

TEACHING TODDLERS A SECOND LANGUAGE -

EXPLORING THE COMBINATION OF SECOND LANGUAGE

LEARNING AND TECHNOLOGY

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ABSTRACT

Learning languages at an early age is considered crucial for a child's development. And as our world grows increasingly more diverse, many children are left in situations that require multiple languages. However, as traditional tools for language learning often focus on teaching one language at a time, this might not support the needs of multilingual children.

In this thesis I explore how technology can contribute to an environment for second language learning in an early age. Borrowing from the traditions of Participatory Design, a tangible artifact intended for exploring languages was created together with the user group. Through the phases of a Future Workshop an interactive painting was created together with a group of preschool children and adult pedagogues.

Through this work I shed light on how technology can contribute to an environment that can support young multilingual children's language acquisition. Furthermore, I contribute with reflections on how young children can explore unfamiliar languages through familiar elements such as well-known fairy tales. Drawing from the experiences of the co-creation process, I present observations concerning the value of participating in the design process.

KEYWORDS: Second Language Learning, Tangible Artifact, Participatory Design, Future Workshop, Children as Co-Designers, Educational Technology, Multilingual Children, Micro Controller, Familiarity

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1 INTRODUCTION

The combination of technology and second language learning is not novel. In periods where grammar dominated the second language learning classroom, methods relied on one of the most ubiquitous technologies found in education, the blackboard. The blackboard was later complemented with the overhead projector. As the didactic methods shifted to focus on learning through oral repetition, language classes in the 1970s and 1980s often included obligatory sessions where students would perform repetition drills. Through the 1980s and 1990s the focus shifted towards communicative language learning that emphasised engaging students in authentic and meaningful interactions [37, p. 304]. Today, emerging trends regarding the use of apps and mobile devices for educational purposes are becoming noticeable [38].

However, as language educational tools are often created for teaching one language at a time this might not accommodate the needs of multilingual children [16]. Due to an increasingly global world, there are growing opportunities and reasons to move to another nation, or the need to learn another language. As a consequence of our increasingly diverse societies, many of today's children face the challenge of learning several languages. Additionally, learning new languages is not the only impediment multilingual children will experience. Developing their native language at the same time is just as crucial, since children's native language are easily lost in the early years if not used. Furthermore, research concerning multilingualism suggest that the level of a child's native language can be a strong predictor for their second-language development [40, p. 136].

Not to forget, a more globalized planet is not the only change that will make these young children experience the world differently than their parents. As technology such as mobile and interconnected devices are increasingly becoming a pervasive part of people's life, generations born into this millennium are also born into an progressively more technological environment [23]. Some even suggest that due to this environment, today's youth think and process information differently from previous generations [35]. Traditional schooling might therefore not longer suffice for today's students [13].

Furthermore, as information and communication technology has been a natural part of their life since birth, their approach and expectations for technology differ from those who immigrated into this technological environment [23]. Therefore, relying solely on our memories of childhood might not be sufficient when designing technology for children. It might be wise to enable those who will use the technology to have a voice in the design [10].

1.1 MOTIVATION

As a child there were nowhere else I would rather spend my time than in the school library. Even at a preschool age I was obsessed with letters and words, and I could use hours trying to figure out what secrets a book or magazine held. As I grew older this enthusiasm flourished into a love of languages and literature.

However, I remember those who did not share my affection for these things; those who struggled through school. When looking into research on why children struggle with education, several studies do suggest that the process of learning languages early on has an effect on a child's performance later in life. It is claimed that the vocabulary of a three year old directly corresponds to their reading skills all the way up to sixteen years of age.

If a child in the end of preschool has an underdeveloped vocabulary, the child will very often remain a weak reader throughout the school years. On the other hand, if a child has a well developed vocabulary at an early age, this often launches an increasing growth of the child's vocabulary later in life [15, p. 48]. Finding new ways to facilitate a language learning