exhibiting certain biological or environmental characteristics related to a heavy probability of developing a chronic physical, emotional, developmental, or behavioral condition. Biological risks include pathologies and physiological anomalies that can increase the possibility of future outbreak of chronic conditions. Environmental risks include those social and economic factors as well as other characteristics of a child's environment that can place children at increased possibility of developing chronic physical, emotional, developmental, or behavioral conditions. According to authors in [32], the concept of *requiring health and related services* should be interpreted in context of professionally accepted pediatric practice standards. The services may include:

- Specialized medical and nursing services (e.g. hospitals specializing in the care of children)
- Therapeutic services (e.g. speech, occupational therapy)
- Family support services (e.g. family counseling and education)
- Equipment and supplies (e.g. assistive devices)
- Related services (e.g. special education, transportation, social services)

Services of *a type beyond that required by children generally* may relate to one or more of the services listed above, or to the consuming of regular health services at a level that surpasses the requirements of most children [32].

In order to create an educational app for children with special needs we needed to understand the theories of learning, methods and techniques used in classroom education of the target group. How special is the education for the children with special needs? Can common pedagogical techniques be used? What is the pedagogical strategy in a class with children

with different disabilities? What is necessary to consider when designing an educational app for this target group? These are the questions that we aimed to answer in order to design a pedagogically sound app that would support our target users in behavioral learning and social adaptation.

There is one clear answer to our questions – it depends. The pedagogical strategy and the level of inclusion of a child into a common education system depend on the disability he or she has and the level of severity. In [33] authors group learner needs, teacher knowledge and pedagogical strategies by disease: deafness, visual impairments, severe learning difficulties and so on. This distinction illustrates that children with different needs require different approaches in learning.

As we saw from the special education class, we got to work with, when children with different needs are gathered in the same class, individual learning plans are created and appropriate support is provided for each child based on the level of skills and particular needs.

For us as designers this meant that we would need to consider all individual differences when designing an app for a heterogeneous class. In order to solve this task we involved special educators in the design process as suggested in most of the reviewed articles.

2.5 Design for playful learning

For most children, including the ones with special needs, play is a natural environment for learning and development [34]. Play can be categorized in developmental terms in three broad groups [35]: functional or sensorimotor play requires the manipulation of objects when their form or color arouses interest. Secondly, the representational play when a child starts to invent imaginary sequences and actions with objects that correspond closely to real world objects. At last, a more symbolic form of play when a child creates new meanings for an object and imagines a purpose other than one that directly relates to its function, for instance using a banana as a telephone.

The presence of disability often raises special challenges related to play and development of representational play can be delayed [36]. In this case, children often prefer the sensory-motor type of play such as banging or spinning. Despite any present disabilities, children enjoy playing and most of them seem to match their play preferences with their abilities [34].

Children, unlike adults, interact with technology in relation to two activities: education and play [37]. In order to create a successful design to support learning activities, theories of learning can be applied. Markopoulos [37] mentions behaviorist and constructivist view as possible theories. Adopting behaviorist view one can try to encourage learning through repeated stimulus and reinforcement. Through constructivist view, it is suggested that children acquire knowledge through experience. Technologies for learning are seen as construction kits instead of instruction programs. Kafai [38] adds to this by defining instructionist and constructionist perspectives for game studies. Instructionist perspective is

derived from thinking in terms of making instructional education materials. These materials are then embedded in a computer game. The constructionist perspective on the other hand aims for the goal of providing students the opportunity of creating their own games. In our case, when children's imagination and explorative functions can be limited by disability they have, a more instructionist approach is more suitable. Nevertheless, we do not want to constrain us to a plain instructional educational game, as it may not be engaging for the target group. Thus, we explored the concepts of fun and playful learning in order to make the game engaging and interesting for children.

Many researchers have explored the relationships between fun, play and learning, relying on argument that fun contributes to being motivated to perform an activity, and in this way contributes to learning effectively [29]. In addition, play is viewed by occupational therapists as the occupational role of infants and young children, and is used to facilitate the achievement of therapy goals [39]. It is confirmed that play and playful design, including gamification, have a huge effect on user motivation and engagement [40]. Gamification is a rather new term that was spread around the second half of 2010 and means including game elements into non-game context such as education in order to make it more engaging [41]. Gamification has been adopted in many different arenas, e.g. health, business and education ([42], [43]). In [42] the authors state that within a socio-cultural trend of ludification, there are at least three trajectories of importance for HCI: pervasive games, gamification and playful interaction. We suggest the concept of gamefulness as complementary to playfulness in terms of design goals, user behaviors and experiences.

We believe that playful and gameful interactions provide a natural environment for learning and development. In [44] the authors see play as an environment where a child has control and sense of competence: "Play can give children with disability a sense of competence and control over environmental circumstances. It can also help a child to learn new skills." [44]

2.6 The role of children in the design process

Involving children into the design process is more complicated than involving adults. They are still children and need to go to school, depend on their teachers and parents for learning and living. In addition younger children are limited verbally and cannot express themselves clearly, especially when it comes to abstract concepts. Due all these reasons children's participation in the design of new technology was reduced. Children have been involved in the design of new technology for years now. First publications on children having input into technology design process first appeared in late 1960's and early 1970's [45]. Since then children have been involved in different projects performing different roles. Children are mainly included in the design process with aim of creating better children's technologies.

Druin [45] has introduced a model (Figure 3) in order to discuss the relation of various roles children can play during the design process. As we move from the inner circles to the outer circles in the model, the role of children changes in two ways: first, it becomes more active

and responsible, and second, children get involved more and more. The inner circle represents the oldest children role – *user*. In this role, a child is an end-user of technology with no involvement in the design process. This approach is not recommendable from user-centered and participatory design perspectives [37]. The next circle represents a more recent role for children in the development process – *tester*. In this role, children are involved as testers of prototypes of the emerging technologies before the product has been released to the world. The impact that children have as testers is limited to suggestions of new features and discovering bugs. The decision of accepting the changes or not is ultimately up to adults. Involving children as participants in the usability testing is the minimal and rather pragmatic requirement for a user centric design [37]. The next role is *informant*. The child plays some part in informing the design process before any technology is developed. Children can be involved at different stages of the design process and provide their input in different forms such as drawings, interviews, observations, etc. The outermost circle represents the more radical view that children can act as *design partners* being an equal stakeholder throughout the whole design process. Druin argues that even though a child is not able to do all an adult can, they should have equal opportunity to contribute in any way they can [45]. As we can see the two first circles represent passive roles from a creational perspective, the third and fourth circles represent roles that carry the notion of active participation.

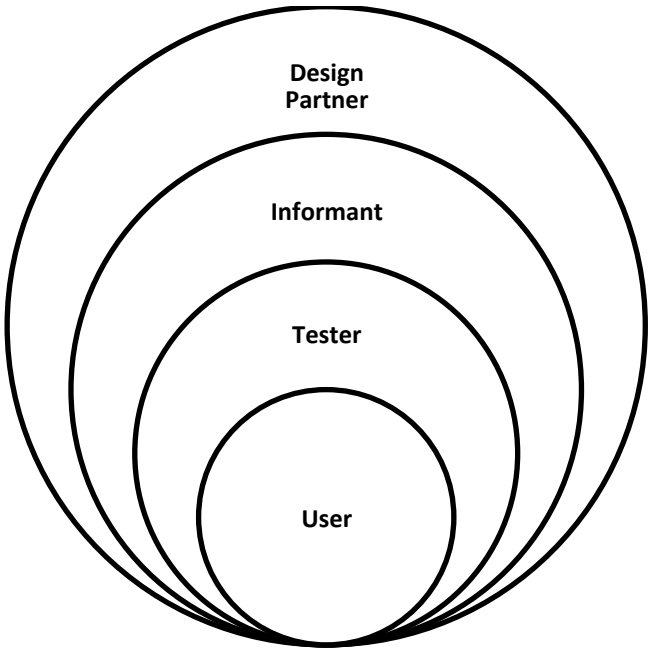

Figure 3 - Relation of the various roles children can play during the design process [45].

2.7 Designing technology with children

Designing technology for and with children (e.g. [10], [37]) is a challenging task. During the past two decades or so, a wide range of techniques have been introduced and applied for designing technology with children. Many of them are based on participatory design techniques (e.g. [46]), and adapted to intergenerational design teams [47]. The view of

involving children as design partners, advocated by Druin, has been used in several studies reported in [48], [49] and [50]. Involving children as design partners introduces several challenges and some debate surrounds the issues as to how participatory design should be adapted. A more moderate view, that still addresses pursuit of involving children during the design phase but considers some of the practical limitations of doing so, is to involve children as informants. This approach was reported in [30] and [51].

A more detailed overview and analysis of the selected articles is shown in the Table 1. Below these articles are reviewed, with the aim of finding the reappearing challenges and possible solutions for them. The articles were analyzed with a particular focus on the role children played in the design process, the way their input was reflected in the outcome and methods used for involving children of different age. In addition, I looked for the methods and techniques that could possibly be used in my research.

A wide range of technologies was developed and reported in these papers. All of them were aimed at supporting learning in different degree and for different age groups. In each case, children were involved in the design phase either as informants or as design partners. Almost all of them involved the children of the same age as the target group during the design process except for one project – UCLA [48]. Kafai describes a case where a group of 6th grade children design and implement some multimedia sites in science that are aimed for the elementary school children. This project is unique as the children are given the opportunity to implement the system thus acting rather as designers than co-designers. Other studies also illustrated a high level of involvement of children. These active forms of involvement are likely to have the greatest impact on the design owing to the immediacy of the collaboration, but equally difficult to implement. These are usually taking form of design workshops or focus groups where both children and adults have equal opportunity to express themselves in a way that is comfortable for them and make an impact on the outcome.

Cooperative inquiry, a set of design techniques developed by Druin [52], is reported as a successful framework when involving children as design partners. Druin defines the framework:

"Cooperative inquiry is an approach to research that includes three crucial aspects which reflect the HCI literature above: (1) a multidisciplinary partnership with children; (2) field research that emphasized understanding context, activities and artifacts; (3) iterative low-tech and high-tech prototyping." [52]

In other words, this framework is based on the belief that collaborating with users is an important way in order to understand what is needed to be developed in new technologies. It is grounded in the traditions of field research where a great part of the information can be collected from the user's context. At last, cooperative inquiry calls for intergenerational teams to visualize their ideas through low-fidelity prototyping using paper, clay, crayons and so on. A modified version of Cooperative inquiry was adopted by Guha when working with 4-6 years old children [49].

Skaife and Rogers [51] suggested another approach – Informant design framework, which is based on the vision of involving children, and not only them, as informants on different design phases. The authors define the framework:

"Essentially, this involves determining the different phases of design, identifying who will be informants in these, what their inputs will be, and what methods will be used. Our emphasis is to view different people as informants through our interaction with them." [51]

Skaife and Rogers find this framework helpful in enabling them as design team to discover what they did not know rather than try to confirm what they already knew. Their view on children in the design process is analogous to the "native informant" of anthropology, because children are aware of the use of technology that adults are not always sensitive to, and that adults need to be told of [51].

Among the problems reported in these articles was necessity to structure the design process when involving children ([49], [30], [48]). The review of the articles showed that the younger the users are the stronger structure is needed in order for them to produce better. Until age of 11-12 years, children have difficulties in understanding abstract ideas and manage long-term, less well-defined projects [37]. Therefore, they need help from adults in order to structure their work and divide larger tasks into smaller pieces:

"By encouraging idea generation in smaller steps, and establishing parameters for collaboration with others, these young children were less frustrated and more productive in the brainstorming process" [49].

Younger children (5-8 years old) had difficulties expressing themselves verbally as mentioned in [49] and [50]. Working one-on-one with children or in small groups (one adult and two-three children) can ensure that children's ideas are communicated and well documented. Such technique as annotations made by an adult on a child's drawing can help young children to express their ideas in words [49].

"Often, children are not that self-aware or verbal about their needs. They must be given opportunities and self-awareness, either through experience with technology or through participatory design exercises that ask them to see possibilities using low-tech prototyping tools" [50].

Moreover, when children do verbalize their ideas it is very important to make sure that adults understand what children have to say. Skaife and Rogers mean that children have a different conceptual framework and terminology than adults, so the adults must be aware of the need to speak a common language [51].

Several authors ([50], [51]) mentioned balanced power relationships as a critical factor to a successful collaboration with children. Druin [50] tells that in their collaboration with children they did not start working as equal partners. The adult researchers had to facilitate children's use of technology and explain how things worked. However, as the children's expertise grew, so did the number of suggestions and design ideas. Eventually, as children's competence grew they were asked for direct design ideas. Becoming partners took some time.

Druin argues that experience, self-awareness and confidence were crucial to develop in their cooperation with children in order to get good results.

Another important consideration for designers who involve children as informants is selection of ideas provided by children during the design sessions. What should be included in the future design and what should be left outside? What motives should drive this decision? Skaife and Rogers [51] support the view that there has to be established criteria to determine what to accept and what to left outside, in respect to the goals of the system. This is especially critical for educational software, where interface and fun factors can conflict with the overall learning aims.

Project name	**Technology**	**Target user group**	**Children roles** [45]	**PD techniques**	**Comment**
UCLA [48]	Interactive multimedia sites in science	Elementary school children, 5-6 years old	Elder children (6^{th} grade) as *designers*	Child to child approach	- It was difficult for children to prepare and manage long-term, less well-defined projects. - They needed support in organizing collaborative work.
Not specified [30]	An iPad app that enables production of multimedia newsletters	6^{th} grade children	Target group children as *informants*	Design workshops with children	- Children needed more guidance in order to produce better. - Short time span.
Not specified [49]	Technology to enable children to play and learn in outdoor settings	Children 5-6 years old	Target group children as *design partners*	Cooperative inquiry modification – Mixing Ideas	- Young children need more structure to collaborate during the brainstorming process. - Difficulties with expressing themselves verbally - Children are challenged by truly collaborating and elaborating on one another's ideas
KidPad [52] [50]	Digital medium	Children 8-10 years	Target group	Cooperative Inquiry	- Children had difficulties with

	with an intuitive zooming interface to support a learning environment	old	children as *design partners*		expressing themselves verbally - Disbalance in power relationship.
ECOi [51]	Novel interactive software for teaching basic concepts of ecology	9-14 years old	Target group children as *informants*	Informant design framework - Analysis of existing problems and methods - prototyping	- Children cannot discuss learning goals that they have not reached yet - Power relationship - Important to decide what input to accept and what not to with respect to the goals of system - Problem in understanding what children mean to say

Table 1 – Selected publications for the literature review on participatory approaches in designing with children.

2.8 Designing technology with children with special needs

Designing for and with children who have special needs is particularly challenging [12]. For these children, the combination of power relationships often reduced communication skills, and additional stakeholders such as parents, teachers or caretakers makes for a complex situation that needs to be handled with sensitivity, both methodological and ethical. At the same time, it is often these kinds of groups that benefit the most from a design process that includes them and enables them to contribute to the outcome [12]. Children with special needs are often exposed socially, whether the reasons are internal or external, e.g. autism, a physical disability, stigmatization or other forms of social exclusion. They are at risk of not being understood, as they often must rely on others when it comes to deciding and communicating their needs. Further, they are exposed for the technology that was not designed with understanding of their needs and abilities [53]. Thus, these children are considered vulnerable also with respect to use and design of technology they rely on for education, socialization or entertainment [54].

Further, the selected articles are reviewed in the same way as in the previous section. A more detailed overview of each article is available in the Table 2. The analysis is complicated by

the fact that the level of details provided on the topics that are of interest for this research varies in all articles.

As we can see from the Table 2, the target group children are mainly involved as testers or informants during the design process. As it was mentioned in section 2.4 the tester's role includes testing of prototypes before they are released to the world. This role is seen as the minimum requirement when using user-centered design approach. Four of the reviewed studies adopted this view ([55], [56], [57], [58]). The design partner role was abandoned in all cases, sometimes due the limited time span and sometimes because the amount of work was seen as too demanding from the children in terms of time, discipline and effort [59]. In [36] Keay-Bright argues that some of the participatory methods such as storyboarding, sketching, brainstorming would have been unrealistic for the target population (in this case, children with autism). However, these methods can be successfully undertaken with teachers. Brederode believes that informant-based design enables good information to be drawn from the analysis, empathy to be created with the children and at the same time, it spares children from the stress [59]. The same approach was reported in the most studies that were reviewed (10 of 16 studies, e.g. [36], [60]). In [61] the researchers used older children as participants in the design process because "the older children were able to give us more detailed feedback about the prototype". In addition, children with normal development and teachers are sometimes used as design partner or informants proxies for the target group (e.g. [36], [58], [60]). Several studies illustrated that it is possible to involve children with special needs, normally developing children and close stakeholders together in the design process in order to get input on the design. As we can see the level of active participation for this user group is lower than in cases with normally developing children thus reducing the impact on the design of new technology. Involving teachers and normally developing children can sometimes give inappropriate results and this need to be handled with cautions. In [58] the authors mention that the input provided by high functioning children and psychologist's comments resulted in some interaction models that were not adequate for the target group. These models had to be reviewed and remodeled. In [60] the authors show satisfactory results when involving non-disabled children as proxies for disabled children but they are very cautious in generalizing from this, and they question how far non-disabled children can be used as proxies and still provide adequate input.

The limited involvement of children with special needs in the design process can be justified by the fact that the disabilities children have might hinder them from participating. In [62] the authors propose an *inclusionary model*, which suggests that appropriate involvement of children with special needs in the design process starts with the *level of involvement* that the team expects from the child, it is further influenced by the *nature and severity of the child's disability* and the *availability and intensity of support* available to the child. Using Druin's levels of child involvement [45] it is possible to create an overview of the different ways in which children can be involved into the design process. Initially, the research team must decide how much involvement of children is possible considering time, access to children and funding. Second, the nature and severity of the disability will suggest how open the role of the

child can be. Children with less severe disabilities may have a more open role and be more involved into the process. In case a child has some severe disabilities, it might be difficult to involve him/her into the process. At last, the availability and intensity of support can open more choices for involvement. For instance, a deaf child cannot participate as a user given no support due the communication issues, but provided with a sign language interpreter the involvement is opened again [62].

The range of technology described in the reviewed articles is even larger than in the previous section. The technology varies in types of devices it is designed for, in input and output methods, whether is personal or requires several participants in order to function. One common thing for all of the technologies described is that all of them were designed and developed specifically for the children with special needs answering to their needs and abilities.

The participatory methods are usually taking form of different kinds of design workshops with children and/or stakeholders. Other, non-participatory methods are interviews and observations. These seem to provide some valuable input to the design as well. The design activities have to accommodate with the children's preferences and possibilities, since some of the PD activities may be unrealistic for the children with special needs, and researchers are often dependent on the "mood" of the participants [63]. In addition, it is of huge importance, an imperative in fact for the researcher to reflect upon when working with children with special needs that benefits from participation in the process are higher than the effort children make by participating.

"When designing with children with disabilities, the issue of beneficence – ensuring that the risk or demand on them does not outweigh the benefits of inclusion – is paramount." [12]

Among the methods mentioned in the reviewed articles was *Fictional inquiry* [64]. The authors involved both teachers and the children with special needs as informants during the design process. The technique itself entails bypassing existing socio-cultural structures by creating partially fictional situations of narrative character that mediate collaborative design activities. The authors describe the technique:

"The technique creates partially fictional settings, artefacts, and circumstances through a shared narrative. The technique creates a space for conducting collaborative design activities where inquiries are conducted as the participants are urged to imagine desirable futures and are confronted with their everyday practice." [65]

Another participatory framework is *context mapping* implemented in [66]. The key principle in this framework is that participants are put into the expert role of their own experiences, and as such actively contribute to design. Van Rijn believes that this framework evoke users to express themselves through making physical artefacts and giving verbal and written explanations. In [66] van Rijn describes two particular techniques that were used with children with autism, their teachers and parents: toolkits for expression and AsSeenOnTV.

Intentionally, tools for expression contain ambiguous building materials such as a set of words or a set of toys with different characteristics. AsSeenOnTV is an example of a script-providing tool, which makes the user to feel in control by presenting "in the frame".

Wizard of OZ method was successfully used in design process in [61]. In this method, the backend functionality of a system is simulated by a human. Henderson concludes that this method facilitated research on both the visual interface and the sign language recognition engine [61].

Among the evaluation methods, the *test-retest* technique described in [56] was particularly interesting as it was used for evaluating a virtual environment that was developed with the aim of assisting development and improvement of real world skills. The procedure of the method is as following: test the skills in real world, then do the same tasks in the virtual environment over a period of time and at last retest the skills in the real settings again. Another technique mentioned by Cobb [56] is *expert assessment* of the virtual environment in order to evaluate usability and appropriateness of the learning scenarios. In [60] the *Fun Toolkit* technique was implemented in order to measure fun and usability of the developed system. This technique is described in [67]. It includes several measuring techniques, the *Smileyometer* for instance, which is based on a 1-5 Likert scale, and uses pictorial representations of emotions from "awful" to "brilliant" (see Figure 27).

Most of the studies that were reviewed are aimed at particular disabilities such as autism, motor impairments or hearing impairments. Only two papers look at heterogeneous groups ([56], [59]). In one case, the target group was involved as testers [56] in the second – as informants [59]. One major issue reported in both articles was diversity in skills and needs that caused difficulties during the design and evaluation phases.

Another issue that can be seen from the analysis is that most of the researches involving children with special needs operate with small samples thus making it difficult to validate the results. Frauenberger sees the participatory techniques as capturing the richness and diversity of individual profiles and experiences in contrast to controlled studies, where the aim is to produce a normative view of a diverse population by combining data points into an "average" [12].

"The process empowers users and informs the design, but by the nature of user involvement, the outcomes are less quantifiable. In contrast to a controlled evaluation study, the aim of PD activities is not to produce the evidence, but to increase acceptance, ownership and the odds of a successful design." [12]

One of the reasons for why there are few participants in researches involving children with special needs is the fact that these children are very difficult to access. This issue has been reported by several authors as one of the most challenging during the design process ([68], [63], [66]).

"It is surprising to learn that, routinely, the greatest obstacles have little or nothing to do with the child's disability but are instead structural, institutional, social, geographical, financial, legal and attitudinal." [68]

There are not many solutions for this issue except for trying repeatedly.

Several challenges reported in these articles are similar to the ones described in the previous section. Children with special needs are similar to the normally developing children in the way that they also have difficulties in verbalizing and expressing themselves. However, in case with children with special needs this issue can occur with older children as well. Many authors reported this issue (e.g. [36], [68]), and the same issue is seen in children with different disabilities: deaf, autism, motor impairments, etc. Because of the children's difficulties in verbalizing and expressing themselves, adults would have issues in understanding and interpreting the signals children give. In one case [69] the communication issue was solved by excluding children from the design process and involving only special education teachers as proxy informants into the design process:

"Since we cannot engage the final user (the children with ASD) in the design process due the communication barriers, we involve special education teachers in the design in two ways: they help design the product in their role as teacher, allowing us to do participatory design, and they act as proxy users for autistic children." [69]

Evaluation of the software developed in that study was not reported in the paper so it is difficult to say how well this approach worked. In [61] the authors describe the design for deaf children whose native language is American Sign Language (ASL). The researchers were unfamiliar with this language and they involved a facilitator fluent in ASL and known to the children. The response to this method was positive:

"We discovered this method worked surprisingly well. The facilitator was often able to recognize critical mistakes in the child's signing before the child had completed the entire phrase. This gave our wizard time to make the cat's response to the child's signing appear seamless." [61]

Some authors reduced involvement of the children in the design process by including them as testers (e.g. [58]) thus limiting the influence children could possibly have on the design outcomes. Keay-Bright in [36] used observation of the free-play activity as input to the design thus collecting natural expressions of the children provided in familiar settings. In this case, the feedback children gave was more general and not tailored for the technology to be developed. A more time consuming approach is to be patient, spend a lot of time with the users, and rely on the special teacher's expertise. This will help to know the target users better and gain a better understanding of their behavior as described in [68].

Another issue that is common between normally developing children and children with special needs is disbalance in power relationship (e.g. [12], [60]). This issue is usually worsened by social, cognitive, physical impairments caused by the disability they have [54].

Ability to adapt methods "on-the-fly" is seen as necessary in order to be able to fulfill a research. Piper mentioned in [63] that it was necessary to change from individual interviews to group interviews in order to make children feel more comfortable. Frauenberger argues that it is necessary to pick the methods that are both suitable for the goals of the study and that are possible for children to perform [12].

At last, in all the studies that were reviewed, teachers and/or special education specialist were involved in the design process. They are familiar with children and are capable of providing valuable input on the design outcome. Piper believes that the teacher is playing an important role both during the design process and as a facilitator of adapting the game in daily routines:

"After each play session, the therapist also plays an important role in grounding the learning experience in the social skills concepts discussed in the class, which can seem extremely abstract to these students." [63]

Project name	**Technology**	**Target user group**	**Children roles** [45]	**PD techniques**	**Comment**
ECHOES [12] [70] Frauenberger	Visual learning environment for a multi-touch surface	Children with Asperger's syndrome or high-functioning autism spectrum conditions 5-7 years old	30 6-years old normally developing children and 3 children with special needs were involved as *informants*	- Desert Island (inspired by the Fictional Inquiry technique [71]) - The Odd-One-Out - The Comic (only with the normally developing children)	- Difficult to transfer findings to the digital domain - Difficult to validate the results - Design activities have to accommodate with the children's preferences - Disbalance in power relationships
The Reactive Colors [36] Keay-Bright	ReacTickles: Interactive whiteboard	Children with autism 4-7 years old	Target group children as *informants* Special teachers as *design partners*	- Observation of free-play activities - Storyboards with teachers	- Impairments in social communication - Difficulties in verbal communication
The Number Race [55], [72] Wilson	Mathematics learning game	Children with mathematics learning difficulties 5-8 years old	Target group children as *testers*	N/A	This paper did not focus on the participatory methods.

Not specified [60] Weightman	Devices for upper limb rehabilitation	Children with cerebral palsy 5-12 years old	Impaired and non-impaired children as *informants*	- Child to child techniques – peer tutoring with non-impaired children	- Disbalance in power relationships - Difficulties in verbalizing thoughts - Unsure how long non-impaired children can provide appropriate input
EyeTracker [68] Hornof	Eye tracker to support drawing	Children with severe motor impairments	Target group children as *informants*	Not specified	- Structural, institutional, geographical, financial, legal and attitudinal challenges - Difficulties in verbalizing - Difficulties in understanding the signals sent by the children
PECS [69] De Leo	PECS: Picture Exchange Communication System	Children with Severe Autism Spectrum Disorder	Special education teachers as proxy *informants*	- Interviews	- Could not involve the target users due to communication barriers
The Virtual Life Skills [56] Cobb	Virtual City: café, supermarket, transport, house	Children and adults with learning disabilities	Target group users as *testers*	- Test-retest experimental design - Expert assessment	- Individual differences determined how much support testers required to use the software
AURORA [57] Dautenhahn	Autonomous mobile robot as a therapeutic tool	Children with Autistic Spectrum Disorder 8-12 years old	Target group users as *testers*	Not specified	- People with autism have difficulty in making sense of the world, in particular the social world
SIDES [63] Piper, O'Brien	SIDES: Shared Interface to Develop Effective	Adolescents with Asperger's Syndrome11-14 years old	Target group as *informants*	- Group and individual interviews - Observations - Testing of	- Difficulties in making students comfortable during interview - Need to adjust

	Social Skills			paper and digital prototype with the users	methods during the design process - Need for an adult moderator during playing - Difficult to get in touch with the user group - Dependency on the "mood" of the participants - Need for an adult moderator
LINKX [66] Van Rijn	Language learning toy	Children with autism	3 boys, target group, parents and care professionals as *informants*	- Context-mapping techniques - Toolkit for expression - AsSeenOnTV - Workbooks	- Difficult to get in touch with the user group
Stepstone [64], [65] Iversen	Interactive learning floor game	Hearing impaired children with a cochlear implant 9-12 years old	Target group and teachers as *informants*	- Fictional Inquiry	- Reduced hearing abilities
MEDIATE [58] Parés	Interactive environment that generates real time visual, aural and vibrotactile stimuli	Children with autism	Children with normal development as *informants* Target group as *testers*	- Child to child	- Disability in communication and socialization due autism - Lack of imagination - No sense of agency - Falling into repetitive attitudes - Using high functioning children as proxies during the design phase resulted in inadequate design for the children with autism.

Not specified [61] Henderson	American Sign Language game	Deaf children 6-8 years old	9-11 years old deaf children as *informants*	- Child to child - Wizard of Oz	- reduced verbal communication - troubles concatenating vocabulary into more complex phrases in sign language
pOwerball [59] Brederode, Markopoulos	Novel augmented reality computer game for a tabletop	Children 8-14 years old with mixed abilities	Both health and handicapped children as *informants*	Interview, observation, testing with children.	- Not possible to involve children as design partners because of the short time span and possibility to put the children under stress - Different skill levels - Methodological issues when evaluating the concept/low-fidelity prototype.
Not specified [73] McElligott	Sound tools and toys	Blind/visually impaired children 3-12 years old	Target group children as *informants*	- Design workshops with children	- The workshops with children reminded of the "technology immersion" technique from the Contextual Inquiry.
PETS [44] Plaisant, Druin	PETS: Personal Electronic Teller of Stories	Children with cerebral palsy	Children 7-11 years old without impairments as *partners* and children with impairments as *informants*	- Cooperative Inquiry - Contextual Inquiry - Participatory Design - Technology Immersion	- Benefits of therapeutic interventions that are administered in a challenging, familiar and fun environment.

Table 2 - Selected publications for the literature review on participatory approaches in designing with children with special needs.

2.9 Summary

This chapter presented an overview of the literature relevant for the topic of this master thesis. What comes forth in the review is that technology and especially assistive technology has large potential in regards of education and supporting learning activities, given that a proper technology design is in place. Involvement of target users is seen as a crucial factor in order to achieve adequate results but it also raises several ethical and methodological challenges that need to be handled with caution and sensitivity.

3 Theoretical Framework and Ethics

In this chapter, I will introduce the theoretical framework and ethical guidelines that underlie this research. As it appeared in the literature review, involvement of children in a design process of technology for their use is a crucial factor in order to succeed in design. I have adapted the phenomenological view as a background for the participatory approach in the research. The reasoning for this decision is presented in this chapter. Further, the FACIT PD framework is used to describe the main principles underlying the choice of methods in this research. At last, I present the ethical guidelines, which helped us to face ethical challenges throughout the research.

3.1 Phenomenology and participatory approach

As shown in the literature review, involving children with special needs into the design process is a task that requires good preparation and a lot of caution. Children are often at risk of not being understood due their limited cognitive and communication s abilities. Several authors mention that children often do not know what they need and they have difficulties in expressing themselves. They often need to rely on other stakeholders e.g. parents or teachers, to determine and communicate their needs. In this complex situation, I as designer am in need of a framework that provides a holistic understanding of the target group's experiences and their surroundings by critically reflecting on design practices [70]. Frauenberger proposes phenomenology as a natural ground for participatory design (PD) arguing that PD originates from a strong tradition of inclusion and empowerment thus drawing on the philosophical foundations of phenomenology [70].

"The philosophical discipline of phenomenology provides the designer with a framework for studying user experience by affording intrinsically contextual view of the way we interact with things around us." [70]

The phenomenological way of thinking has assisted me throughout the whole design process providing the mechanism for interpreting emergent input from the young participants. As a designer, I needed to understand the user's everyday context in which the technology I was designing would be used. Phenomenological presence became a practical way of thinking when planning for meetings with children. I aimed to arrange the workshops in a way that is natural for children and at the same time could scaffold their process of contribution to the design.

Further, I used the phenomenological thinking as a foundation for the interpretation and analysis of the contributions from children. Grounded theory served as basis for the qualitative analysis of the collected data. It allowed detaching the literal input that the user group provided from the deeper phenomenological properties and using it as input to the design. The children I worked with often had issues in expressing themselves and a deeper

understanding of the context was needed in order to interpret what they wanted or what they meant to say.

3.2 Participatory approach

It came clearly forward from the literature review that participatory approach and inclusive design are of high importance when designing for children. The inclusionary model mentioned in the section Designing technology with children with special needs in the Literature Review chapter, and described in [62] is suggested as a framework for designers to approach the special needs of children with disabilities. This framework states that the appropriate involvement of children with special needs into the design process starts with the *level of involvement* a team expects from children. The basis of this model includes the levels of involvement described by Druin [45]. Further involvement of children is influenced by the *nature and severity of the child's disability*. This will suggest a more open or a more limited role for the child. At last, the *availability and intensity of support* available to the child might again open the possibilities limited by the disability.

Even though I would have loved to include children as design partners and apply a proper participatory design method, this level of involvement was not possible for the children, due to their limitations. In addition, logistic issues that arose during the design process made this hard. First, the fact that the special class I started working with was closed down and access to the children was complicated. Then, I managed to find other children with similar issues to continue to work with, but we were geographically separated. The potential costs for frequent traveling would explode the budget. Despite all these issues, I was eager to involve the children in the design process as much as possible since I understood the advantages in doing so. Children's role as informants was the best match in this situation. The severity of children's disabilities varied a lot but special teachers or occupational therapists were always involved in the sessions with children in order to give them a proper support and a sense of the familiar. The teachers and therapists were also seen as informants on different stages of the design process since they could provide valuable input from their point of view.

The method I choose to start with was similar to the one Skaife and Rogers examined in [51] – the Informant Design method. In this method, children are asked to be informants and offer input and feedback at different stages of the design process. In this framework, the authors view not only children, but other stakeholders as well, as information sources, experts in their areas that enable the researchers as a design team to discover things they did not know; rather than proving something they already knew [51].

An important decision that I had to make before starting the whole design process involving children as informants was to decide what input and feedback from children will be included into the design and what need to be left outside [51]. In the study conducted by Skaife and Rogers, they were heavily influenced by the pedagogical criteria. In my case, the decisions

were led by both pedagogical and therapeutic goals – make the children understand the socially acceptable behavior rules and transfer these rules on themselves.

3.3 Defining the participatory techniques

In order to decide on what techniques to use the FACIT PD approach described in [47] was taken. As authors claim in the paper, this framework can assist in choosing an existing technique or in developing a new one based on the needs of the research despite of the stage in the design cycle. This framework covers eight dimensions concerning design partner, design goal and design technique. The partner dimensions are *partner experience* and *need for accommodation*. The design goal dimensions are *design space* and *maturity of design*. At last, the technique dimension includes *cost*, *portability*, *technology* and *physical interaction*. By specifying each of this dimensions I hoped to be able to find the most appropriate techniques that could be used with the target user group.

The *partner experience* dimension examines how much experience is necessary in order to participate in design sessions. This dimension can vary from *no expertise* to *high expertise*. Since I was going to work with children with special needs who never participated in design activities before, the expertise level needed to be near *no expertise,* see Figure 4. Techniques needed to be easy, natural and accessible so the children would be able to participate.

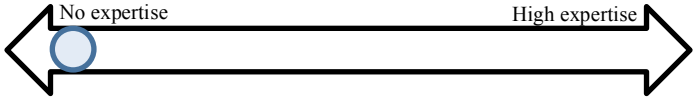

Figure 4- The spectrum of the partner expertise dimension

The *need for accommodation* dimension bear to the age and cognitive ability of the design partners involved. The value ranges from *no accommodations* to *accommodations needed*. As illustrated in the literature review, special educators are normally included in the design process in order to support the children when they need it. My supervisor had no expertise with special education field, and my own two years in occupational therapy were not enough. We thus enlisted help from specialists during the activities involving children. For this dimension we are placed close to the *Accommodations needed* value, see Figure 5.

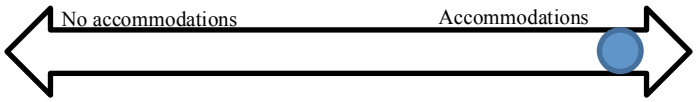

Figure 5 - The spectrum of the need for accommodation dimension

The next group is the design goal dimensions. This group includes *design space* and *maturity of design* dimensions. The *design space* dimension deals with the definition of the design problem. The dimension varies from *non-specific* to *highly specific.* If the design problem is non-specific as for example in the beginning of the design process, the technique may need to be generalizable. If researchers and designers have a specific user interface to analyze, the design problem is highly specified, and the technique used need to answer to these goals. For us the value of this dimension changed over time. In the beginning of the design process, the

design problem was non-specific. A general input from children on the future design was required, so the techniques needed to be generalizable. As the design process continued, more and more specific design questions arose, and we were looking for the feedback on those. So the selection of techniques based on the value of this dimension varied depending on where in the design process we were, see Figure 6.

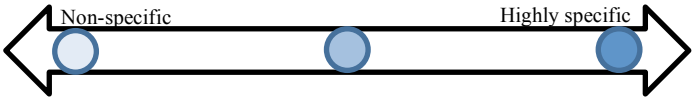

Figure 6 - The spectrum of the design space dimension

The *maturity of design* dimension looks on how far in the design process the current design is. The dimension varies from *early* in design process to *late*. If a design activity occurs early in the process, then the main goal of the technique is to facilitate generation of ideas and set the design direction. In the middle of the design process, a technique might be used for formative evaluation of the emerging prototype. At the end of the design process, it will need to facilitate the summative evaluation of design and analysis of results. The value of this dimension changed as well as we went on in the design process, see Figure 7.

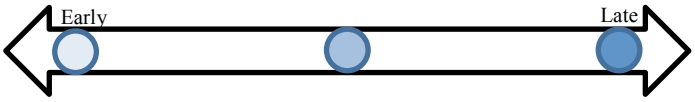

Figure 7 - The spectrum of the maturity of design dimension

The last four dimensions describe the technique itself: *cost*, *portability*, *technology dimension* and *physical interaction*. The cost dimension refers to the financial aspect of the technique as price for materials required for the technique. The value of this dimension varies from no-cost to high-cost materials. Example of a no-cost technique would be paper prototyping, while high-cost techniques would involve usage of technology such as a video camera or a tablet. As our goal was to design a game for iPad, we had to involve this technology into the design process. However, during the initial design sessions involving children and formative evaluation sessions low-cost materials such as coffee beans, coins and paper prototyping were possible to use, see Figure 8.

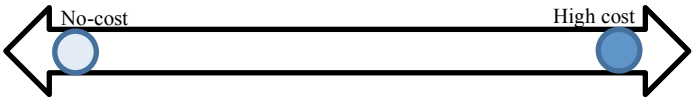

Figure 8 - The spectrum of the cost dimension

The portability dimension refers to the physical mobility of the artifacts generated by the technique. It ranges from non-portable to highly portable. A non-portable technique would need to be in one location, while a portable technique opens possibilities for transferring the technique itself as well as the results of it. We were working with children from schools and children form an occupational therapy center. All of them were placed far away from our location so highly portable techniques were necessary in order to conduct the research, see Figure 9.

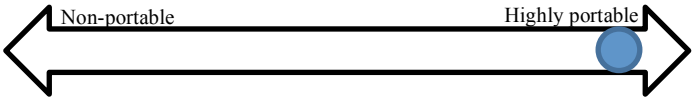

Figure 9 - The spectrum of the portability dimension

The *technology dimension* refers to the sophistication level of the technology utilized in the technique. It ranges between *low-tech* usage and *high-tech*. Utilization of glue, paper and scissors is an example of a low-tech technique. Using computers, tablets or other technology is considered as high-tech usage. The authors in [47] mention that there is a positive correlation between cost and technology level; more high-tech techniques are used, the higher the cost tend to be. As we mentioned in the cost dimension description, we were designing for iPad so we had to involve high-tech design techniques most of the time, Figure 10.

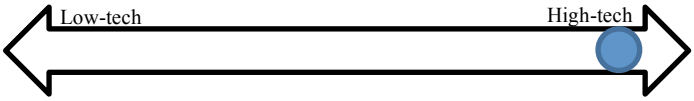

Figure 10 - The spectrum of the technology dimension

The *physical interaction* dimension examines the degree to which designers will physically move around during the design process because of the technique. It varies from *low movement* to *high movement*. Some techniques would require children and designers sit and draw thus involving little physical motion. Other techniques on the other hand would include moving around the room, and this is considered as high movement. In our case, we preferred techniques that required low physical interaction even though it would be interesting to see how the high movement techniques would work with our target group, Figure 11.

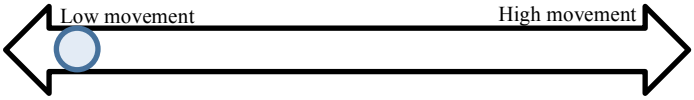

Figure 11 - The spectrum of the physical interaction dimension

In order to summarize the needs described through the FACET PD framework I would like to put all the dimensions in one table (Table 3). This table is my attempt to explain and justify the choice of different techniques we used when working with children during the design process.

Dimensions	**Less**		**More**
Partner experience	X		
Need for accommodation			X
Design space	X	X	X
Maturity of design	X	X	X
Cost	X		X
Portability			X
Technology level	X		X
Physical interaction	X		

Table 3 - An overview of the techniques' requirements based on FACET PD

The FACIT PD framework is used in this work as a background for identifying existing techniques that are suitable in the context of technology design involving children with special needs. The selection of the techniques used in this research is based on the mapping of

the existing techniques discovered during the literature review against the requirements defined in this section. The application of the techniques and discussion of their usefulness are described in chapters on iPad assessment, chapter 5 The iPad Assessment, and design, chapter 6 Design and Prototype.

3.4 Ethical issues

Involvement of children with special needs into a design process requires ethically sound methods that are sensitive enough to the specific needs for inclusion of the target group [12]. Lewis and Porter [74] suggested a set of guidelines for doing researches involving children with learning disabilities. They distinguish between ten different sections: research aims, ethics (encompassing access/gatekeepers; consent/assent; confidentiality/anonymity/secrecy, recognition, feedback and ownership and social responsibility), sampling, design and communication. These guidelines have inspired the whole design process in this study and formed a framework that informed our practice.

The *research aims* section responds to the growing expectation that emphasis in research should lie on inclusive and participatory nature; research *with*, instead of research *on*, people with learning disabilities. Participation of children with disabilities is strongly encouraged, but it is agreed that involving this target group into the design process is challenging. Thus, the level of participation should match the level of abilities of the participants [74].

The *access/gatekeepers* section addresses a number of critical ethical issues that arise due the inequalities between the researcher and the researched. Disbalance in power relationship and additional stakeholders add more complexity to the issues already raised by disabilities. Third-party participants will always have their own views about the value of research and who should and could contribute to it [74]. In this research, close stakeholders were heavily involved in the design process both as informants and as decision makers.

The *consent/assent* section refers to the needs to recognition of the rights of the individual to agree or disagree to their involvement in research. Those who agree to participate in a study should do it knowingly. In case of a research going over a period, participants should have the possibility to withdraw their participation from the research. This consent process has often been described as ongoing [74]. In our case, the children and their stakeholders were aware of the context of the study and had possibility to withdraw from the research at any stage without explanations. In addition, this ethical principle raised our awareness of the necessity to keep the consent ongoing.

The *confidentiality/anonymity/secrecy* section examines issues related to ensuring anonymity for the participants. The authors mention that children with learning disabilities are more vulnerable to abuse, so the researcher needs to be aware of the possible outcomes that can arise both during the research and when the results are published [74]. For this reason, I do not use real names of the children or any pictures that would make it possible to identify the children (Refer to the consent forms in Attachment 1 and Attachment 2).

The *recognition, feedback and ownership* section relates to the principle of mutuality in the activity. This concern is one of the fundamentals that underlie a participatory research. As a minimum, participants should have the opportunity to get a feedback about the outcomes of the study [74]. Both children and adult participants had a possibility to get an insight into the ongoing work during the design process and suggest changes. In addition, I did everything that was in my power in order to reach out to all the children and stakeholders who participated in the research in order to show them the result of the app as well as communicate the main conclusions of this work.

The *social responsibility* section looks into the ethical issues of ensuring a research's integrity. The authors mention that a research can uncover some facts that might go against the values of the researcher, participants or funders [74]. For me it was important to act in accordance with the children's good, putting aside the research interests if they were countering the children's interests.

The *sampling* section addresses the diversity of the children with learning disabilities. There is a high probability that participants might have multiple impairments. Health care and education support provided to the target group can also vary depending on the location [74].

The *design* section refers to the discussion regarding involving children with special needs into the decision-making process. The authors argue that questions asked outside a meaningful context might result in a lack of response or acquiescence, rather than a reflection of the research design. Further, they mention that individuals will need to have self-esteem to believe that their views are appreciated and understood. Additional methods and techniques such as inviting a familiar person to interviews or having group conversations might be required in order to make this work [74].

The *communication* section addresses the issues of establishing a relationship with participants. Developing of appropriate communication skills is seen as one of the greatest challenges for the researcher, especially when meeting the participants for the first time. Researcher will have to find the best medium through which the communication can take place. The medium can be a human supporter, or a technique such as cards, but it has to be meaningful for the recipient [74].

3.5 Summary

In this chapter, I introduced the theoretical framework and ethical guidelines forming the ground principles underlying the research described in this thesis. Phenomenology was chosen as a natural ground for the participatory approach and adapted in this research, helping to get a holistic understanding of the target group experience and their surroundings by critically reflecting on design practices. Inspired by the phenomenological thinking, the Informant design method proposed by Skaife and Rogers were chosen as the initial participatory approach. Next, the FACET PD framework was introduced in order to justify for

the participatory techniques used in this research. Finally, the ethical guidelines proposed by Lewis and Porter, were introduced as underlying for this research.

4 Methods

In this chapter, I will describe the methods used in this research. All methods are divided in four groups according to the purpose of their use: methods for gathering information, design methods, evaluation methods and methods for data analysis. They will be addressed in turn.

4.1 Methods for gathering data

Methods for data gathering helped us to collect the qualitative data thorough the research. Among the methods used are passive and participant observations, semi-structured interviews and video recording.

4.1.1 Observation

Since we were interested in understanding how children interact with technology in their natural settings, observation was chosen as one of the research methods. Both participant observation and passive observation were used in different contexts.

Passive observation

What is: During passive observation sessions the researcher is acting like a "fly on the wall", taking an unobtrusive position [75], but at the same time he follows the activity moving around when needed. The real-life of people is observed for a period in order to understand how people behave in a given context. This method can help to uncover the reality of what people really do, as opposed to what they say they do [76].

Our use: In our case, in situations when our personal presence was not possible, the observation via Skype was implemented. This method was used during the formative and summative evaluations of the app prototypes. Being a passive observer gave us the possibility to pay close attention to the actions and feedbacks provided by children. It also allowed us to diagnose the issues related to the app performance.

Participant observation

What is: Unlike the passive observation, the participant observation method implies immersion of the researcher into the everyday rhythms and routines of the community, a development of relationships with representatives from the community who can help the researcher to understand the underlying reasons for diverse actions [77].

Our use: In this work, this method was used at early stages of the research during the assessment of the iPad as an educational tool and identifying needs for further development of

the app. The possibility of communication with children played an important role in conceptualizing the app design and performing the proof of this concept.

4.1.2 Interview

What is: Interview is one of the most common and powerful ways to understand people. The predominant form of interview is face-to-face and one-to-one [76]. As described in [77] interviews can range from highly structured, where the researcher asks a set of predefined questions, semi-structured, when the researcher and participants set some broad topics to discuss, and open-ended, where the interview is more like a friendly talk without any predefined topics.

Our use: In our work, we actively used semi-structured interviews with our adult participants. First with the main teacher from the original special education class when discussing the issues of the class, and individual issues of each child to the extent needed for future planning of the design activities. In addition, later, we interviewed the occupational therapist from the occupational therapy center regarding the children's behaviors and her impressions of the app. Finally, the occupational therapist from the boarding school for children with speech disabilities was interviewed as an external specialist who could provide us the expert evaluation of the app. The use of semi-structured interviews opened for a more open dialog with the specialists, while at the same time helping us to keep the focus of the interviews. This method was also actively used as a complementary technique for interpreting the children's behavior during design and test activities.

4.1.3 Video

What is: This method implies video recording of everyday events as they happen in real-life context in order to capture people's interaction with each other, technology, and the environment around them. This method enables design teams to analyze tasks and gain deeper insight through replay of the recordings [76].

Our use: All sessions where children were involved, were video recorded and reviewed during the data analysis. I, my supervisor or the occupational therapist using our mobile phone cameras made the video records. Drawing on the ethical consideration of not disclosing the children's identities, only their hands during performing tasks on iPad or with physical objects were filmed with full parental consent. Video recording was crucial in our situation, especially when none of us, the researchers, could be present during the sessions. These records were actively used during the data analysis as a ground for the decisions made regarding the design and the final evaluation.

4.2 Design methods

Design methods described in this section served as background for the participatory techniques used during the design process of the app. Among these methods, we applied brainstorming, scenario playing, personas and prototyping.

4.2.1 Brainstorming sessions

What is: Brainstorming sessions, open-ended discussions with a goal of generating ideas are often used at early stages of a design process. During these sessions, low-tech materials such as paper and whiteboards are widely used in order to quickly write down or sketch the emerging ideas. This technique is usually performed at early stages of a design process in order to come up with many ideas, which then need to be handled through other methods.

Our use: During our research, we used this method with the main teacher of the original special education class and external interaction designers from the institute in order to generate several ideas and concepts for the future app.

4.2.2 Scenario playing

What is: Scenarios are storylines that advocate how people might interact with a piece of technology or a particular design. Playing a storyline provokes discussion, helping to develop and evaluate ideas. This method enables ideas to be proven from a human and experimental standpoint. Scenarios can vary from real-world narratives based on the everyday tasks to more speculative, science fiction ones that can open up discussion around broader social challenges [76].

Our use: In our research, the scenario playing method was used with children from the original special education class in order to examine the concept of shopping and evaluate whether it is appropriate for our target user group or not. In addition, scenarios were used during the brainstorming session with external interaction designers.

4.2.3 Personas

What is: A persona is an imaginary character that represents user archetypes based on real people and at the same time does not copy any of them. Personas are developed to understand behaviors and needs of the user groups and often appear in scenarios as fictional players. The goal of using a persona is to illustrate the user's potential behavior patterns [76].

Our use: We used personas when playing scenarios with the external interaction designers during development of the final concept of the game. Since the access to the children was limited at the time of the brainstorming session, we had to explore other possibilities, and personas seemed to be an adequate option. We created three personas representing the children from the original special education class, without copying any of them. Further,

several concepts for the future app were created and role-played by us in order to discover the benefits and limitations of each of them.

4.2.4 Prototyping

What is: The prototyping method implies the creation of a physical representation of the final design for evaluation. A prototype can range from a quick mock-up in low-tech materials, used to test an initial concept, to a more sophisticated product closer to production. Prototyping makes abstract concepts real, communicates ideas clearly and helps to reduce the risk of costly mistakes at later stages. In addition, users have a more direct interaction with the technology compared to a verbal or illustrative description of an idea [76].

Our use: We have used both the low-tech prototyping on paper and high-tech prototyping on iPad. The paper prototype was first developed in order to evaluate the concept of the game before it was implemented in code. The prototype was tested with children from the occupational therapy setting during formative evaluation sessions, allowing them to provide the feedback on a very early stage of implementation. Children were also asked to create some elements that were later taken into the design of the app. The first version of the high-fidelity prototype implemented using HTML5 and JavaScript was again evaluated at the occupational therapy center with children. These iterations of the formative evaluation strongly influenced the outcome of the research. Both children and the occupational therapist involved in the sessions had possibility to share their ideas, likes and dislikes regarding the app.

4.3 Evaluation methods

In order to evaluate the overall performance and usability of the app, the usability testing was adapted at different phases of the design process.

4.3.1 Usability testing

What is: Usability testing involves representatives from the target user group performing representative tasks in representative environments. Interfaces that are intended to be used by humans are usually usability tested. These interfaces may include computer or laptop graphical interfaces, touch screens and a variety of devices such as mobile phones. Despite the type of interface, the main goal of usability testing is to improve the quality of an interface by finding flaws in it and by discovering what is working well [78]. Usability testing can be performed at different phases of the design process, serving different goals in respect of the emerging technology.

Formative testing

What is: Usability testing that happens early in the design process is also known as *formative testing* and may include low-fidelity prototypes of the emerging technology made of paper or other materials. This type is often more informal, with more open communication between the researcher and testers. The goal with such testing is to verify the design concept at early stages of its development. In addition, participants may feel more comfortable giving feedback or criticizing the interface when they see that not much work has been done on it yet [78].

Our use: We have conducted the formative testing on both the low-fidelity paper prototype of the app and the high-fidelity prototype implemented in HTML5 and JavaScript. The results from these sessions were analyzed and transformed into design features that were later implemented in the app.

Summative testing

What is: Usability testing that takes place at a later stage of the development process, when a more finished prototype is ready, is known as *summative testing*. The goal of this method is to evaluate the effectiveness of specific design choices.

Our use: During the summative evaluation of the final version of the app we measured two main usability factors: accessibility, whether children are able to use the iPad and the app, and appearance, whether children understood the overall concept of the app and single elements of the game such as action icons depicting different behaviors. In addition to measuring usability, we were also looking at the enjoyment level caused by the app and behavior learning effect that the app has on children.

4.4 Methods for data analysis

4.4.1 Grounded theory

What is: Grounded theory is different from other more traditional experimental research methods in the way a theory is generated. It starts from a set of qualitative data, which create a ground for an emerging outcome. Multiple rounds of data collection and data analysis may be conducted during the process of theory development, allowing the underlying theory to emerge from the data. This method generally consists of four stages: open coding, development of the concepts, grouping concepts into categories, forming a theory [72].

Our use: I choose to use grounded theory inspired approach for two reasons: firstly, it provides a systematic way of analyzing unstructured qualitative data, and secondly, this method answers to the phenomenological thinking by providing a framework for generating analysis results out of the data collected from children.

4.5 Summary

In this chapter, I presented the methods used for data collection, technology design, prototype evaluation and data analysis. For data gathering, we used passive and participant observations, interviews and video recording. Among the design methods, we used brainstorming, scenario playing, and prototyping. For evaluation purposes, we implemented usability testing at different phases of the design process. Finally, the grounded theory served as a basis for the qualitative data analysis in this research.

5 The iPad Assessment

In this chapter, I will answer the first research question of this thesis regarding the iPad assessment at the special education class. First, I will introduce the context of the design and its change over time. Further, I will address the three sub-questions covering the first research question mentioned in the Introduction chapter:

- What are the children's abilities in regards of using the iPad as a tool?
- What are the children's abilities in regards of academic skills?
- What are the children's individual skills when using iPad apps based on gamification concepts?

Finally, the assessment results will be presented.

5.1 Context of the design

The research started with a special education class which included six boys aged 8-12, the main teacher, and two assistant teachers. One of the assistants was dedicated to one particular boy with extra needs. The school just purchased iPads and started using them during class hours from the spring semester of 2012. The leadership of the school was also interested in adapting use of iPad in their special education class. All boys in the class had different issues and followed individually tailored learning plans. Even though the class got the iPads, the apps installed on them were the same as for the rest of the school. It became clear very quickly that the special education class could not use most of the installed apps. Already at the first visit to the class, we understood that communication with children could be a great challenge for us as designers due the children's vulnerabilities and our incompetency when it comes to working with this target group. My supervisor did not have any experience with this target group at all, and my two years of occupational therapy were not enough, thus making us vulnerable in this situation as well.

Together with the completion of data gathering, the semester was over and summer vacation started. During the summer, we worked on the concept development together with other interaction designers and the main teacher from the class. After the summer vacation, the special class was closed down and children were distributed in six different schools. A possibility to do the formative evaluation with children from an occupational therapy center arose just when we felt that the project was in danger. In [54] we reported that the main teacher and the children from the special education class were positive to participating in the final evaluation of the prototype. However, the reality turned out to be too complex when the prototype was ready: all the children from the original class were placed in different schools, with new teachers and new classmates. Fortunately, the occupational therapist stepped in here as well and helped us to find the children with the similar issues and of the similar age as the

boys in the original class to perform the final evaluation. In addition, it was possible to conduct several summative evaluation sessions at a boarding school for children with speech disabilities (not involving the children from the original class). The occupational therapist we worked with was familiar with that school and she helped to match the children by age and disability again.

5.2 Assessment of the iPad as a tool

In order to answer the first sub-question "What are the children's abilities in regards of using the iPad as a tool?" we performed a participant observation of the children in their classroom while playing with them with iPads. The informed consent forms were collected from the parents prior to this visit to the class since this was the first time we met the children. We cautiously explained that children's participation is voluntary, and they can withdraw from the study at any moment without any explanations. We also explained the goals of the study and activities children would participate in and asked for permission to video record the sessions. All parents let their children participate and gave us permission to record the sessions. Children also seemed to be eager to participate in this activity.

During our first meeting with children at the school, we aimed at establishing the initial contact with them through creating an engaging and friendly atmosphere through fun, simple games such as Crazy Face and Puppet Pals, which have worked well for us in the past. In this manner, we talked and played with the kids, observed how they interact with iPads, and talked to the teachers. All boys seemed to enjoy the presence of new people in the class as well as they were clearly excited about the new technology and were willing and eager to try new things. The technology was new to almost all children, only one boy in the class had an iPad at home. In addition, we observed how children play with iPads, looking for the preferred interaction patterns and activities. We were also interested in examining whether they have any issues in handling the iPad.

The results from the observation clearly illustrated that all children were able to perform such basic actions as unlock the iPad, open an app, close an app, and switch between several apps without any sufficient challenges. This result was satisfactory for the purposes of this study.

5.3 Assessment of academic skills

After the first visit, I conducted an hour-long interview with the main class teacher in order to address the second sub-question and find out more about children's abilities in regards of academic skills. We were talking about specific issues and problems for each child, as well as the class as a whole. The teacher was very positive to participating and she was excited about the potential benefits the iPad could provide in engaging all boys in some school related activity. One of the things we learned from this interview was that despite the fact that boys go in the same class, there is no or little team feeling among the boys. In addition to that, we

clarified the cognitive, social and physical development levels of students to the extent needed in order to plan further activities. The teacher shared with us the individual learning plans for all boys for the current month, so we could match the app selection to the level of skills for each child.

From the initial contacts with children and the main teacher, we got a better insight into the class and gathered a better understanding of the heterogeneity of the group. All boys were different. Some issues were similar in nature for all children, e.g. concentration issues, but different in severity. Other issues were very different in nature, e.g. speech difficulties vs. vision impairments. It became clear very quickly that the special education class could not use most of the apps installed on the iPads. There were no apps specially tailored for the needs of this class. There were no apps that all of them could use at the same time, in the same way as a typical class would do. The selection of the apps from the Apple App Store was further limited by the fact that most of the apps out there are in English, and none of the children was native English speakers. In fact, they were all children of immigrants, having as mother tongue a language different from the instruction language at school. In combination with other issues the children had, this limitation was significant. After realizing all this, we decided to create an app together with these students and their teachers. Both the main teacher and the assistants were positive to the idea of contributing to an app specially tailored for the class needs.

5.4 Assessment of individual skills through gamification

The main teacher stated her need in regards of app design as something that all children could use in the class together and that supports learning. Then she added that the learning objective was not important as long as it suits all the children; it could be spelling, music, math or drawing. Her desire was to address the creation of the sense of "being a class". Hence, the next step for us as designers was to explore the possibility of designing a single educational app that all the children in the class could use and discuss together.

Relying on the observations from the first meeting and the information we got from the main teacher, we decided to conduct individual skill assessment sessions with each child drawing on the concept of gamification. This activity was conducted in order to answer our third, and last, sub-question "What are the children's individual skills when using iPad apps based on gamification concepts?"

Based on the individual learning plans received from the teacher we selected a set of apps from the App Store for each child. The aim here was to see them play learning games and observe what they can do, keeping the larger goal of a common app in mind. Each session lasted about 20-30 minutes, depending on child's physical and emotional condition. Three to five apps were tested with each child, see Figure 12. The way children interacted with iPad

and the games, their engagement, amount of time spent on each game and ability to complete at least one round were the parameters we observed.

Figure 12 - The children trying existing apps for spelling, memory and entertainment. Photo: A. Culén.

The analysis of the workshop resulted in two categories of outcomes: 1) individual skills concerning children's behavior and 2) their academic skills. The findings in the first category showed that four boys had poor self-confidence and social awkwardness, five had problems with drawing and imagination, all had minor cognitive difficulties, three students had speech issues and poor vocabulary, one had severe visual impairments and two of boys had major impulse control issues, three had large concentration issues while all had concentration issues to a certain degree. At last, two had poor fine-motor skills and had difficulties touching small objects on the screen. All these issues posed certain challenges for us as designers, both in terms of our participatory approach, and in terms of ethics. The later considered such questions as: are our methods and our techniques sensitive enough and are we eligible to distinguish the issues children have from, for example, lack of desire to participate and issues caused by the disability they have. All boys seemed to be happy to participate and work with iPad, trying new things on the tablet. However, when, for instance, one of the boys left the iPad in the middle of game and run out of the room, we were confused and did not know how to interpret this behavior. Was he bored and did not enjoy the participation or was this behavior caused by the lack of impulse control? Another example is when a student switched fast between apps without really playing them. He just demonstrated them to us as a very quick slideshow. This behavior could be caused by excitement about the apps and the technology or an expression of concentration issues. During interpretation of such behavior, we relied on the teacher. She also helped us several times when communicating with children with speech issues.

The findings in the second category, academic skills, showed a large diversity among the children. Some of them had problems with counting and spelling letters, while other could

read almost fluently. After realizing this and discussing with the main teacher, we felt that a better direction would be to focus on value design [79]. Value design implies cultivating and bringing values to the fore of the design. Methods and techniques are seen as means to achieving the engagement with values during the design process, and not the other way around [79]. In our case, the value design implied a more therapeutic approach, corresponding to a condition that is common for all children in the class such as concentration difficulties or social isolation.

In order to get a better insight into the issues around concentration problems, we performed a literature search on concentration disorders and technology used to improve concentration. The work we chose to look closer at was the work of Kingberg [80] on exercising working memory using gamification as an aid treatment of ADHD. ADHD or Attention-deficit/hyperactivity disorder affects 3-5% of school age children with serious impairment in both academic performance and social functioning [80]. This study examined whether systematic training of working memory tasks during 5-week period would improve working memory, improve other executive functions and reduce ADHD symptoms. The treatment consisted of performing working memory tasks implemented in a computer program developed for this study (RoboMemo). The results revealed that working memory could be improved by training in children with ADHD. The training resulted also in reduction of ADHD symptoms as claimed by the parents of the participants. Further, we considered using commercially available tools such as Lumosity (http://www.lumosity.com/) for improving the brain performance. Both tools proved to be inadequate for our target group in the given context. After brainstorming with the teacher, we finally decided to design an app that would aim to improve concentration, without working memory training, and focus on the behavior in a common everyday situation such as shopping for food.

5.5 Proving the concept with children

In order to prove our concept we conducted a scenario playing session including both children and the main teacher. We brought some physical objects for sale, coins with different denominations and coffee beans, as well as we prepared some iPad apps for shopping. We simulated as we were in a store and children got to choose what to buy. Afterwards they were asked to pay for the thing he chose. We tried both coins and coffee beans since not all kids understood the concept of money. For instance, few children did not understand that one five-krone coin is the same as five one-krone coins. These kids were able to use coffee beans to pay the right amount of "money". They also tried the existing iPad apps for shopping. This method was used individually with each child. The results confirmed that all children could be engaged in the process of playing. We also tried discussing with children their preferences for the future app. Children showed a lot of interest in proposing design ideas such as what kind of shop they would like to go to, and what they would like to buy. They also expressed that real pictures or good iconic representations of objects were preferable. Despite that some of the children could not do the math, they liked the idea of being able to pay for

merchandise. We also observed that they preferred to play alone, but the option to compare result points gained during the game was acceptable.

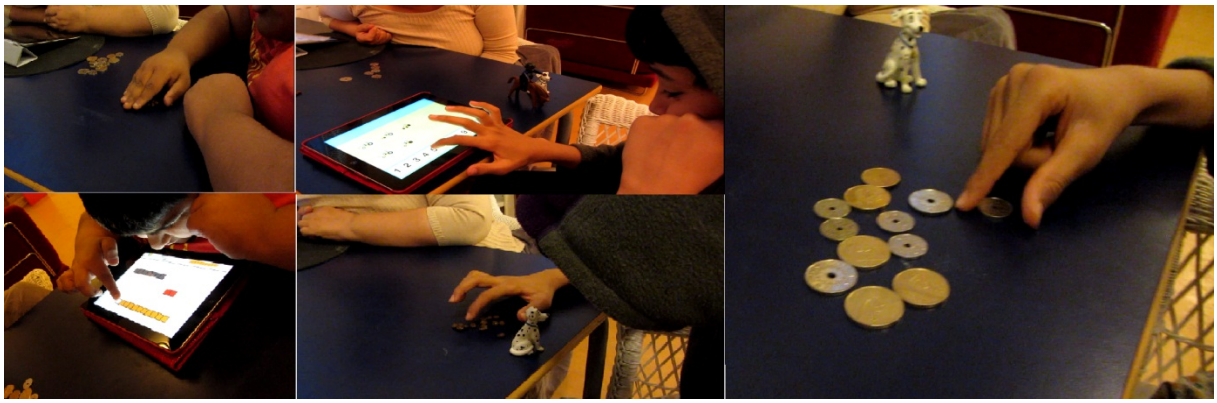

Figure 13 - Children playing shopping scenarios on physical objects and iPad. Photo: A.Karpova

Finally, we had a concept of an app that we thought would be appropriate for all the involved children. All these pre-design activities took much longer time than anticipated and stretched over the whole semester from January until the beginning of summer vacation. At the start of the project, the school informed us about the possibility of closing down the special education class and distributing children to other schools. At the end of semester, this possibility became a reality and the class was shut down. The children started at six different schools the next year. Even though they were distributed, both the main teacher and the children were interested in participating in the further design process. I continued keeping contact with the main teacher through the whole design process. However, the situation around participation and timing became more complicated and we had to explore other possibilities of involving children into the design process. In addition, we had too little experience in special education or working with children with special needs. The main teacher supported the study a lot in interpreting the children's behavior and sharing with her experience with the children. Despite that, additional skills and knowledge were needed in order to handle the problem. Thus, we requested help from an occupational therapist. First, she acted as a consultant, and later we asked her to perform formative and summative tests on our prototypes with some of her younger patients.

5.6 Summary

In this chapter, I answered the first research question of this study regarding assessment of the iPad as an educational tool. First, I described the context of the design and its development over time. In order to address the first sub-question of the research question we conducted a participant observation of the children playing with iPads. This activity helped us to get to know the target group better as well as it illustrated the complexity of the group. The observation confirmed that all children were capable of using the iPad, but no apps that all children could use together were found. Then followed a one-hour interview with the main teacher where we got a deeper understanding of the class as completely, children's individual

challenges and levels of academic skills. The results from the interview indicated that levels of skills among the children are very diverse, and the class is struggling with finding activities that all children can be involved. Based on the data gathered from these initial contacts we decided to assess individual academic skills of each child drawing on the concept of gamification, with a larger goal of creating one common app in mind. The analysis of these assessments confirmed that the group we got to work with was highly heterogeneous in terms of skills and needs. Thus, after discussion with the main teacher, we decided to focus on some basic challenges common to all boys such as concentration and social isolation. A workshop with children was conducted as a proof of concept of this idea. The analysis of the workshop results indicated that all children were able to participate in the activity, as well as they provided us some hints on the future design of the app.

6 Design and Prototyping

In this chapter, I will present the design process of the behavior-learning app, I will describe the final version of the prototype and evaluation of it conducted involving children from the occupational center and the boarding school for children with speech disabilities. Taking from the video game taxonomy developed by Gordon [81], we considered interests, age and gender of our target group. Gordon says that nowadays, as there is a large pool of different types of games, people choose categories of video games based on their interests. In addition, different age groups have different interests that have to be considered in order to be engaging for the target population. Gordon distinguishes between preadolescents, adolescents and adults, showing how interests are changing over the years. Our target group falls under preadolescents group, whose one of the main targets is to find freedom from the control of their parents and teachers. We also explored application of padia and ludus principles. Where padia is the principle of diversion, free improvisation and playful actions, and ludus is representing restricted by rules, gameful actions [82]. This distinction is important for me as designer as finding a balance between creating an environment ruled by strict principles and (ludus) and a spontaneous, free-play environment is necessary in order to keep the game engaging but still challenging and effective in learning [83]. Further, knowing that imagination was an issue for some of the children, I focused more on gamification and gameful interactions, thus providing more structure during the game. In addition, having a set of predefined goals and possibility of measuring the results was seen as helpful for evaluation, both formative and summative.

6.1 Design brainstorming with the main teacher

During the summer vacation 2012, I conducted a design brainstorming session with the main teacher from the special education class. The main goal for this session was to find out what works individually for each child and what works on the meta-level for all children. Together with the main teacher, we discussed the findings from the initial meetings, individual skill assessment workshops and the proof of concept workshop. We used sketching to document our ideas regarding what kind of app could fit all the children (see Figure 14). Some of the suggestions from the teacher were to use clear colors, good representational icons, use as little text as possible and introduce the possibility to adjust the difficulty level. In addition, she mentioned that tasks included in the game should be simple and various in order to keep children engaged. The games that would fit the target group, according to the teacher, could be task-based games such as labyrinths, puzzles and get a ball into a hole.

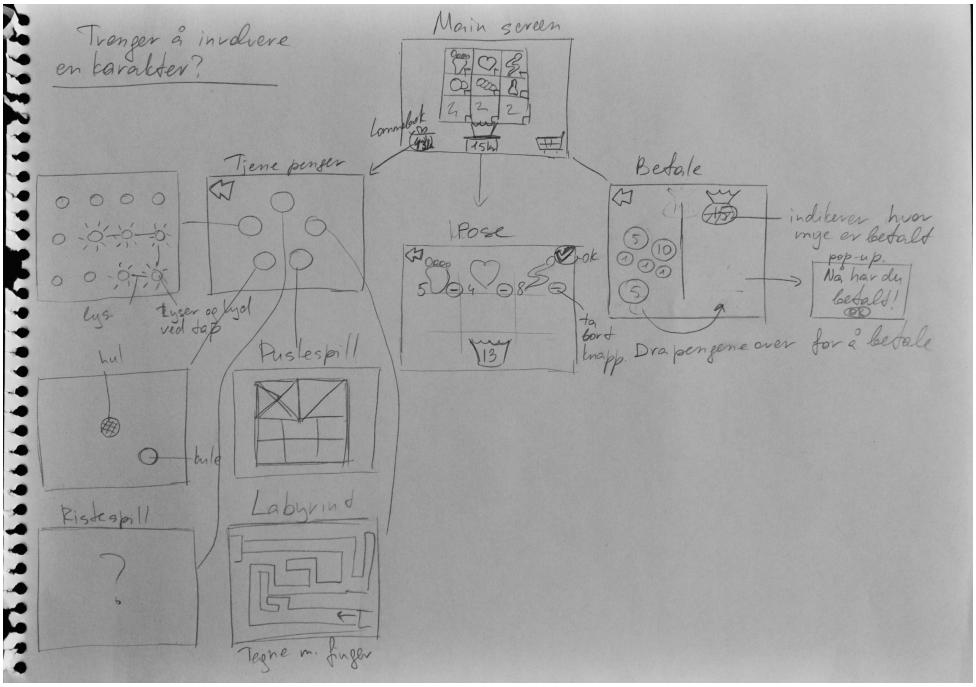

Figure 14 - Sketching game ideas with the main teacher. Photo: A.Karpova

6.2 Design brainstorming with interaction designers

The review of technologies developed during the projects mentioned in the Literature Review section and my own searches on App Store showed that apps for children are primarily aiming few goals: entertainment, learning, therapy and apps for quality of life (e.g. calendar, shopping helper). Further, the presence of gamification adds more dimensions to this division.

A brainstorming session with three interaction designers (including me) from my institute was conducted where the problems observed in the class among the children were matched against the game types we extracted from the literature review and the App Store searches. We distinguished between pure entertainment apps such as piano playing games or “Cut the Rope” (http://www.cuttherope.ie/), learning games aimed at improving academic skills, therapeutic games such as RoboMemo [80] and Lumosity (http://www.lumosity.com/), and apps for improving quality of life. Further, we discussed what types of games were possible to implement for our target group in the given context, and eliminated those that either were inappropriate for us as researchers or for the children due the issues they have, see Figure 15.

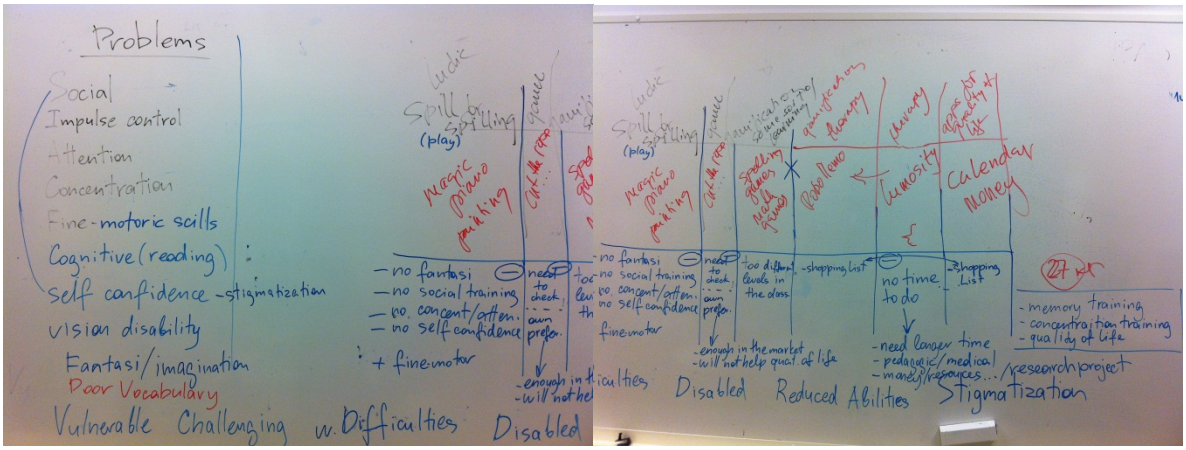

Figure 15 – Captured discussions regarding the game concept. Photo: A.Karpova

Next, based on this discussion several gamification scenarios were made and evaluated. The scenarios suggested were shopping, as suggested by the main teacher, a GPS map to help children orient in the outdoor settings, a musical app focusing on rhythms and a clothing and backpack packing app. These scenarios addressed concentration issues, impulse control, or both. Further, three personas representing the six children were made, none of them representing a particular child as proposed by Moser [84]. This was done with respect to the children's anonymity when we invited others to participate in the workshop. Further follows the description of the personas we made:

1. Persona 1 – a 12 years old boy from Pakistan with reduced vision ability, socially isolated and with low confidence. He can read but has issues with imagination.
2. Persona 2 – an 8 years old boy from Somalia with impulse control issues, attention and concentration issues, and speech disability. In addition he cannot read.
3. Persona 3 – a 10 years old boy from Afghanistan with ADHD, low self-confidence and socially isolated.

We role-played the suggested scenarios using these personas; each of the participants took one persona. This role-playing assisted us in gaining a deeper understanding of the proposed scenarios and helped us to determine what could work best with our target group.

We discovered that creating an app that would require taking the device outdoors might be challenging for children as they can lose it or get it stolen. Thus, the GPS map concept was eliminated. Designing a good musical app would require more knowledge in music. None of us had that knowledge and inviting more people was not possible at that moment. The musical app concept had to be abandoned as well. When weighting the shopping concept against the clothing concept, we considered the suggestions from the main teacher from the special education class, and decided to go with the shopping concept, since we already had proved that this concept could work with children with different levels of skills and needs.

Based on the inputs from the main teacher and decisions made during the workshop with interaction designers a "board game"-like app helping teachers and parents to teach children the appropriate behavior in a store was created. The game included rules around appropriate

and inappropriate behaviors in a store, for instance, picking a carriage or a desired item versus screaming and destroying items. The player throws a dice in order to move through the board, representing a store or a shopping center, at the end of the board he or she can select an item based on the amount of points collected during the game. Based on what the field, that the child lands on, depicts, the child needs to move backward of forward, or stay, if nothing is depicted on the field. For example, if the field depicts a screaming child or a child running in the store, both unacceptable behaviors in the context, the player has to move some sells backward. In opposition, if the player lands on a field depicting walking next to parents or selecting a food to buy, he can jump some sells forward. Through playing the game, the child is in favor of learning commonly accepted behavior rules at store (see [34], page 20). The first low-fidelity prototype of the game was made on paper and tested with children (see Figure 16) with full parental consent.

Figure 16 - A child testing the shopping game concept. The child could choose the board, readymade activities in the store, the ones that are encouraged and the ones that are discouraged. The child was also encouraged to add new activities. Photo: N. Karpova.

6.3 Formative evaluation of the low-fidelity prototype

The low-fidelity prototype testing was conducted in the occupational therapy center with four children of similar age and with similar problems as the children from the original special education class. I was excited about this opportunity as it opened the possibility of validating the concept with similar user group outside the classroom context. The occupational therapist was in charge of holding the sessions while I was observer via Skype. Each session lasted for about 10-15 minutes and each of them was embedded in children's regular appointments with the therapist. The children tended to forget the Skype entirely, so I believe that by doing so I avoided some bias in favor of the prototype based on the children's desire to please a new person, researcher, by giving only the positive feedback.

The intention with these sessions was to see whether the game was no too easy or too complex, and if it was understandable for children. The relation between desirable and non-desirable behavior and moving the avatar back and forth needed to be clear. In addition, the time each child spent on the game was important: could children concentrate long enough to finish at least one level, go through one board and pay at the finish line.

During the sessions children were asked to pick a board they liked most first (the boards differed in color, shape and the number of fields) and then place the behavior icons on the board. When all available icons were placed, children were asked to draw additional icons they would like to have in the game, see Figure 17 for examples. After the game was completed, children were asked to play it.

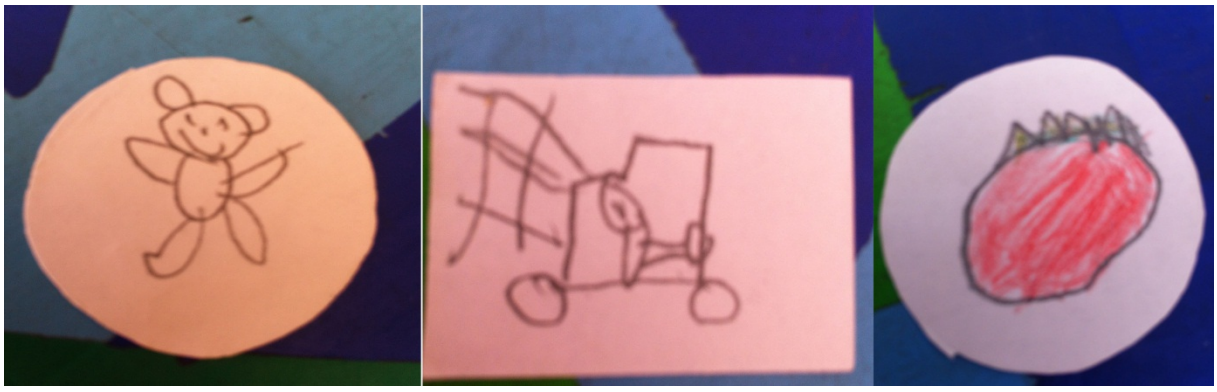

Figure 17 - The children made additional icons. Sometimes they were clearly identifiable, such as the teddy, other times they were harder to identify, such as the tractor or the tomato. Photo: N. Karpova.

All the children enthusiastically participated in the completion of the board: picked the board shape, placed the existing icons and drew new ones. Interest in playing the game varied. One boy did not play at all, preferring to throw the dice alone. He did not show any signs of understanding the rules either. This was the most extreme case. Other children enjoyed playing the game following rules. One boy expressed extra excitement about the game; he asked to play several times during the same therapy session and asked for the game at the next visit to the therapist.

Through this activity, we could see that children preferred the shortest path. Some of them commented on their choice by pointing out that they liked the green color. Several children mentioned that they would rather go shopping toys than food. Overall, the feedback of the children to the game was positive. One child was not able to carry out the game due to cognitive issues. The others understood the rules and successfully completed the game. Similarly, to the importance of getting feedback from children, it was important to get the response from the therapist. She meant that the game could have positive effect on the children when used meaningfully. She also mentioned that she would like to have a large analogue version of the game on the floor in her office. Involving children's bodies to move through the game, could have further positive implications on her therapy sessions, as it would include body motions. The therapist was also pleased to hear some of the children think aloud during the sessions.

Therefore, the first high-fidelity prototype was implemented using HTML5 and JavaScript. Since the implementation was done in web-languages, the prototype could be viewed in any internet browser. See Figure 18 for the example of how the prototype looked at an Android tablet.

Figure 18 - The first high-fidelity prototype implemented on the Android platform. Photo: A. Karpova.

6.4 Formative evaluation of the high-fidelity prototype

The high-fidelity prototype was again evaluated at the occupational therapy center. This time we tested app with two children. One of them was familiar to the game through the low-fidelity prototype testing and the other was new to it. Each evaluation session lasted for about 10-15 minutes and each of them was embedded into the regular therapy sessions. Giving the occupational therapist control over the testing worked well during the low-fidelity prototype testing, so she was conducting this testing as well. I was observing the sessions without engaging into the process. The first participant played the game several times without any issues since he already was familiar with it. The second participant needed some time and explanations from the therapist, but after she successfully completed the game. Both children were engaged in playing the game and asked if they could play it again next time.

The analysis of these testing sessions confirmed that the game needed several levels of difficulties. I saw it clearly when the first boy played the same level several times, increasing difficulty would help keeping him engaged longer. In addition, the performance of the game was not as smooth as expected. The pieces were hard to move and animations lagged. This was caused by the technology used in implementing the game. Several sources (e.g. [85], [86]) show that implementing a high interactive game using HTML5 and JavaScript requires certain techniques in order for the game to work properly. The response time and the overall performance of the game needed to be faster so that the user experience would be on a decent level. Further, the occupational therapist mentioned that having a larger number of action

icons, both positive and negative, would be beneficial, since the current number of action icons was rather small and it was possible to finish a board without actually landing on any of them. In addition, she mentioned that adding sound would improve the attraction of the game and make it more engaging for children. She also commented that the gaming peace had to be controlled by the game, moved automatically or restricted in some way, so that children could not cheat – intentionally or not – jump over more cells that the dice showed.

The overall impression of the game was positive for both the children and the occupational therapist. Both children were talking about the game on next visits to the therapist and expressed interest in playing it again. The therapist commented that the combination of the tablet technology, gamification concepts and more traditional occupational therapy techniques has a large potential both for children's daily lives and for her practice as therapist.

6.5 Finishing the prototype

After the formative evaluation, the whole codebase of the game was rewritten several times in order to improve the performance and response time of the game. I also wanted to include the feedback collected during the formative evaluation sessions. I did not have a lot of experience in web development so I needed to search for best practices and guidelines for implementing highly interactive games and animations in HTML5 and JavaScript on Internet. Pages and forums like [87], [88] and [89] were a good source in finding the relevant materials and troubleshooting the code. See the Attachment 3 - The source code of the app.

The graphical look was also remade in order to match the new implementation technique. Only those icons that could not be created using HTML and CSS were drawn by hand, such as behavior actions and shopping elements in the game (see Figure 19).

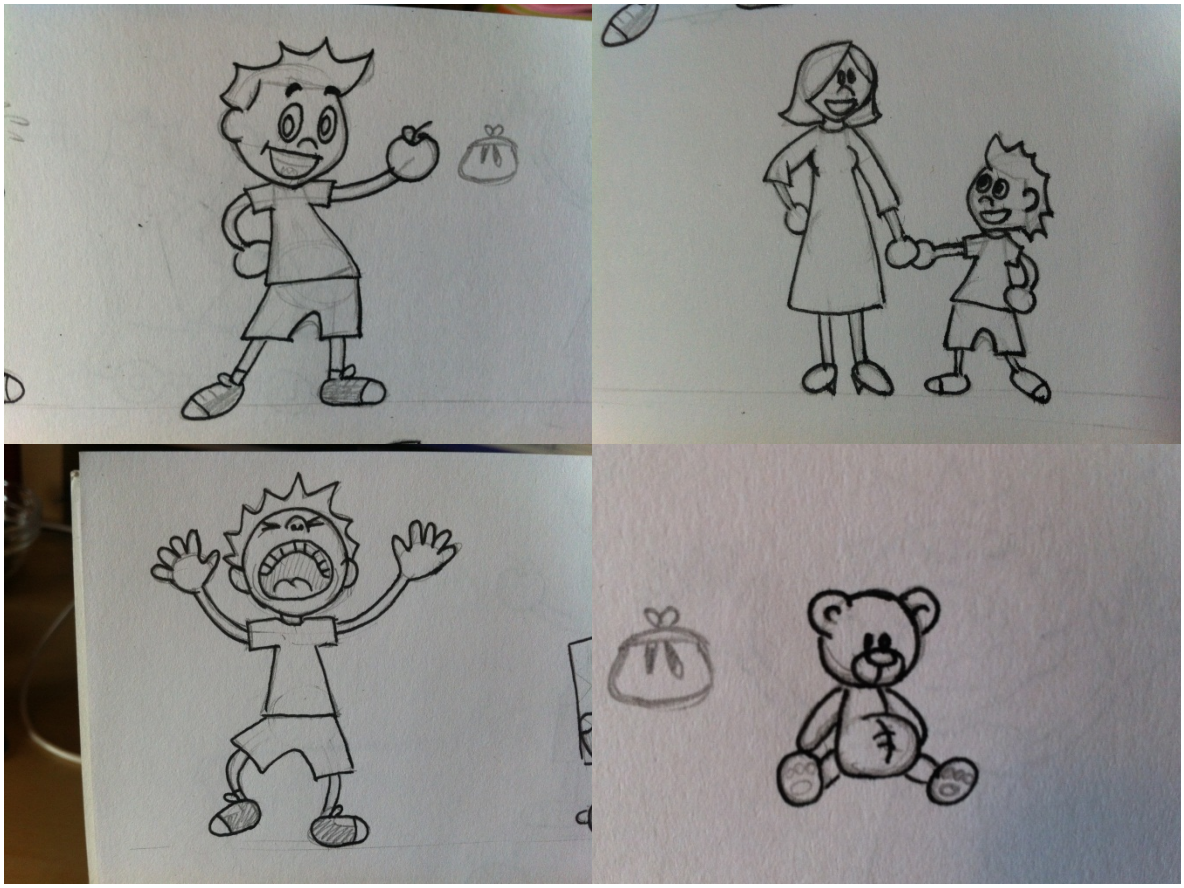

Figure 19 - The new look of the main avatar and elements in the game drawn by hand. Photo: A.Karpova

Finally, I was able to implement the game so the animations performed on a decent level, and the game ran smoothly on iPad. The game currently consists of two levels with increasing difficulty. The first level is a food store; the second level is a toy store, see Figure 20 and Figure 21. After each level, the participant gets three prize options to choose from, an apple, an ice cream and a lollipop for the first level; and a ball, a toy car and a teddy bear for the second level, see Figure 22. All options have different price. The availability of prizes is based on the number of points collected during the level. Some of them are "locked" since the total amount of points is insufficient. After an item is chosen, the avatar is depicted with this item in hand, and the price for the item is subtracted from the total point sum, see Figure 23.

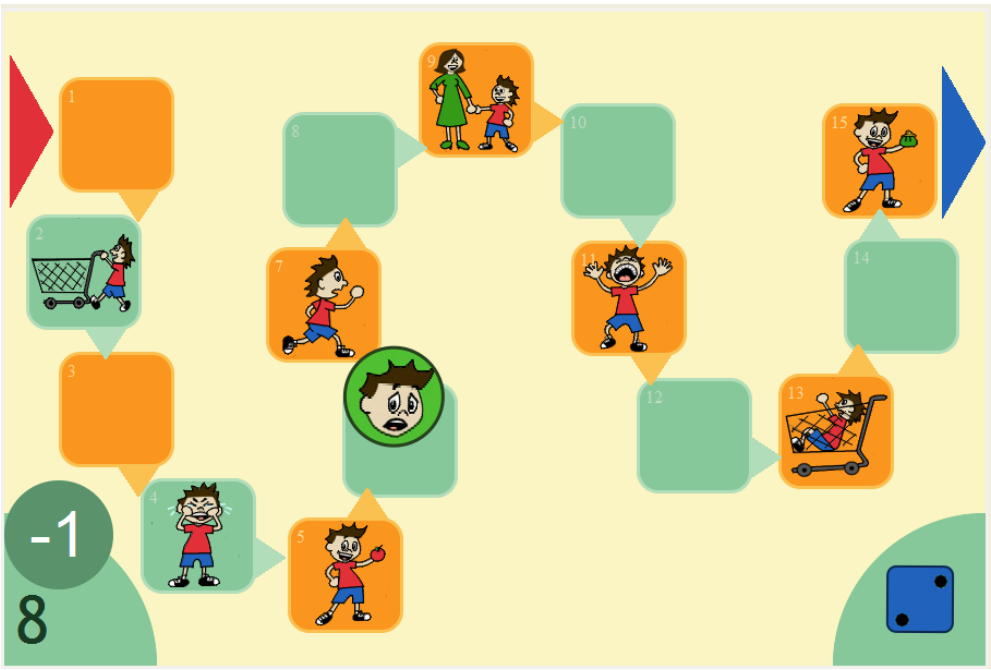

Figure 20 - Level one. The gaming piece is automatically moving back because it landed on a negative action icon – running. The facial expression of the gaming piece is sad while moving backwards. One point is subtracted from the point sum. Photo: A.Karpova

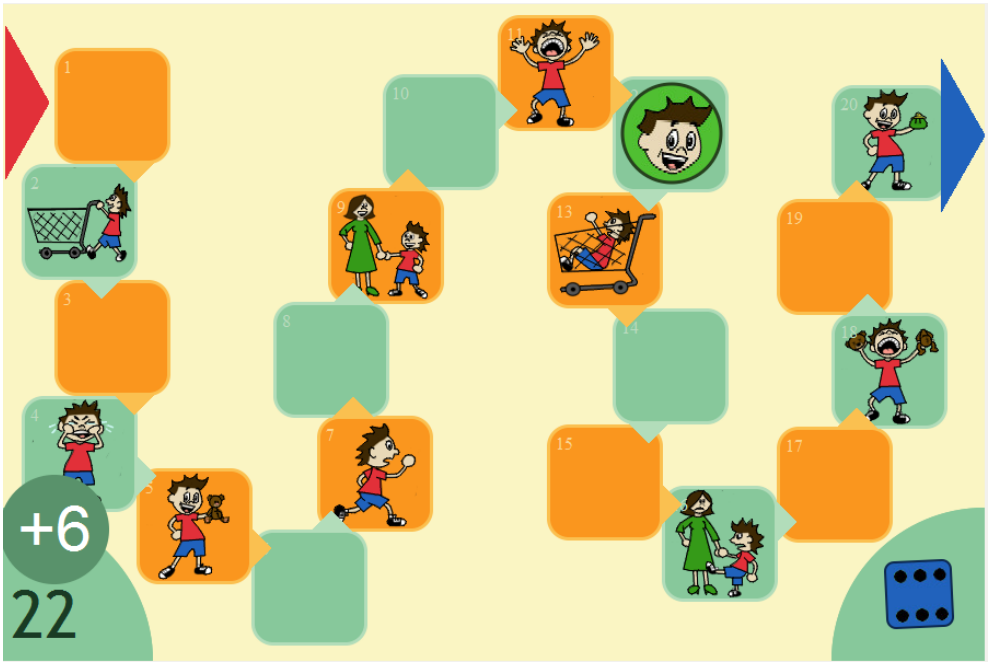

Figure 21 – Level two. There is a longer path on this level with more action icons. Six points are added to the point sum after throwing the dice and moving the gaming piece. Photo: A.Karpova

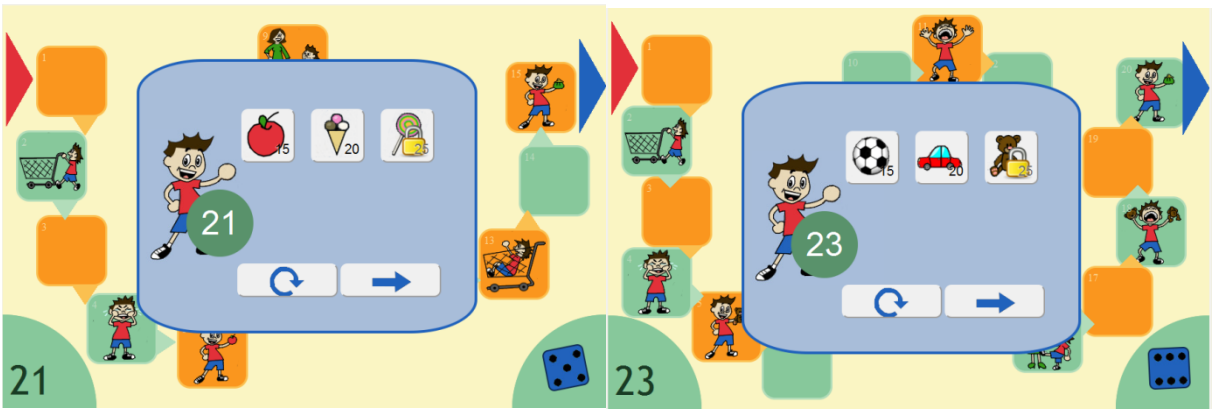

Figure 22 - Participants can choose between three options. An apple, an ice-cream and a lollipop after the first level, on the left; and a ball, a toy car and a teddy bear after the second level, on the right. Some options are "locked" because the sum of points collected during the level is insufficient. Photo: A.Karpova

Figure 23 - After the player selected an item, the avatar is depicted holding the item. The total sum of points is reduced with the price of the item. Photo: A.Karpova

6.6 Summative evaluation

The summative evaluation of the prototype was partially conducted in the occupational center and partially in a boarding school for children with speech disabilities. In total 15 children aged 6-10 participated in the evaluation, where 10 of them were children from the boarding school and five children were from the occupational therapy center, where we previously conducted the formative evaluation. The occupational therapist conducted all the sessions and I was watching some of them via Skype. We had good experience using Skype from the formative evaluation sessions, and we decided to continue with this approach. We were not

able to observe all the sessions, but video records were made for each of them, so we could review them afterwards. Further, I discussed with the occupational therapist her experience from conducting the sessions and collected more information on the children that were involved in the testing. After, when all sessions with the children were finished, we interviewed the occupational therapist from the boarding school regarding her experience with the game, since she was present at all sessions with the children as an observer.

6.6.1 Evaluation criteria

In order to evaluate the final version of the prototype three measures were selected based on the reviewed literature and suggestions from the occupational therapist: usability, enjoyment and behavior learning.

Usability

Usability is traditionally seen in conjunction with work systems, it is described using terminology that relates to task-driven activities in a given context. The term *usability* is defined by ISO 9241-11 [90] as the extent to which a product can be used by specific user group to achieve certain goals with effectiveness, efficiency and satisfaction in a given context of use. Since children, like adults, often use technology in order to perform some tasks, usability is thus considered as a critical design feature. In our study the *accessibility* of the game, whether children are able to access the iPad and control the game, and its *appearance*, whether the action icons and the whole look of the game are understandable for children, were chosen as critical usability factors and measured during the final evaluation. Bot accessibility and appearance were evaluated by observing the testing sessions.

Enjoyment

Enjoyment or fun is lately considered as an important design feature in educational software for children as it contributes to being motivated, and as such, it can contribute to learning effectively [37]. Gordon [81] believes that “people play to learn as well as to have fun, but they stop playing immediately if the toy or game gets boring”. This statement confirms the importance for an app/game to be fun in order to keep younger players engaged. In addition, fun is considered as a necessary foundation for later skill learning [56]. If a user enjoys playing a game, he would be motivated to do it again and explore more features within it. Sim [91] advocates different definitions of fun. He mentions the definition proposed by Carroll [92], who suggests that things are fun when they attract, capture, and hold attention by provoking new or unusual emotions in contexts that usually arose none, or arose different emotions. One limitation with this definition is that it should say that emotions should be pleasurable [91]. For measuring fun, Sim [91] suggests using observational methods along with survey methods based on the Fun Toolkit [67].

In our case, we tried using both observation and the Smileyometer technique from the Fun Toolkit. The Smileyometer turned out to be inadequate with our target group, as children were picking the smiley they liked most instead of evaluating the game. Observations of emotional and physical expressions provided by children during the game created the background for the further analysis.

Behavior learning

Since one of the main goals of the game is to teach children the proper behavior in a store, the level of behavior learning was considered as an important measure. It was recognized that expecting to see changes in children's real world behavior would be too ambitious in such a short time scale of the final testing. Other outcomes, which may lay the foundations for further skill learning, should also be identified, as suggested in [56]. Fun and enjoyment described in the previous section was seen as one of the possible foundations. We first looked for the signs of enjoyment such as smiles, engagement and requests to play again during the game testing sessions. After a period, we asked the closest stakeholders if children remembered the game and were talking about it at home, during visits to shops or in other context. Another example was suggested by the occupational therapist. She believes that correct understanding of the game's rules and expressing adequate reactions during the game play a significant role in forming the foundation for the later behavior learning.

6.6.2 Procedure

An altered version of the test-retest technique described in [56] was used to perform the summative evaluation of behavior learning supported by the game. Usability and enjoyment were measured using passive observation during the testing sessions. The initial test-retest method is showed in the Figure 24 while the adapted method is depicted in the Figure 25.

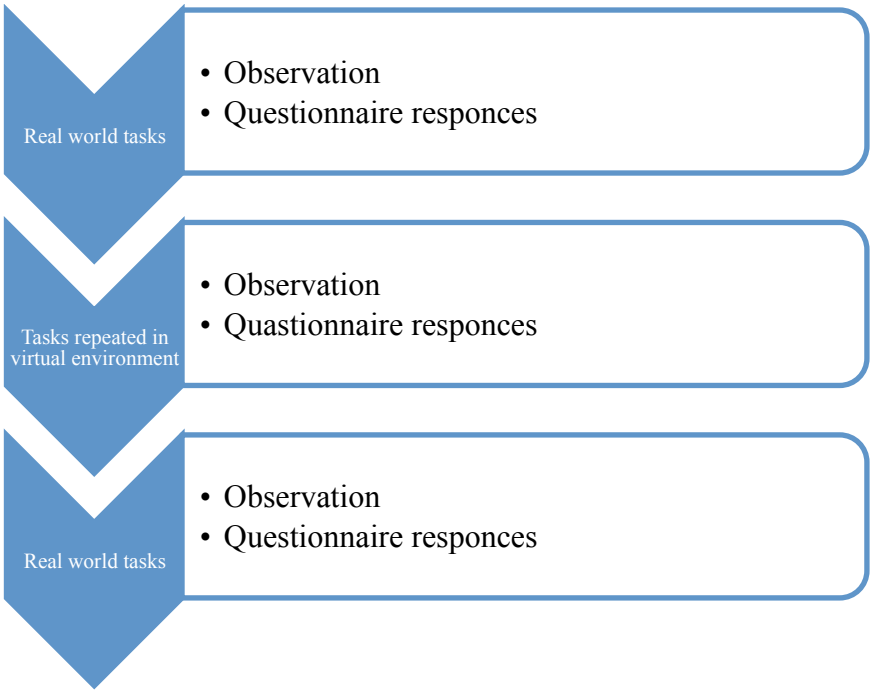

Figure 24 - Initial test-retest technique

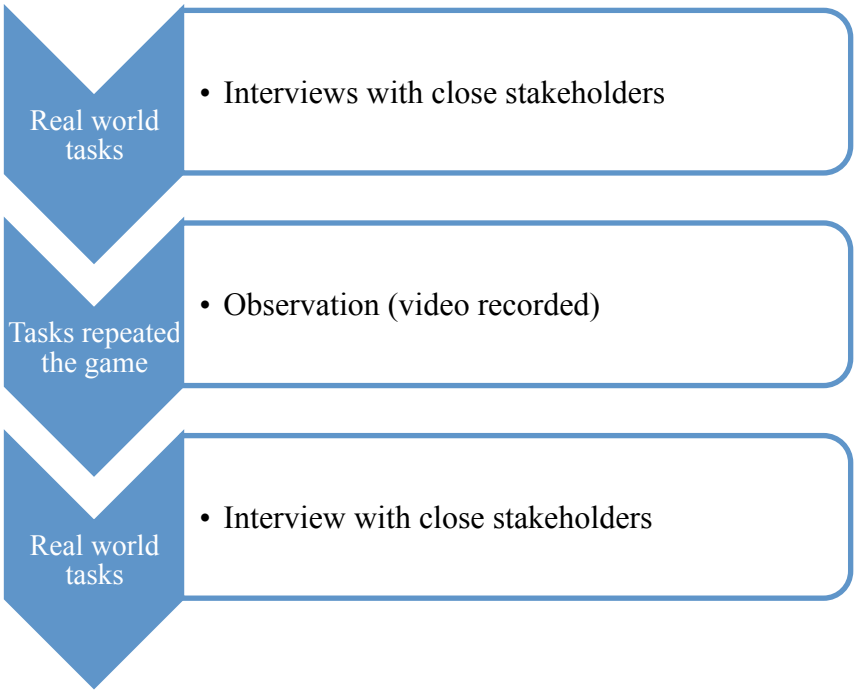

Figure 25 - The modified test-retest technique

In the initial method, the researchers were observing how testers together with their support workers performed a set of tasks in real settings. In our case the logistic issues did not allow us to participate and observe our target group during a shopping tour, so we interviewed close stakeholders of the children regarding their behavior in stores. These interviews aimed to capture the current level of behavior during shopping. At the occupational center, the parents or grandparents who followed children to the session were interviewed. At the boarding school, the caretakers were taking part in the interviews. The analysis of responses revealed

that behavior varied from child to child, from slight whimpering when they wanted to get something to hysterical outbreaks when a child could throw him- or herself on the floor and start screaming. Elder children showed a better understanding of socially accepted norms of behavior, while younger children had difficulties with that and could behave strongly inadequate. In general, it was reported that all children could start misbehaving in different degrees depending on the context.

In the next step of the original technique, the testers were asked to perform the same tasks in a virtual environment while researchers were observing and video recording the sessions. We did not change anything in this phase. Children played the game several times and all the sessions were recorded on video. Evaluation sessions were conducted by the occupational therapist individually with children, and lasted for 10-15 minutes. These sessions were embedded into the regular therapy sessions both at the occupational center and at the boarding school. At the boarding school, the evaluation was performed at a stationary computer because no iPads were available at that moment. The measurement of usability was limited by this fact: we could not test accessibility of the game, only its appearance. The situation was better at the occupational therapy center where four of five children played the game on an iPad, see Figure 26.

Figure 26 - Children playing the final prototype version on an iPad. Photo: N.Karpova

The therapist discussed the game with children before playing it. They went through each action icon in order to see whether children understood the icons and, not least, if they were agree on what is appropriate behavior and what is not. All children understood the single actions and agreed on the behavior descriptions. Some of them had difficulties in generalizing the context of shopping out of the graphical representations. After the introduction, children were asked to play the game. The first time the occupational therapist had to help all children to get through the level: she explained the rules, helped with the devices, and helped to move the gaming piece in correct direction. After each finished level, children were asked if they want to continue. Most of them played up to three times or more, after that the therapist had to stop the session because of the time limits. Finally, children were asked if they wanted to play the game again at the next visit.

When the sessions were over, children were asked to evaluate the game using Smileyometer, which is a “fun” measuring technique successfully, implemented and reported in [60]. It is a part of the Fun Toolbox, which contains metrics for empirical evaluation of fun. The

Smileyometer is based on a 1-5 Likert scale, and it uses pictorial representations of emotions. It ranges from “awful” to “brilliant”, see Figure 27.

Figure 27 - The Smileyometer scale

This method seemed to answer our requirements: it did not require any expertise from the children’s side; the occupational therapist and a special pedagogue were there to support the children during evaluation; and at least and not last, it was highly portable. Nevertheless, it became clear very quickly, that this technique worked inadequate in our context. The children picked the smileys they liked instead of giving a mark to the game. We observed that very clearly when a boy who played twice and said that he did not like the game very much, picked the “brilliant” smiley. The correlation between the smiley and the own experience of the child turned out to be too difficult. This technique had to be abandoned since it would not give us valid results.

The last phase, retest in the real settings, had to be changed again due the logistic issues. After one-two weeks, we interviewed the close stakeholders (parents and social workers) again on the topic of about the children’s response to the game. During these weeks, both the occupational therapist that was involved into the design process and the occupational therapist from the boarding school were using the game during the therapy sessions as they wished. We were interested to know whether the children remembered the game at home, in class, during shopping or in other contexts. We were also interested in knowing whether the behavior was changed. More details on each child are available in the Table 4 and the analysis of the results is presented in the upcoming Analysis and Discussion chapter. Further, we interviewed the therapist at the boarding school regarding her experience with the game.

Name (fictional)/ Disability (-ies)	**Time spent in therapy**	**Usability**	**Enjoyment**	**Behaviour learning**	**Comments**
Mary 8 years old, developmental cognitive disability, dysarthria, Testing 17.09.13	1 year at the boarding school	Recognized the setting without any help. Difficulties with controlling the mouse, sharp and cutting	Played 3 times and wanted to play more. Actively participated during the game and expressed emotions.	- Limited knowledge about the outside world and behavior rules - Clearly understood the goal of the game.	Testing was conducted on a computer. When landing on the «Kicking mother» cell: «Oh, I don’t want to! You cannot kick

		moves.	Switched to the next level herself.	Showed adequate emotions when landing on both negative and positive cells.	your mom!" She has even jumped over this cell once even though she had to land on it. This girl has a limited level of knowledge about the real world because she has lived in the boarding school since she was 3 years old, after her parents were terminated their parental rights. She is from a social risk family.
Rob 10 years old, speech delay, (Alalia) Testing 17.09.13	3 years at the boarding school	Recognized the setting without any help. No difficulties with controlling the mouse.	Played 3 times and wanted to come next day to win the teddy bear.	- He is familiar with behavior rules - Clearly understood the goal of the game. Showed adequate emotions when landing on both negative and positive cells. However, expression of emotions was poor. - Remembered the game after a week and asked to play it again	Testing was conducted on a computer. He told that he is too old to buy a teddy bear first but at the end, he wanted to win it as well. Focused a lot on his new shirt. Very result oriented. He knows the behavior rules nut has no chance to realize them because of the family situation (social risk family).

Harry 8 years old, speech delay (Alalia), ADHD, Spasticity of the upper limbs, poor movement coordination Testing 17.09.13	2 years at the boarding school	Recognized the setting without any help. Got the rules quickly. It was difficult to hold the button and move the mouse at the same time. The therapist helped to handle the mouse during the first round.	Played 3 times and wanted to continue. Actively participated and expressed emotions during the game.	- He is familiar with shopping routines, but can misbehave sometimes - Understood the goal of the game. He understood what was wrong and what was appropriate behavior during discussion with the therapist but during the game, both negative and positive behavior cells caused laughter. He clenched his fists when landed on the negative cells. Jumped over the negative cells several times when he actually was supposed to land on them. - Asked to play the game at the next visit to the therapist	Testing was conducted on a computer. The boy speaks very little, mainly repeating what the therapist is saying. Very unclear speech. The boy is from a socially safe family, often visiting stores but his mother has an authoritarian upbringing style.
Martin 8 years old dysarthria Testing 17.09.13	1 month at the boarding school	Recognized the setting without any help. Understood what was wrong and	Played 3 times and wanted to continue. When asked if he want to play next time	- Can sometimes misbehave during shopping - Understood the goal of the	Testing was conducted on a computer. Very poor speech ability, he answered with some

		what appropriate behavior was. Difficulties when working with the mouse because of shaking hand.	shouted "Yes!" and threw up his hands in the air. He actively participated during the game and expressed emotions.	game. He showed adequate emotions during the game. Even his hand started shaking more when he realized that he is going to land on a negative cell. - Asked to play the game at the next visit to the therapist	simple words and syllables ("Ma", "No"). He liked to press the dice and did it many times in a row without moving the avatar. Because of the shaking in the hand, he moved the avatar outside the path. He was very happy when he could buy something in the end. Shouted and threw hands in the air.
Chris 9 years old, developmental cognitive disability, speech delay (Alalia), ADHD Testing 17.09.13	2 years at the boarding school	Recognized the setting without any help and had no problems working with the mouse.	Played the game twice and then said that this is enough for today. However, he said that he 'd come tomorrow and win more toys. Selected "brilliant" at the Smileyometer.	- Attention is drawn away easily at store. Can misbehave sometimes. - Understood the goal of the game. He poorly showed emotions during the game but expressed them with the voice ("Ah", "Oh")	Testing was conducted on a computer. This boy was very calm. He did not show a lot of excitement about the game. He said that it was childish. His conscious attention was at a very low level due ADHD.
Mark 10 years old speech delay (Alalia) Testing 17.09.13	3 years at the boarding school	He had difficulties with understanding the concept of paying. He did not	He played 3 times and wanted to continue. He actively participated and showed	- He knew the basic behavior rules. - He reacted adequately on both negative and positive	Testing was conducted on a computer. This boy could not match the price and amount of

		understand the question when the therapist asked him how he would pay at the end: with card or coins. Other actions were understood without any troubles.	emotions during the game.	cells. When coming close to a negative cell he did not want to throw the dice in order not to land on that cell.	money he had. "Why can't you buy this? Because there is a lock" Not because he has not enough money. His parents are currently in divorce process and he is very uneasy about that.
Lisa 10 years old Hydrocephalus and developmental cognitive disability Testing 20.09.13	3 years at the boarding school	Recognized the setting without any help and had no problems working with the mouse.	She played 3 times and wanted to continue. "Will you come again? Yes, I need to teach the boy to behave" She picked "Good" at the smileyometer. She liked to throw the dice and count the number of steps.	- She is often visiting stores, but never gets a chance to buy something by herself. - She reacted adequately but showed very poor emotions.	Testing was conducted on a computer. This girl was slow. She was good at counting and she liked to follow the path.
Denis 8 years old speech delay (Alalia), autism, echolalia Testing 20.09.13	1 year at the boarding school	He understood single actions (what was good and wrong) but he could not generalize the concept. He needed help in understanding that the game was about a store. No issues with mouse.	He played 3 times and always waited for new instructions during the game. He did not do any actions on his own.	- Can sometimes misbehave at store - He understood the goal of the game and showed adequate reactions on both negative and positive actions. He promised to behave well.	Testing was conducted on a computer. The therapist at school commented that he is not taking any decisions in real life either, waiting for someone to tell him what to do. He likes all new things at school, but his interest is superficial. He

					asks questions but do not listen to answers.
Alex 8 years old speech delay (Alalia) Testing 20.09.13	1 year at the boarding school	He recognized the setting without any help. Did not need help with mouse.	He played 2 times, won the car and the ball and said that he did not need anything else. When he was asked if he wanted to come and play tomorrow, he said yes.	- He knew some basic behavior rules - He understood the goal of the game and showed adequate emotions on both negative and positive actions. He also promised not to misbehave	Testing was conducted on a computer. He is from a socially good family where grandparents are supporting him in all startups. They are strict but adequate.
Mike 8 years old Autism Testing 20.09.13	0 month at the boarding school	N/A	Played one minute and then run away, lied down on the floor and started playing with toys.	N/A	Testing was conducted on a computer. This boy has just started at this school and he slept over for the first time. He does not understand why he is at this school and wants to go home. He refuses everything even food. This is the first time he was left alone without parents, and this situation is highly stressful for him.
Marte 6 years old Dysarthria and	3 months at the occupational	Recognized the setting without any	She liked to throw the dice, match	- This girl could whimper	Testing was conducted on a laptop. She

ADHD Testing 27.09.13	therapy center	help but needed help with the touchpad on the laptop.	the number with steps and to follow the path. She asked for the game several times on the next therapeutic sessions.	during shopping tours when she wanted to get something from her parents - She understood the goal of the game and showed adequate emotions during the game. She did not get sad because of landing on the negative cells; conversely, she enjoyed the process of teaching the boy to behave properly. She even told about the game to her grandmother who picked her after the session. - The grandmother told on one of the next sessions that Marte remembered the game when they were at a store and she saw a boy sitting in a carriage. She told then that this is not a proper behavior.	liked to press the dice and make it turn; she did it several times without moving the avatar.

Thomas 8 years old speech delay (Alalia)	2 years at the occupational therapy center	This boy played the paper version of the game and recognized it very quickly. He did not have any troubles with iPad.	In total, he played around 6 times and asked for more. He asked for the game on the next sessions as well. "Why do you want to play? I want to see how the boy will behave." "Can I get another ice cream?"	- This boy did not have behavioral issues before playing this game. - He understood the goal of the game and showed adequate reactions. - Started noticing inappropriate behavior at other children.	Testing was conducted on an iPad. Sometimes he jumps over some cells, sometimes counts the same cell twice. He used to jump over "bad" cells very often; he refused to land on them.
Victoria 6 years old Cerebral palsy, limited movements in hands, autistic lines, developmental disability 28.09.13	1 month at the occupational therapy center	The girl understood the context after a short explanation. She had difficulties with the touch screen of the iPad (severe motor impairments and cold fingers)	She only played once. The therapist had to interrupt playing because she saw that this girl needed some time to adapt to this technology. However, she enjoyed "pawing over" the screen and making things to move. She even forgot her shyness.	Before playing the game, she misbehaved heavily during shopping tours. She could fall down and start screaming. - She understood the goal of the game and expressed her emotions through the voice (e.g. "Ah!").	Testing was conducted on an iPad. The girl appeared very shy and emotionally closed. The screen reacted very badly on the girl's touching (because of the cold fingers?). The girl "paws over" the screen without following the rules. She speaks very little and mainly repeats after the therapist. It looked like she had difficulties in understanding where to push and what to move.

Amalia 6 years old Speech delay 28.09.13	1 month at the occupational therapy center	She needed some time and leading questions in order to understand the context. She understood the single actions but struggled with putting it all together in one context. She did not understand where to go in the game and needed a close guidance from the therapist in order to finish the game. This girl had no problems with the iPad.	She played 2 times but it is difficult to say if she liked it because she did not show any emotions. She looked indifferent. Even her eyes did not express anything. She did not refuse the game when she was asked to play though.	- She did not argue with her parents during shopping. - It is difficult to say if she understood the goal of the game. She played because she was asked to. She did not show any emotions during the game. - She did not mention the game at the next visits.	Testing was conducted on an iPad. This girl seemed very shy and closed, and resentful. She is coming from a family where the father is very authoritarian and expects her to give the right answer. Probably she was afraid to express emotions and give the wrong answer during the game.
Tirion 6 years old Speech delay, autistic lines 28.09.13	1 year at the occupational therapy center	Did not understand the rules. He was more interested in tapping the dice and count. He did not even look at the action icons. The therapist had to facilitate the completion of each round. He had difficulties with moving the avatar on	He "played" twice without following the rules. Stopped playing in the middle of a game.	N/A	Testing was conducted on an iPad. This boy likes to throw the dice and see the animation. He counts the points he gets without moving the avatar. He does not follow the rules. We cannot say that he actually played the game.

		the iPad.			

Table 4 - Data from the summative evaluation sessions.

6.6.3 Feedback from the external specialist

Finally, an interview with the occupational therapist from the boarding school was conducted in order to gain an evaluation of the game from an expert who was not involved into the design process. She was present at all the sessions with children, observing them without interruption. The therapist liked that the game was easy and understandable, but at the same time teaching basic emotions. She noticed that children react adequately to the main character, getting happy or sad together with him.

She recognized the potential of using this game in therapy sessions in order to learn children behavior skills. Nevertheless, she added that transferring the skills to the real settings would take time since in the real world there are many external factors that interrupt children and can draw their attention away. Many children were associating themselves to the main character in the game, saying something like “this is me going with mom” or “this is me taking the carriage”, but they dissociated themselves once they landed on a negative action icon saying something like “It is not me! I don’t want to do this”. The therapist meant that this equation is positive, as it provokes cooperation and empathy within children.

When she was asked about what other skills, except for behavior skill learning, this game may contribute to, she mentioned conscious attention, concentration, basic math skills, emotions, memory and, what she liked most of all, logic. She observed many children jumping over the negative cells, because they did not want to be punished, even though they were supposed to land on these cells. She was very pleased to see this logical work in some children and meant that this was positive even though the children were breaking rules of the game.

Among the suggestions for further development the therapist mentioned adding more complexity to the game (more levels, more action icons, diverse types of stores), adding animation to the action icons so it will be possible to depict more actions that are complex, enrich the selection of awards at the end of each level and add options targeting girls.

6.7 Summary

In this chapter I described how the design process was conducted using the methods described in the Methods chapter. We considered age, gender and the interests of our target group, following the taxonomy developed by Gordon [81]. We also looked at the concepts of padia and ludus; we also looked at how these can influence the design of the future game. Based on the reviewed theoretical concepts and our own observations from the special education class, a game concept was developed together with the main teacher and other interaction designers from my institute. We role-played several potential scenarios of the game using personas. Based on the experiences from this role-playing, we were able to exclude inappropriate

concepts and end up with one left. Further, this concept was verified through a series of formative evaluation sessions using low-fidelity paper prototyping with children. The feedbacks from both the children and the occupational therapist were collected and analyzed. The input provided by the formative evaluation was taken further into the development of the high-fidelity prototype. When the first high-fidelity prototype was implemented, a couple of formative evaluation sessions were again conducted in the occupational therapy center. Both the children and the occupational therapist were very positive to the game and expressed a high level of engagement. One of the main findings from this evaluation was that the performance of the game was poor and needed improvement in order to provide a better user experience. The whole codebase of the app was rewritten in order to achieve a decent level of performance and the graphical look of the game was remade to match the new implementation approach. Finally, the summative evaluation of the app was conducted. The evaluation criteria were chosen based on the literature review and suggestions from the occupational therapist from the occupational therapy center. The criteria included usability, enjoyment and behavior learning. The evaluation was conducted with 15 children, where 10 of them were from the boarding school for children with speech disabilities, and five were from the occupational center. Finally, the results from the interview with the occupational therapist from the boarding school were presented. Further analysis and discussion on the evaluation results are presented in the next chapter Analysis and Discussion.

7 Analysis and Discussion

In this chapter, the data collected during the design process, including evaluations will be analyzed and the findings will be discussed, in an effort to answer the second research question: “How to design with children with special needs?” Thus, the first section of this chapter discusses our analytic framework for assessment of what one can achieve with the prototype that was designed. The discussion is divided into three parts according to the evaluation criteria defined in the previous chapter: usability, enjoyment and behavior learning. The second section of this chapter discusses methods used in the research and challenges we met while applying them in the context of design with children with special needs, thus answering the first sub-question: “Which methods and techniques, developed for designing with normally developing children work in the setting with children with special needs?” Finally, section three discusses the ethical challenges and considerations and answers the second sub-question: “What are the added ethical considerations in this situation?”

7.1 Analysis of the evaluation results

In order to evaluate the assessment results of what children can achieve using the app developed in this research, I draw on the evaluation metrics applied during the summative evaluation: usability, enjoyment and behavior learning. They will be discusses in turn.

7.1.1 Usability

As I mentioned in the previous chapter, the usability was measured by looking at the accessibility of the game (whether children are able to use the tablet and the game) and its appearance (whether children understand the images and the overall concept of the game). The results revealed that those children who had previous experience with iPad (e.g. had one at home), had no problems in accessing it. Other children, who never used the iPad before, could experience some troubles. For example, one girl with motor impairments had significant difficulties with the iPad. Her movements were sharp, and touch screen of the iPad did not respond to her touches. The occupational therapist commented that the girl had very cold and wet fingers. In addition to the motor impairments, this factor could play a significant role. Another boy had difficulties in moving the gaming piece, but he could successfully press the dice and make it rotate. It looked like the combination of holding the finger on the surface of the tablet was too demanding. Overall, we can conclude with that the accessibility of the game was on a descent level.

The appearance of the app showed to be satisfying as well. Most of the children recognized the shopping context and understood all action icons available in the game. Noteworthy is the fact that all of them were agreed on what was appropriate behavior and what was not. The icon, where the boy was kicking his mother, caused the strongest indignation. Nobody wanted

to land on this icon, and some children even cheated in order not to end up there; they simply jumped over it. Few children struggled with understanding of the overall concept but had not issues in understanding the single actions. The extreme case of refusal of the game happened at the boarding school when an autistic boy played for one minute and then run away. The therapist at the school commented on this case that the boy was very new to the school and therapy; this was the first time he was left without parents, thus, experiencing an enormous stress.

Based on this data, the usability level of the game can be evaluated as satisfactorily. Most of the children understood the rules of the game, single actions and the overall concept. The difficulties in working with iPad are seen as temporary, because those who had issues with the touch screen never used it before. The observations we made and the feedback we got from children provide a reach set of usability improvements for the game that can be taken in the future development.

7.1.2 Enjoyment

Most of children played the game three or more times and wanted to play more on the next visit. Six of them played twice or less times. When they were asked why they did not want to play more, one boy said that it is enough for today and he will come tomorrow to play again. Another boy said that he has won everything he needed, but he was willing to come again. These comments indicate that more complexity in the game is needed in order to keep children engaged. One girl did not really answer the question. She was indifferent and did not express any emotions during the game. At least, she did not refuse to play. In one case, the therapist had to interrupt the testing session since she felt that controlling iPad was too difficult the child. Further, the autistic boy, who liked to press the dice, did not really follow the rules of the game, but he enjoyed rotating the dice and counting points. The occupational therapist commented behavior of the autistic children (one who refused to play at all at the boarding school, and the second who did not follow the rules) that these children will probably need to be introduced to the game several times before they can start using it. She added that, to get used to something new takes usually longer time for autistic people than for other individuals.

The occupational therapists from the boarding school and from the occupational therapy center told us that many children were asking to play the game again at the following visits. In addition, children from the boarding school even told their classmates about the game.

The results signify that most of the children enjoyed the game and wanted to play it again. The cases where children did not show a lot of engagement were studied closer in order to understand why and how the game can be improved to be more fun for them. Some of the conclusions were to include more complexity to the game and add more levels, introduce a female character and provide toys that would be interesting for girls. As of now the game was

mostly aimed for boys (the male character, a car and a football as awards) so I was not surprised when girls did not show a lot of engagement in the game.

7.1.3 Behavior learning

As I mentioned earlier, expecting changes in children's behavior in such a short time span of the evaluation was too ambitious so we identified other outcomes that may lay the foundations for further skill development. Enjoyment was picked as one of the possible foundations, because if a user enjoys playing the game, he would be motivated to do it again and explore more features within it. Other criterion we looked at was the understanding of the game rules and expressing adequate reactions during the game. The occupational therapist we worked with believes that correct understanding of rules and adequate reaction to these rules is a crucial factor in terms of adequate skill learning. At last, we interviewed the parents of the children from the occupational therapy center and social workers from the border school regarding the children's experience with the game. We were interested in knowing whether children remembered the game, talked about it at home or in the classroom, or during shopping tours.

The results from the observations, video analysis and interviews with the occupational therapists illustrated that most of the children understood the rules and expressed adequate reactions during the testing. The expression of emotions varied among children, some of them were clearly expressing both sadness and happiness, while other lacked the emotional expression but provided the feedback through bodily movements such as clenching fists, or through voice modulations ("Ah! Oh…"). One boy was laughing at all action icons, both positive and negative, but we were able to differentiate his expressions by looking at his bodily movements: he clenched his fists and was generally tense when landing on negative cells, but relaxed again once he met a positive action icon. One girl at the occupational therapy center was very indifferent during the testing sessions. She did not express any emotions or expressed herself bodily. Even her eyes did not show any joy when she played. In this case, the fact that she did not refuse to play, was a positive sign. The autistic boy who liked to rotate the dice, expressed enjoyment, but he did not show any sign of understanding of the game's rules. Thus, we cannot say if the expressed enjoyment can be seen as a positive foundation for the further skill learning. Probably he will need more practice with the game before he starts using it as intended.

Most of the children remembered the game and asked for it at next visits to the therapists. The social workers form the boarding school reported that all children were talking about the game and the rules at the following store visits. Some parents from the occupational center reported the same. Interestingly, they noticed that children were seeing inappropriate behavior in other children and were telling them to behave properly. Children did not change their own behavior yet, but the fact that they started using the learned rules in real settings validates that the game had some impact on the children. It is still too early to say if the children will be able to behave according to rules, but all the foundations are there.

7.2 Discussion on the methods used

Even though the literature review gave us several methods for involving children in the design process, none of them could be implemented "as-is" in our context since none of them were adapted for working with children with special needs. In the Theoretical Framework and Ethics chapter, I positioned this work in relation to existing methods and frameworks, stating that the Informant framework suggested by [51] was selected as a starting point, but many changes had to be made to this framework during the design process in order to fit in our context. There were several reasons for that. Reflecting on all work that has been done during this research I can tell that establishing good communication routines with the children, providing them a meaningful context for the design activities was the main challenge. All specialists involved in the study were very helpful and enthusiastic about it. However, the children's voices were still rather quiet. The interpretation of children's responses and behavior, while applying different methods, was complicated by issues in communication caused by both children's disabilities and lack of our knowledge on these disabilities. Most of the children had poor speech skills, and sometimes our communication was in addition complicated by supplementary impairments. This situation was further worsened by the fact that we had too little experience in working with children with special needs. Our knowledge about their conditions was limited by the selection of the articles and books we actively used through the project. Therefore, for instance, it was difficult for us to distinguish when a particular behavior was caused by the disability a child had or when it should be considered as a sign that he or she attempt to say something. As, for example, in case when one boy laughed at both negative and positive action icons during the game, it was difficult for us to say if he laughed because he considered these actions funny or this laughter was unconscious and caused by the disability. In first case, his reaction can be considered as inadequate because laughing at the inappropriate behavior was the opposite of the expected reaction. However, knowing that his laughter could be unconscious triggered us to look deeper at his bodily reactions. Then, we could clearly see that the boy's body was strained and he clenched his fists when he landed on negative cells, and he was more relaxed when he landed on positive cells, thus still expressing adequate reactions. These two examples show the need for proper understanding of children's behavior. Unfortunately, we did not have that knowledge and had to rely on the specialists in special education and occupational therapy who were familiar with the children. Bringing additional stakeholders into the design process influenced the way design methods were applied and the process itself. It was not possible to predict how the design process would turn out, but we were willing to take this risk in order to carry out the study.

Another major challenge that influenced the communication with children, the methods and the project in total was getting access to children. As I learned from the literature review, accessing children with special needs is complicated by the presence of additional stakeholders who are in charge of deciding for children. In this case, the original class I started to work with was closed down and children were distributed to six different schools.

We continued the research at an occupational therapy center, which was located far from our location, and our participation in the activities with children was limited to observations via Skype and a couple of visits to the center. For the summative evaluation of the final version of the prototype an opportunity at a boarding school for children with speech disabilities appeared. This school was located in the same city at the occupational therapy center, so it also was far away from our location. Changing the design settings forced us to alter the ways of conducting the design methods. For example, we requested the occupational therapist to conduct the evaluation sessions since none of us had possibility to attend these sessions personally. As result, we were not able to interrupt the sessions, left with the only possibility of observing them. However, I believe that this change made a positive impact since reducing the number of adults present in the same room with children reduced the potential pressure from our side on the children.

Teachman and Gibson state in [93] that the quality of data gathered through interviews is always depending on the interviewer and adjunct to that, a good toolkit. I believe that the same goes for all other methods and techniques when working with vulnerable special needs children; one needs a more versatile as well as sensitive toolkit for establishing a good design space involving children and other stakeholders who's knowledge might help during the design process. I started with well-known and used techniques, but some of them had to be changed and some abandoned due the inappropriateness in our context.

7.3 Discussion on ethical considerations

The major ethical consideration has been how to ensure an ongoing consent, especially in cases when the child's behavior was caused by the impairment he or she had and could be interpreted in several ways. As, for example, in the case that I mentioned earlier when a boy suddenly stopped playing and run away in the middle of game. This behavior could be a part of the impulse control or a sign that he do not want to continue participation anymore. By interpreting the behavior in one way or another we could make the child even more socially vulnerable by excluding him from the further research or break our own principle of voluntary participation by forcing the child to participate.

As I mentioned earlier we had to rely on other caretakers when it came to interpretation of children's behavior. In such sensitive situation, the disbalance in the power relationship between our younger participants and us adults showed to be an issue. Involving interpreters into the design sessions increased the number of adults per each child, thus increasing the pressure on the child. I feel that this concern played a more important role in the classroom setting, when three adults worked with one child, and the child being at school did not have many other choices. In the occupational therapy settings, in particular when I observed via Skype and the occupational therapist was in one-on-one conversation with children, this issue was reduced. As noted, some children just did not engage with the game and that was, naturally, perfectly fine.

7.4 Summary

In this chapter, I answered the second research question: "How to design with children with special needs?" I started with analysis of the data collected during the summative evaluation in order to show what outcomes one can expect from using the app developed during this research with children. The findings were divided in three groups according to the evaluation criteria defined in the Summative Evaluation chapter: usability, enjoyment and behavior learning. The observations and the video analysis illustrated that the usability of the game was on a satisfactory level, and it also gave us several hints on further improvement of the game. The enjoyment level was high; most children liked to play the game and asked for it at next therapy sessions. We could not expect that children's behavior would change in such short time span, so in order to evaluate the behavior learning level we looked for other foundations that could lay the ground for further skill development. Enjoyment, understanding of rules and expressing adequate reaction during the game were considered as such foundations. Most of the children had no problem in understanding the shopping concept and following the rules. All of them adequately reacted to the game. In cases where understanding was complicated, the reasons were studied closer in order to find out why and suggest possible ways of improving the game. Our observations were confirmed by the occupational therapist from the boarding school for children with speech disabilities, who was invited to observe the evaluation sessions with children, and, afterwards, she was asked to provide her expert evaluation of the prototype. Her impression of the game was positive and she clearly saw the potential this game had in therapy settings of social adaptation. She also proposed several improvements that could possibly make the game more engaging for elder children (10-12 years old) and girls. Her suggestions matched our own observations.

Bridging the diversity of needs and ways in which vulnerabilities get expressed was very challenging and resulted in focus shifting from educational games, through exploration of therapeutic games, to a final solution addressing behavior modification through gamification. The evaluation results illustrated that the app might be useful for individual sessions both in the therapy setting and in the classroom.

Further, I answered two sub-questions related to the second research question:

- Which methods and techniques, developed for designing with normally developing children work in the setting with children with special needs?
- What are the added ethical considerations in this situation?

Challenges in establishing a meaningful conversation between us, researchers, and our target group whose communication skills are impaired by a range of disabilities, is seen as the major issue. In addition, we did not have enough knowledge about the disabilities children had, thus not being capable of improving the situation. Further, challenges in accessing the children played an important role in this research influencing the way in which the design methods were applied.

Issues in communication with children caused the major ethical consideration on how to ensure an ongoing consent, especially in cases when the child's behavior was caused by the impairment he or she had and could be interpreted in several ways. In these cases, we had to rely on the special educators familiar with the children. We felt that involving additional stakeholders increased the disbalance in power relationships between children and us. This issue was reduced by letting the occupational therapist conduct testing sessions being one-on-one with children.

Despite the challenges we met, working with children has been rewarding. I have learned a lot from the children, the specialists involved into the design process and from overcoming the challenges that rose as we went through the design process. The children seemed to feel good about the project and the game, because all of them, both from the class and from the occupational therapy, wanted to continue the participation and were eager to see the finished product.

8 Conclusion

The area of design with special children represents a complex design context. Through work in this thesis, I have attempted to shed some light around use of technology to assist children with special needs in the classroom setting. The biggest challenge met while doing the assessment of the iPad was heterogeneity of abilities the children had. Consequently, design was chosen in order to attempt to make an app which all children could use, and which would add some value to their lives. The design process enabled looking into methodological and ethical challenges when designing with children with special needs.

My findings make obvious that some of methods needed adjustments in order to work properly, i.e. Smileyometer, where the children, because of the lack of abstraction skills were consistently choosing the larges smile because it looked most friendly to them. Further, some of techniques had to be abandoned, e.g. instead of making children perform shopping tasks in real settings, we had to rely on other stakeholders e.g. parents and teachers, speaking on the behalf of children. Many methods could be applied without changes, but additional interpretation of children's action was called for in order to understand what they mean or feel. For instance, when a child, in the middle of the play, leaves, I needed to understand the most likely reason for that, and for this, had to rely on teachers or special occupation therapists for interpretation. Overall, this indicates that better techniques and methods for working with this user group are still needed, including more sensitive interview techniques, design methods and ways of including professionals such as special educators, occupational therapists, medical experts, or other specialists with knowledge relevant for the project, outside of Human-Computer Interaction field.

Finally, I was personally very satisfied with the results of the evaluation of the app I have designed. It received positive feedback most of the time and that is more than one can expect within this context.

8.1 Future development

There is a large potential in examining what kinds of expertise and knowledge are relevant for different projects involving the children with special needs. Involving professionals can be both helping, by opening additional communicational possibilities for children with special needs, and opposing, by altering the meaning of the children's feedback. In order to make the best out of the knowledge the professionals possess, better guidelines and ways of managing interdisciplinary teams and understanding members roles and levels of involvement need to be studied further.

In addition, methods often need to be adjusted to a particular context. Currently, there is no framework allowing for flexible adjustment of design methods. The literature review showed that there is a growing interest in including children as design partners or informants in the

design process of a new technology, thus giving them a voice and a chance to make impact on this technology. Nevertheless, there are not many studies including children with special needs into the design process, and even less that aim for heterogeneous groups of children with diverse needs, thus, no well-established methods and techniques exist. Therefore, there is a large potential in studying what are the best ways of adapting existing methods and creating new ones that are better suited for work with such target user group.

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Appendix

Attachment 1 - Consent form for participating in the study (English)

Consent form for participating in the study:

"Designing assistive applications for and with vulnerable users"

This study is conducted by Associate Professor Alma Culén and master student Anna Karpova at the Department of Informatics of the University of Oslo. The goal is to study the process of designing assistive applications for and with vulnerable children for the purposes of master thesis research and publication of the same.

Children will be asked to participate in several sessions for designing and testing of an assistive application. They will be observed during this sessions and asked several questions regarding their actions. Notes will be taken by hand. When pictures are taken, they will be of the device on which the design suggestions are shown and they will never contain children's faces or anything else by which the children can be identified. Below you can opt from any pictures at all, even when they only show the device on which the child is working.

Children's participation is voluntary and they can withdraw from the study at any time, no explanation is needed. Children's answers and actions will be documented. Please, check a box below:

- ☐ No pictures at all
- ☐ Pictures of the device
- ☐ Pictures of the child but not showing the face or anything else the child can be identified by

All information collected during the study will be fully confidential, and fully anonymized. Children's names will not be disclosed or kept on records, even temporarily, in any form. All collected data will be deleted upon the completion of the master thesis.

The study is will be taken from January 2013 until November 2013.

Parents/ Guardians Signature: Children's Name:

_____ _____

Project Coordinators:

Alma Culén (+47 92432355) Anna Karpova (+47 45016542)

_____ _____

Date/Place:

_____

Attachment 2 - Consent form for participation in the study (Russian)

Согласие на принятие участия в исследовании:

«Разработка вспомогательных программ для уязвимых пользователей и вместе с ними»

Это исследование проводится доцентом Алмой Кюлен и студенткой Анной Карповой на факультете информатики в Университете города Осло (Норвегия). Целью этого исследования является изучение процесса разработки вспомогательных программ для мобильных устройств для уязвимых пользователей и совместно с ними в рамках дипломной работы и для публикации.

Детям будет предложено принять участие в нескольких сессиях по разработке и тестированию одной вспомогательной программы. Во время проведения сессий за детьми будет вестись наблюдение со стороны и детям будут заданы вопросы касательно их действий. Наблюдения будут записаны вручную. В тех случаях, когда мы будем фотографировать, фотографии будут содержать исключительно устройство на котором идёт разработка. Детские лица либо другие части тела по которым можно опознать ребёнка не будут запечатлены на фотографиях в целях анонимности. Ниже вы можете выбрать опцию «Не фотографировать вообще», в этом случае даже устройство, на котором работает ребёнок не будет заснято.

Участие детей в исследовании является добровольным, и они могут отказаться от участия в любое время. Никаких дополнительных объяснений не требуется. Ответы и действия детей будут задокументированы. Пожалуйста, выберите одну из опций ниже:

- ☐ Никаких фотографий вообще
- ☐ Можно фотографировать устройство, на котором работает ребёнок и его руки
- ☐ Можно фотографировать ребёнка, не показывая лица либо другой части тела, по которой ребёнок может быть опознан

Вся информация, собранная в ходе исследования, будет строго конфеденциальна и анонимна. Имена детей не будут раскрыты или сохранены, даже временно, в любой форме. Все данные, собранные в ходе исследования, будут удалены после окончания исследования.

Исследование проводится с января по ноябрь 2013 года.

Подпись родителя/опекуна Имя ребёнка

_____ _____

Координаторы проэкта:

Алма Кюлен (+47 92432355) Анна Карпова (+47 45016542)

_____ _____

Дата/Место:

_____

Attachment 3 - The source code of the app

Note that Kinetic.js library used for creating animations is not included here. It can be downloaded from http://kineticjs.com/.

index.html

```
<!DOCTYPE HTML>
<html>
<head>
<title>LearnStoreApp</title>
<meta http-equiv="Content-Type" content="text/html; charset=ISO-8859-1">
<link rel="stylesheet" href="css/LearnStoreApp.css">
<!-- the line below is required for access to the appMobi JS library -->
<!--
<script type="text/javascript" charset="utf-8"
src="http://localhost:58888/_appMobi/appmobi.js"></script>
<script type="text/javascript" charset="utf-8"
src="http://localhost:58888/_appMobi.js"></script>
<script type="text/javascript" language="javascript">
      // This event handler is fired once the AppMobi libraries are ready
      function onDeviceReady() {
         //use AppMobi viewport to handle device resolution differences if you want
         //AppMobi.display.useViewport(768,1024);

         //hide splash screen now that our app is ready to run
         AppMobi.device.hideSplashScreen();
      }

      //initial event handler to detect when appMobi is ready to roll
      document.addEventListener("appMobi.device.ready",onDeviceReady,false);
</script> -->
<script src="js/kinetic.js"></script>
<script src="js/LearnStoreApp.js"></script>
</head>
<body id="content" onload = "init()">

   <div id="wrapper">

    <div id = "left-corner"></div>
    <div id = "right-corner"></div>
    <div id = "start"></div>
    <div class = "orange-tile tile" id = "one">1</div>
    <div class = "green-tile tile" id = "two">2</div>
    <div class = "orange-tile tile" id = "three">3</div>
    <div class = "green-tile tile" id = "four">4</div>
    <div class = "orange-tile tile" id = "five">5</div>
    <div class = "green-tile tile" id = "six">6</div>
    <div class = "orange-tile tile" id = "seven">7</div>
    <div class = "green-tile tile" id = "eight">8</div>
```

```
    <div class = "orange-tile tile" id = "nine">9</div>
    <div class = "green-tile tile" id = "ten">10</div>
    <div class = "orange-tile tile" id = "eleven">11</div>
    <div class = "green-tile tile" id = "twelve">12</div>
    <div class = "orange-tile tile" id = "thirteen">13</div>
    <div class = "green-tile tile" id = "fourteen">14</div>
    <div class = "orange-tile tile" id = "fifteen">15</div>
    <div id = "finish"></div>
    <div id = "scores"></div>
    <div id = "container"></div>
    <div id = "show-scores">0</div>
    <div id = "win-message">
      <div id = "buttons">
         <button type="button" class = "button" id = "button1" onclick =
"selectPrise(15)"><span class="buttontext">15</span></button>
         <button type="button" class = "button" id = "button2" onclick =
"selectPrise(20)"><span class="buttontext">20</span></button>
         <button type="button" class = "button" id = "button3" onclick =
"selectPrise(25)"><span class="buttontext">25</span></button>
      </div>

      <div id = "win-scores"><span id = "win-scores-span"></span></div>
      <button type="button" id = "retry" onclick =
"window.location.href='LearnStoreApp.html'"><span id="nextLevelText"></span></button>
      <button type="button" id = "next-level" onclick =
"window.location.href='level2.html'"><span id="nextLevelText"></span></button>
      <!--<div><a href="level2.html">></a></div>-->
    </div>
   </div>
</body>

</html>
```

level2.html

```
<!DOCTYPE HTML>
<html>
<head>
<title>LearnStoreApp</title>
<meta http-equiv="Content-Type" content="text/html; charset=ISO-8859-1">
<link rel="stylesheet" href="css/level2.css">
<!-- the line below is required for access to the appMobi JS library -->
<!--
<script type="text/javascript" charset="utf-8"
src="http://localhost:58888/_appMobi/appmobi.js"></script>
<script type="text/javascript" charset="utf-8"
src="http://localhost:58888/_appMobi.js"></script>
<script type="text/javascript" language="javascript">
      // This event handler is fired once the AppMobi libraries are ready
      function onDeviceReady() {
```

```
        //use AppMobi viewport to handle device resolution differences if you want
        //AppMobi.display.useViewport(768,1024);

        //hide splash screen now that our app is ready to run
        AppMobi.device.hideSplashScreen();
      }

      //initial event handler to detect when appMobi is ready to roll
      document.addEventListener("appMobi.device.ready",onDeviceReady,false);
</script> -->
<script src="js/kinetic.js"></script>
<script src="js/LearnStoreApp.js"></script>
</head>
<body id="content" onload = "init2()">

   <div id="wrapper">

    <div id = "left-corner"></div>
    <div id = "right-corner"></div>
    <div id = "start"></div>
    <div class = "orange-tile tile" id = "one">1</div>
    <div class = "green-tile tile" id = "two">2</div>
    <div class = "orange-tile tile" id = "three">3</div>
    <div class = "green-tile tile" id = "four">4</div>
    <div class = "orange-tile tile" id = "five">5</div>
    <div class = "green-tile tile" id = "six">6</div>
    <div class = "orange-tile tile" id = "seven">7</div>
    <div class = "green-tile tile" id = "eight">8</div>
    <div class = "orange-tile tile" id = "nine">9</div>
    <div class = "green-tile tile" id = "ten">10</div>
    <div class = "orange-tile tile" id = "eleven">11</div>
    <div class = "green-tile tile" id = "twelve">12</div>
    <div class = "orange-tile tile" id = "thirteen">13</div>
    <div class = "green-tile tile" id = "fourteen">14</div>
    <div class = "orange-tile tile" id = "fifteen">15</div>
    <div class = "green-tile tile" id = "sixteen">16</div>
    <div class = "orange-tile tile" id = "seventeen">17</div>
    <div class = "green-tile tile" id = "eighteen">18</div>
    <div class = "orange-tile tile" id = "nineteen">19</div>
    <div class = "green-tile tile" id = "twenty">20</div>
    <div id = "finish"></div>
    <div id = "scores"></div>
    <div id = "container"></div>
    <div id = "show-scores">0</div>

    <div id = "win-message">
      <div id = "buttons">
        <button type="button" class = "button" id = "button1" onclick =
"selectPrise(15)"><span class="buttontext">15</span></button>
```

```
        <button type="button" class = "button" id = "button2" onclick =
"selectPrise(20)"><span class="buttontext">20</span></button>
        <button type="button" class = "button" id = "button3" onclick =
"selectPrise(25)"><span class="buttontext">25</span></button>
      </div>

      <div id = "win-scores"><span id = "win-scores-span"></span></div>
      <button type="button" id = "retry" onclick =
"window.location.href='level2.html'"><span id="nextLevelText"></span></button>
      <button type="button" id = "next-level" onclick =
"window.location.href='level2.html'"><span id="nextLevelText"></span></button>
      <!--<div><a href="level2.html">></a></div>-->
    </div>
   </div>

</body>
</html>
```

LearnStoreApp.js

```
var playMode = true;
var scoresValue = 0;
var currentDiceNumber = 0;
var level = 0;

/*Kinec layers*/
var buttonLayer = new Kinetic.Layer();
var diceLayer = new Kinetic.Layer();
var avatarLayer = new Kinetic.Layer();

/*List of tiles*/
var tiles = {};

function init(){
        document.getElementById('scores').innerHTML = scoresValue;
        level = 1;

        var sources = {
                avatar:'images/avatar.jpg',
                avatar_grumpy: 'images/avatar_grumpy.jpg',
                1: 'images/1.jpg',
                2: 'images/2.jpg',
                3: 'images/3.jpg',
                4: 'images/4.jpg',
                5: 'images/5.jpg',
                6: 'images/6.jpg',
                //veider: 'http://www.html5canvastutorials.com/demos/assets/darth-vader.jpg',
        };
```

```
        loadImages(sources, initStage);
        initTiles();
}

function init2(){
        document.getElementById('scores').innerHTML = scoresValue;

        level = 2;

        var sources = {
                avatar:'images/avatar.jpg',
                avatar_grumpy: 'images/avatar_grumpy.jpg',
                1: 'images/1.jpg',
                2: 'images/2.jpg',
                3: 'images/3.jpg',
                4: 'images/4.jpg',
                5: 'images/5.jpg',
                6: 'images/6.jpg',
                veider: 'http://www.html5canvastutorials.com/demos/assets/darth-vader.jpg',
        };


        loadImages(sources, initStage);
        initTilesLevelTwo();
}

/*Loads images and calls initStage functions*/
function loadImages(sources, callback){

        var images = {};
        var loadedImages = 0;
        var numImages = 0;

        for(var src in sources) {
      numImages++;
   }

        for(var src in sources) {
      images[src] = new Image();
      images[src].onload = function() {
        if(++loadedImages >= numImages) {
                                callback(images);
        }
      };

                images[src].src = sources[src];
                console.log("Loading images: "+images[src]);
   }
}
```

```
function initStage(images){

	//Set the stage
	var stage = new Kinetic.Stage({
		container: 'container',
		width: 900,
		height: 600
	});

	//Define play/pause buttons
	//addButtons(images, buttonLayer, stage, avatarLayer, diceLayer);

	//Define dice
	initDice(images);

	//Define avatar
	initAvatar(images);

	//Add buttons, dice and avatar to the stage
	//stage.add(buttonLayer);
	stage.add(diceLayer);
	stage.add(avatarLayer);
}

/*Initiates dice to throw*/
function initDice(images){

	var randomKey = Math.floor((Math.random()*4)+1);
	//var imageObj = images[randomKey];
	console.log("Randkey: "+randomKey);
	var dice = new Kinetic.Rect({
		width: 60,
		height: 60,
		//fill: '#2062bc',
		stroke: '#0d2950',
		strokeWidth: 2,
		x: 840,
		y: 540,
		offset: [30, 30],
		cornerRadius: 8,
		fillPatternImage: images[randomKey],
		fillPatternRepeat: 'no-repeat',
      //fillPatternOffset: [0, 0]
	});

	//console.log("dice background"+dice.getFillPatternImage());

	dice.on('click tap', function(){
	if(playMode == true){
		animateDice(dice, diceLayer);
```

```
                randomKey = Math.floor((Math.random()*6)+1);
                // //console.log("randomKey = "+randomKey);

                setTimeout(function(){
                        dice.setFillPatternImage(images[randomKey]);
                        diceLayer.draw();
                }, 2000);
                currentDiceNumber = randomKey;
      calculateScores (randomKey);
        }

    });

    diceLayer.add(dice);
}

/*Rotates dice when tapped*/
function animateDice(dice){
        var angularSpeed = Math.PI/2;

        var anim = new Kinetic.Animation(function(frame) {
       var angleDiff = frame.timeDiff * angularSpeed / 500;
       dice.rotate(angleDiff);
      }, diceLayer);

   anim.start();

   //stop animation after one second
   setTimeout(function(){
        anim.stop();
   }, 2000);

   // //Highlight the dice
   // var avatarFromLayer = avatarLayer.getChildren();
   // //console.log (avatarFromLayer[0]);
   // highlightElement(avatarFromLayer[0], avatarLayer);
}

/*Initiates the avatar for player*/
function initAvatar(images){
        console.log("Check image "+images.avatar);
        var avatar = new Kinetic.Circle({
                radius: 45,
                //fill: '#4fbf31',
                stroke: '#26411e',
                strokeWidth: 3,
                x: 50,
                y: 100,
                draggable: true,
                fillPatternImage: images.avatar,
```

```
        fillPatternOffset: [60, 65]
                /*shadowColor: 'white',
                shadowOffset: [3, 3],
                shadowBlur: 15*/
        });

        console.log("getPattern "+avatar.getFillPatternImage());

         avatar.on('dragend touchend', function(){
        checkHotspots(avatar, images);
   });

        avatarLayer.add(avatar);
}

function initTiles(){

        tiles = {
                1: {
                        name: 'empty',
                        id: 'one',
                        x: 0,
                        y: 0,
                        isNegative: null
                },
                2: {
                        name: 'withCarriage',
                        id: 'two',
                        x: 0,
                        y: 0,
                        isNegative: false
                },
                3: {
                        name: 'empty',
                        id: 'three',
                        x: 0,
                        y: 0,
                        isNegative: null
                },
                4: {
                        name: 'crying',
                        id: 'four',
                        x: 0,
                        y: 0,
                        isNegative: true
                },
                5: {
                        name: 'withApple',
                        id: 'five',
                        x: 0,
```

```
        y: 0,
        isNegative: false
},
6: {
        name: 'empty',
        id: 'six',
        x: 0,
        y: 0,
        isNegative: null
},
7: {
        name: 'running',
        id: 'seven',
        x: 0,
        y: 0,
        isNegative: true
},
8: {
        name: 'empty',
        id: 'eight',
        x: 0,
        y: 0,
        isNegative: null
},
9: {
        name: 'withMom',
        id: 'nine',
        x: 0,
        y: 0,
        isNegative: false
},
10: {
        name: 'empty',
        id: 'ten',
        x: 0,
        y: 0,
        isNegative: null
},
11: {
        name: 'screaming',
        id: 'eleven',
        x: 0,
        y: 0,
        isNegative: true
},
12: {
        name: 'empty',
        id: 'twelve',
        x: 0,
        y: 0,
```

```
                isNegative: null
            },
            13: {
                name: 'inCarriage',
                id: 'thirteen',
                x: 0,
                y: 0,
                isNegative: true
            },
            14: {
                name: 'empty',
                id: 'fourteen',
                x: 0,
                y: 0,
                isNegative: null
            },
            15: {
                name: 'paying',
                id: 'fifteen',
                x: 0,
                y: 0,
                isNegative: false
            }
        };

        var list = document.getElementsByClassName("tile");

        for (var i = 0; i < list.length; i++) {
        tiles[i+1].x = list[i].offsetLeft;
        tiles[i+1].y = list[i].offsetTop;
        }
}

function initTilesLevelTwo(){

        tiles = {
            1: {
                name: 'empty',
                id: 'one',
                x: 0,
                y: 0,
                isNegative: null
            },
            2: {
                name: 'withCarriage',
                id: 'two',
                x: 0,
                y: 0,
                isNegative: false
            },
```

```
3: {
        name: 'empty',
        id: 'three',
        x: 0,
        y: 0,
        isNegative: null
},
4: {
        name: 'crying',
        id: 'four',
        x: 0,
        y: 0,
        isNegative: true
},
5: {
        name: 'withApple',
        id: 'five',
        x: 0,
        y: 0,
        isNegative: false
},
6: {
        name: 'empty',
        id: 'six',
        x: 0,
        y: 0,
        isNegative: null
},
7: {
        name: 'running',
        id: 'seven',
        x: 0,
        y: 0,
        isNegative: true
},
8: {
        name: 'empty',
        id: 'eight',
        x: 0,
        y: 0,
        isNegative: null
},
9: {
        name: 'withMom',
        id: 'nine',
        x: 0,
        y: 0,
        isNegative: false
},
10: {
```

```
            name: 'empty',
            id: 'ten',
            x: 0,
            y: 0,
            isNegative: null
        },
        11: {
            name: 'screaming',
            id: 'eleven',
            x: 0,
            y: 0,
            isNegative: true
        },
        12: {
            name: 'empty',
            id: 'twelve',
            x: 0,
            y: 0,
            isNegative: null
        },
        13: {
            name: 'inCarriage',
            id: 'thirteen',
            x: 0,
            y: 0,
            isNegative: true
        },
        14: {
            name: 'empty',
            id: 'fourteen',
            x: 0,
            y: 0,
            isNegative: null
        },
        15: {
            name: 'empty',
            id: 'fifteen',
            x: 0,
            y: 0,
            isNegative: null
        },
        16: {
            name: 'kicking',
            id: 'sixteen',
            x: 0,
            y: 0,
            isNegative: true
        },
        17: {
            name: 'empty',
```

```
                id: 'seventeen',
                x: 0,
                y: 0,
                isNegative: null
            },
            18: {
                name: 'destroying',
                id: 'eighteen',
                x: 0,
                y: 0,
                isNegative: true
            },
            19: {
                name: 'empty',
                id: 'nineteen',
                x: 0,
                y: 0,
                isNegative: null
            },
            20: {
                name: 'paying',
                id: 'twenty',
                x: 0,
                y: 0,
                isNegative: false
            },
        };

        var list = document.getElementsByClassName("tile");

        for (var i = 0; i < list.length; i++) {
        tiles[i+1].x = list[i].offsetLeft;
        tiles[i+1].y = list[i].offsetTop;
        }
        //console.log("Init 2, scores: "+scoresValue);

        document.getElementById('scores').innerHTML = scoresValue;

}

/*Checks whether the avatar is near a hotspot-tile*/
function checkHotspots(avatar,images){
        var ax = avatar.getX()-25;
        var ay = avatar.getY()-45;

        for (var t in tiles){

            var nextT = parseInt(t)+1;
            var prevT = parseInt(t)-1;
            var nextItem = tiles[nextT];
```

```
                var prevItem = tiles[prevT];

                if(tiles[t].isNegative!=null){

                        if(ax >= tiles[t].x-40 && ax <= tiles[t].x+40 && ay >=tiles[t].y-40 &&
ay <= tiles[t].y+40){

                                if(tiles[t].isNegative==false){ //Move the avatar forward
                                        //Next item in the list
                                        if(nextItem==null){ //check if the avatar is on finishline
                                                //console.log("Finish!");
                                                animateAvatar(images, avatar, 200, 0);
                                                avatarLayer.draw();
                                                setTimeout(function(){
                                                        showWinMessge();
                                                }, 3000);
                                                //initTilesLevelTwo();
                                        }else{
                                                var moveX = nextItem.x - ax;
                                                var moveY = nextItem.y - ay;
                                                //avatar.move(moveX, moveY);
                                                //console.log("log from check...X Y "+ moveX +
" "+moveY);
                                                animateAvatar(images, avatar, moveX, moveY);
                                                avatarLayer.draw();
                                        }
                                        calculateScores (1);
                                }else{ //move the avatar backward
                                        var moveX = prevItem.x - ax;
                                        var moveY = prevItem.y - ay;
                                        avatar.setFillPatternImage(images.avatar_grumpy);
                                avatar.setFillPatternOffset(60,65);
                                        animateAvatar(images, avatar, moveX, moveY);
                                        avatarLayer.draw();
                                        calculateScores (-1);

                                }
                        }
                }
        }
}

function resetAvatar(avatar, images){
        console.log("Resetting avatar");
        avatar.setFillPatternImage(images.avatar);
   avatar.setFillPatternOffset(60,65);
   avatarLayer.draw();
}
function animateAvatar(images, avatar, moveX, moveY){
```

```
        var ax = avatar.getX() + 255;
        var ay = avatar.getY() - 45;

    var velocityX = moveX;
        var velocityY = moveY;

        var anim = new Kinetic.Animation(function(frame) {
           // move a node to the right at 50 pixels / second
           var distX = velocityX * (frame.timeDiff / 3000);
           var distY = velocityY * (frame.timeDiff / 3000);
           avatar.move(distX, distY);

        }, avatarLayer);

        anim.start();

        //stop animation after one second
    setTimeout(function(){
      anim.stop();
      resetAvatar(avatar, images);
    }, 1500);
}

/*Calculates scores for the cirrent game*/
function calculateScores (number){
        setTimeout(function(){
        scoresValue = scoresValue+number;
                document.getElementById('scores').innerHTML = scoresValue;
                //console.log("Scores value: "+scoresValue);
                if(number>0){
                        document.getElementById('show-scores').innerHTML = "+"+number;
                }else{
                        document.getElementById('show-scores').innerHTML = number;
                }
                document.getElementById('show-scores').style.display = "-webkit-box";
                //document.getElementById('show-scores').style.display = "block";
                setTimeout(function(){
                        document.getElementById('show-scores').style.display = "";
                }, 1000);
     }, 2000);

}

function showWinMessge(){
        document.getElementById('win-message').style.display = "block";
        setScoreValue();
        if(scoresValue<15){
                document.getElementById("button1").disabled = true;
                document.getElementById("button2").disabled = true;
                document.getElementById("button3").disabled = true;
```

```
                if(level ==1){

        document.getElementById('button1').style.backgroundImage="url('images/apple_lock
ed.png')"

        document.getElementById('button2').style.backgroundImage="url('images/icecream_l
ocked.png')"

        document.getElementById('button3').style.backgroundImage="url('images/lolipop_loc
ked.png')"
                }else if(level == 2){

        document.getElementById('button1').style.backgroundImage="url('images/ball_locked
.png')"

        document.getElementById('button2').style.backgroundImage="url('images/car_locked.
png')"

        document.getElementById('button3').style.backgroundImage="url('images/teddy_lock
ed.png')"
                }

        }else if(scoresValue>15 && scoresValue<20){
                document.getElementById("button2").disabled = true;
                document.getElementById("button3").disabled = true;
                if(level == 1){

        document.getElementById('button2').style.backgroundImage="url('images/icecream_l
ocked.png')"

        document.getElementById('button3').style.backgroundImage="url('images/lolipop_loc
ked.png')"
                }else if(level == 2){

        document.getElementById('button2').style.backgroundImage="url('images/car_locked.
png')"

        document.getElementById('button3').style.backgroundImage="url('images/teddy_lock
ed.png')"
                }

        }else if(scoresValue>20 && scoresValue<25){
                document.getElementById("button3").disabled = true;
                if(level == 1){

        document.getElementById('button3').style.backgroundImage="url('images/lolipop_loc
ked.png')"
                }else if(level == 2){
```

```
        document.getElementById('button3').style.backgroundImage="url('images/teddy_lock
ed.png')"
                }

        }

}

function selectPrise(price){
        if(price<=scoresValue){
                if (level == 1){
                        if(price == 15){
                                document.getElementById('win-
message').style.backgroundImage="url('images/win_apple.jpg')"
                                scoresValue = scoresValue-price
                                setScoreValue()
                        }else if(price == 20){
                                document.getElementById('win-
message').style.backgroundImage="url('images/win_icecream.jpg')"
                                scoresValue = scoresValue-price
                                setScoreValue()
                        }else if(price == 25){
                                document.getElementById('win-
message').style.backgroundImage="url('images/win_lolipop.jpg')"
                                scoresValue = scoresValue-price
                                setScoreValue()
                        }
                }else if(level == 2){
                        if(price == 15){
                                document.getElementById('win-
message').style.backgroundImage="url('images/w_ball.jpg')"
                                scoresValue = scoresValue-price
                                setScoreValue()
                        }else if(price == 20){
                                document.getElementById('win-
message').style.backgroundImage="url('images/w_car.jpg')"
                                scoresValue = scoresValue-price
                                setScoreValue()
                        }else if(price == 25){
                                document.getElementById('win-
message').style.backgroundImage="url('images/win_teddy.jpg')"
                                scoresValue = scoresValue-price
                                setScoreValue()
                        }
                }


        }else{
                console.log("Not enough :(");
```

```
        }

}

function setScoreValue(){
        if(scoresValue>0){
                document.getElementById('win-scores-span').innerHTML = scoresValue;
        }else{
                document.getElementById('win-scores-span').innerHTML = scoresValue;
        }
}
```

LearnStoreApp.css

```
#content{
        background-color: #f0eede;
}
#wrapper{
        background-color: #FAF5C3;
        width: 900px;
        height: 600px;
        margin-right: auto;
        margin-left: auto;
        border: solid 3px #f2f1ed;
}
#left-corner{
        width: 0;
        height: 0;
        border-bottom: 140px solid #87c89b;
        border-right: 140px solid #87c89b;
        border-top-right-radius: 140px;
        position: relative;
        top: 460px;
}

#right-corner{

        width: 0;
        height: 0;
        border-bottom: 140px solid #87c89b;
        border-left: 140px solid #87c89b;
        border-top-left-radius: 140px;
        float: right;
        position: relative;
        top: 320px;
}

/* Tiles properties */

#start{
```

```
        width: 0;
        height: 0;
        border-top: 70px solid transparent;
        border-left: 40px solid #e23039;
        border-bottom: 70px solid transparent;
        position: relative;
        bottom: 100px;
        left: 5px;
}

#one{
        position: relative;
        bottom: 220px;
        left: 50px;
}
#two{
        position: relative;
        bottom: 200px;
        left: 20px;
        background-image: url('../images/w_carriage.png') !important;
}

#three{
        position: relative;
        bottom: 180px;
        left: 50px;
}

#four{
        position: relative;
        bottom: 170px;
        left: 125px;
        background-image: url('../images/crying.png') !important;
}

#five{
        position: relative;
        bottom: 240px;
        left: 260px;
        background-image: url('../images/w_apple.png') !important;
}

#six{
        position: relative;
        bottom: 470px;
        left: 310px;
}

#seven{
        position: relative;
```

```
        bottom: 700px;
        left: 240px;
        background-image: url('../images/running.png') !important;
}

#eight{
        position: relative;
        bottom: 930px;
        left: 255px;
}

#nine{
        position: relative;
        bottom: 1100px;
        left: 380px;
        background-image: url('../images/w_mom.png') !important;
}

#ten{
        position: relative;
        bottom: 1150px;
        left: 510px;
}
#eleven{
        position: relative;
        bottom: 1130px;
        left: 520px;
        background-image: url('../images/screaming.png') !important;
}

#twelve{
        position: relative;
        bottom: 1110px;
        left: 580px;
}

#thirteen{
        position: relative;
        bottom: 1220px;
        left: 710px;
        background-image: url('../images/in_carriage.png') !important;
}

#fourteen{
        position: relative;
        bottom: 1450px;
        left: 770px;
}

#fifteen{
```

```
        position: relative;
        bottom: 1680px;
        left: 750px;
        background-image: url('../images/w_money.png') !important;
}
#finish{
        width: 0;
        height: 0;
        border-top: 70px solid transparent;
        border-left: 40px solid #2062bc;
        border-bottom: 70px solid transparent;
        float: right;
        position: relative;
        bottom: 1820px;
}

.orange-tile{
        width: 90px;
        height: 90px;
        background-color: #fa961e;
        border-top-right-radius: 20px;
        border-top-left-radius: 20px;
        border-bottom-right-radius: 20px;
        border-bottom-left-radius: 20px;
        border: 3px solid #fac050;
        color: #fad48c;
        padding: 5px;
}
#one:before, #three:before, #eleven:before{
        content: "";
        position: absolute;
        top: 100px;
        left: 50px;
        width: 0;
        height: 0;
        border-left: 20px solid transparent;
        border-right: 20px solid transparent;
        border-top: 30px solid #fac050;
        z-index: 3;
}
#five:before, #seven:before, #thirteen:before {
        content: "";
        position: absolute;
        top: -30px;
        left: 50px;
        width: 0;
        height: 0;
        border-left: 20px solid transparent;
        border-right: 20px solid transparent;
        border-bottom: 30px solid #fac050;
```

```
        z-index: 3;
}
#nine:before {
        content: "";
        position: absolute;
        top: 50px;
        left: 100px;
        width: 0;
        height: 0;
        border-top: 20px solid transparent;
        border-left: 30px solid #fac050;
        border-bottom: 20px solid transparent;
        z-index: 3;
}

.green-tile{
        width: 90px;
        height: 90px;
        background-color: #87c89b;
        border-top-right-radius: 20px;
        border-top-left-radius: 20px;
        border-bottom-right-radius: 20px;
        border-bottom-left-radius: 20px;
        border: 3px solid #b2ddba;
        color: #bcdcc0;
        padding: 5px;
}
#two:before, #ten:before{
        content: "";
        position: absolute;
        top: 100px;
        left: 50px;
        width: 0;
        height: 0;
        border-left: 20px solid transparent;
        border-right: 20px solid transparent;
        border-top: 30px solid #b2ddba;
        z-index: 3;
}
#four:before, #twelve:before {
        content: "";
        position: absolute;
        top: 50px;
        left: 100px;
        width: 0;
        height: 0;
        border-top: 20px solid transparent;
        border-left: 30px solid #b2ddba;
        border-bottom: 20px solid transparent;
        z-index: 3;
```

```
}
#eight:before {
	content: "";
	position: absolute;
	top: 10px;
	left: 100px;
	width: 0;
	height: 0;
	border-top: 20px solid transparent;
	border-left: 30px solid #b2ddba;
	border-bottom: 20px solid transparent;
	z-index: 3;
}

#six:before, #fourteen:before {
	content: "";
	position: absolute;
	top: -30px;
	left: 10px;
	width: 0;
	height: 0;
	border-left: 20px solid transparent;
	border-right: 20px solid transparent;
	border-bottom: 30px solid #b2ddba;
	z-index: 3;
}

/*Scores properties*/
#scores{
	position: relative;
	bottom: 1350px;
	width: 120px;
	left: 10px;
	height: 60px;
	font-family: "Trebuchet MS", Helvetica, sans-serif;
	font-size: 60px;
	color: #1a3b24;
}
/*Canvas properties*/
#container{
	position: absolute;
	top: 10px;
	z-index: 100;
}

/*Arrows*/
.forward-arrow {
	/*background-color: green;*/
}
.back-arrow {
```

```
	background-color: red,
}

/*Styling for scorebox*/
#show-scores {
	width: 100px;
	height: 100px;
	/*background: red;*/
	-moz-border-radius: 50px;
	-webkit-border-radius: 50px;
	border-radius: 50px;
	position: relative;
	bottom: 1500px;
	z-index: 5;
	display: none;
	-webkit-box-pack: center !important;
	-webkit-box-align: center !important;
	font: 60px Arial;
	color: white;
	background-color: #59926b;
}

/*Styling for win message*/
#win-message{
	width: 500px;
	height: 400px;
	background: #a8bdd9;
	-moz-border-radius: 100px / 50px;
	-webkit-border-radius: 100px / 50px;
	border-radius: 100px / 50px;
	text-align: right;
	position: relative;
	bottom: 1850px;
	left: 200px;
	z-index: 110;
	border: 4px solid #2062bc;
	display: none;
	background-image: url('../images/win.jpg');
	background-repeat:no-repeat;
	background-position:10px;

}

#win-message a{
	position: absolute;
	/*bottom: 50px;*/
	right: 30px;
}

#win-message a:link, #win-message a:visited {
```

```
        color: #2062bc;
        font: 80px Arial;
        text-decoration: none;
}
#win-message a:hover{
        color: #2062bc;
        font: 90px Arial;
        text-decoration: none;
}
#win-scores{
        color: white; /*#2062bc;*/
        font: 50px Arial;
        position: relative;
        left: 70px;
        top: 90px;
        width: 100px;
        height: 100px;
        background: #59926b;
        -moz-border-radius: 50px;
        -webkit-border-radius: 50px;
        border-radius: 50px;
        text-align: center;
}
#win-scores-span {
        position: relative;
        top: 20px;
}
#buttons {
        position: relative;
        top: 60px;
        right: 50px;

}
.button{
        width: 80px;
        height: 80px;
        /*background-position: 0px -3px;*/
        background-repeat: no-repeat;
        margin: 10px;
        text-align: right;
        line-height : 10px;
        -moz-border-radius: 10px;
        -webkit-border-radius: 10px;
        border-radius: 10px;
}
.buttontext{
        position: relative;
        top: 20px;
        font: 20px Arial;
        text-shadow: -1px 1px 2px #fff;
```

```
}
#button1{
	background-image: url('../images/apple.png');
}
#button2{
	background-image: url('../images/icecream.png');
}
#button3{
	background-image: url('../images/lolipop.png');
}
#next-level{
	width: 150px;
	height: 50px;
	-moz-border-radius: 10px;
	-webkit-border-radius: 10px;
	border-radius: 10px;
	line-height: 50px;
	text-align: center;
	position: relative;
	right: 50px;
	top: 100px;
	background-image: url('../images/next.png');
	background-repeat: no-repeat;
	background-position: 0px -30pxpx;
}
#nextLevelText{
	font: 50px Arial;
	position: relative;
	bottom: 8px;
	color: #2062bc;
}
#retry{
	width: 150px;
	height: 50px;
	-moz-border-radius: 10px;
	-webkit-border-radius: 10px;
	border-radius: 10px;
	line-height: 50px;
	text-align: center;
	position: relative;
	right: 50px;
	top: 100px;
	background-image: url('../images/reload.png');
	background-repeat: no-repeat;
	background-position: 0px -30pxpx;
}
```

level2.css

```
#content{
```

```
        background-color: #f0eede;
}
#wrapper{
        background-color: #FAF5C3;
        width: 900px;
        height: 600px;
        margin-right: auto;
        margin-left: auto;
        border: solid 3px #f2f1ed;
}
#left-corner{
        width: 0;
        height: 0;
        border-bottom: 140px solid #87c89b;
        border-right: 140px solid #87c89b;
        border-top-right-radius: 140px;
        position: relative;
        top: 460px;
}

#right-corner{

        width: 0;
        height: 0;
        border-bottom: 140px solid #87c89b;
        border-left: 140px solid #87c89b;
        border-top-left-radius: 140px;
        float: right;
        position: relative;
        top: 320px;
}

/* Tiles properties */

#start{
        width: 0;
        height: 0;
        border-top: 70px solid transparent;
        border-left: 40px solid #e23039;
        border-bottom: 70px solid transparent;
        position: relative;
        bottom: 120px;
        left: 5px;
}

#one{
        position: relative;
        bottom: 240px;
        left: 50px;
}
```

```
#two{
	position: relative;
	bottom: 240px;
	left: 20px;
	background-image: url('../images/w_carriage.png') !important;
}

#three{
	position: relative;
	bottom: 240px;
	left: 50px;
}

#four{
	position: relative;
	bottom: 240px;
	left: 20px;
	background-image: url('../images/crying.png') !important;
}

#five{
	position: relative;
	bottom: 280px;
	left: 125px;
	background-image: url('../images/w_teddy.png') !important;
}

#six{
	position: relative;
	bottom: 330px;
	left: 230px;
}

#seven{
	position: relative;
	bottom: 540px;
	left: 290px;
	background-image: url('../images/running.png') !important;
}

#eight{
	position: relative;
	bottom: 750px;
	left: 250px;
}

#nine{
	position: relative;
	bottom: 960px;
	left: 300px;
```

```
        background-image: url('../images/w_mom.png') !important;
}

#ten{
        position: relative;
        bottom: 1170px;
        left: 350px;
}
#eleven{
        position: relative;
        bottom: 1330px;
        left: 455px;
        background-image: url('../images/screaming.png') !important;
}

#twelve{
        position: relative;
        bottom: 1380px;
        left: 560px;
}

#thirteen{
        position: relative;
        bottom: 1380px;
        left: 500px;
        background-image: url('../images/in_carriage.png') !important;
}

#fourteen{
        position: relative;
        bottom: 1380px;
        left: 560px;
}

#fifteen{
        position: relative;
        bottom: 1380px;
        left: 500px;
}
#sixteen{
        position: relative;
        bottom: 1430px;
        left: 605px;
        background-image: url('../images/kicking.png') !important;
}
#seventeen{
        position: relative;
        bottom: 1590px;
        left: 710px;
}
```

```
#eighteen{
	position: relative;
	bottom: 1800px;
	left: 760px;
	background-image: url('../images/destroying.png') !important;
}
#nineteen{
	position: relative;
	bottom: 2010px;
	left: 710px;
}
#twenty{
	position: relative;
	bottom: 2220px;
	left: 760px;
	background-image: url('../images/w_money.png') !important;
}

#finish{
	width: 0;
	height: 0;
	border-top: 70px solid transparent;
	border-left: 40px solid #2062bc;
	border-bottom: 70px solid transparent;
	float: right;
	position: relative;
	bottom: 2350px;
}

.orange-tile{
	width: 90px;
	height: 90px;
	background-color: #fa961e;
	border-top-right-radius: 20px;
	border-top-left-radius: 20px;
	border-bottom-right-radius: 20px;
	border-bottom-left-radius: 20px;
	border: 3px solid #fac050;
	color: #fad48c;
	padding: 5px;
}
#one:before, #three:before, #thirteen:before{
	content: "";
	position: absolute;
	top: 100px;
	left: 50px;
	width: 0;
	height: 0;
	border-left: 20px solid transparent;
	border-right: 20px solid transparent;
```

```
        border-top: 20px solid #fac050;
        z-index: 3;
}
#seven:before {
        content: "";
        position: absolute;
        top: -20px;
        left: 10px;
        width: 0;
        height: 0;
        border-left: 20px solid transparent;
        border-right: 20px solid transparent;
        border-bottom: 20px solid #fac050;
        z-index: 3;
}
#nine:before, #seventeen:before, #nineteen:before  {
        content: "";
        position: absolute;
        top: -20px;
        left: 50px;
        width: 0;
        height: 0;
        border-left: 20px solid transparent;
        border-right: 20px solid transparent;
        border-bottom: 20px solid #fac050;
        z-index: 3;
}
#five:before, #eleven:before, #fifteen:before {
        content: "";
        position: absolute;
        top: 50px;
        left: 100px;
        width: 0;
        height: 0;
        border-top: 20px solid transparent;
        border-left: 20px solid #fac050;
        border-bottom: 20px solid transparent;
        z-index: 3;
}

.green-tile{
        width: 90px;
        height: 90px;
        background-color: #87c89b;
        border-top-right-radius: 20px;
        border-top-left-radius: 20px;
        border-bottom-right-radius: 20px;
        border-bottom-left-radius: 20px;
        border: 3px solid #b2ddba;
        color: #bcdcc0;
```

```
        padding: 5px;
}
#two:before{
        content: "";
        position: absolute;
        top: 100px;
        left: 50px;
        width: 0;
        height: 0;
        border-left: 20px solid transparent;
        border-right: 20px solid transparent;
        border-top: 20px solid #b2ddba;
        z-index: 3;
}
#twelve:before, #fourteen:before{
        content: "";
        position: absolute;
        top: 100px;
        left: 10px;
        width: 0;
        height: 0;
        border-left: 20px solid transparent;
        border-right: 20px solid transparent;
        border-top: 20px solid #b2ddba;
        z-index: 3;
}
#four:before{
        content: "";
        position: absolute;
        top: 50px;
        left: 100px;
        width: 0;
        height: 0;
        border-top: 20px solid transparent;
        border-left: 20px solid #b2ddba;
        border-bottom: 20px solid transparent;
        z-index: 3;
}
#ten:before, #sixteen:before {
        content: "";
        position: absolute;
        top: 10px;
        left: 100px;
        width: 0;
        height: 0;
        border-top: 20px solid transparent;
        border-left: 20px solid #b2ddba;
        border-bottom: 20px solid transparent;
        z-index: 3;
}
```

```
#six:before, #eight:before {
	content: "";
	position: absolute;
	top: -20px;
	left: 50px;
	width: 0;
	height: 0;
	border-left: 20px solid transparent;
	border-right: 20px solid transparent;
	border-bottom: 20px solid #b2ddba;
	z-index: 3;
}
#eighteen:before {
	content: "";
	position: absolute;
	top: -20px;
	left: 10px;
	width: 0;
	height: 0;
	border-left: 20px solid transparent;
	border-right: 20px solid transparent;
	border-bottom: 20px solid #b2ddba;
	z-index: 3;
}

/*Scores properties*/
#scores{
	position: relative;
	bottom: 1880px;
	width: 120px;
	left: 10px;
	height: 60px;
	font-family: "Trebuchet MS", Helvetica, sans-serif;
	font-size: 60px;
	color: #1a3b24;
}
/*Canvas properties*/
#container{
	position: absolute;
	top: 10px;
	z-index: 100;
}

/*Arrows*/
.forward-arrow {
	/*background-color: green;*/
}
.back-arrow {
	background-color: red,
```

```
}

/*Styling for scorebox*/
#show-scores {
	width: 100px;
	height: 100px;
	background: red;
	-moz-border-radius: 50px;
	-webkit-border-radius: 50px;
	border-radius: 50px;
	position: relative;
	bottom: 2030px;
	z-index: 5;
	display: none;
	-webkit-box-pack: center !important;
	-webkit-box-align: center !important;
	font: 60px Arial;
	color: white;
	background-color: #59926b;
}

/*Styling for wim message*/
#win-message{
	width: 500px;
	height: 400px;
	background: #a8bdd9;
	-moz-border-radius: 100px / 50px;
	-webkit-border-radius: 100px / 50px;
	border-radius: 100px / 50px;
	text-align: right;
	position: relative;
	bottom: 2350px;
	left: 200px;
	z-index: 110;
	border: 4px solid #2062bc;
	display: none;
	background-image: url('../images/win.jpg');
	background-repeat:no-repeat;
	background-position:10px;

}

#win-message a{
	position: absolute;
	/*bottom: 50px;*/
	right: 30px;
}

#win-message a:link, #win-message a:visited {
	color: #2062bc;
```

```
        font: 80px Arial;
        text-decoration: none;
}
#win-message a:hover{
        color: #2062bc;
        font: 90px Arial;
        text-decoration: none;
}
#win-scores{
        color: white; /*#2062bc;*/
        font: 50px Arial;
        position: relative;
        left: 70px;
        top: 90px;
        width: 100px;
        height: 100px;
        background: #59926b;
        -moz-border-radius: 50px;
        -webkit-border-radius: 50px;
        border-radius: 50px;
        text-align: center;
}
#win-scores-span {
        position: relative;
        top: 20px;
}
#buttons {
        position: relative;
        top: 60px;
        right: 50px;

}
.button{
        width: 80px;
        height: 80px;
        /*background-position: 0px -3px;*/
        background-repeat: no-repeat;
        margin: 10px;
        text-align: right;
        line-height : 10px;
        -moz-border-radius: 10px;
        -webkit-border-radius: 10px;
        border-radius: 10px;
}
.buttontext{
        position: relative;
        top: 20px;
        font: 20px Arial;
        text-shadow: -1px 1px 2px #fff;
}
```

```
#button1{
	background-image: url('../images/ball.png');
}
#button2{
	background-image: url('../images/car.png');
}
#button3{
	background-image: url('../images/teddy.png');
}
#next-level{
	width: 150px;
	height: 50px;
	-moz-border-radius: 10px;
	-webkit-border-radius: 10px;
	border-radius: 10px;
	line-height: 50px;
	text-align: center;
	position: relative;
	right: 50px;
	top: 100px;
	background-image: url('../images/next.png');
	background-repeat: no-repeat;
	background-position: 0px -30pxpx;
}
#nextLevelText{
	font: 50px Arial;
	position: relative;
	bottom: 8px;
	color: #2062bc;
}
#retry{
	width: 150px;
	height: 50px;
	-moz-border-radius: 10px;
	-webkit-border-radius: 10px;
	border-radius: 10px;
	line-height: 50px;
	text-align: center;
	position: relative;
	right: 50px;
	top: 100px;
	background-image: url('../images/reload.png');
	background-repeat: no-repeat;
	background-position: 0px -30pxpx;
}
```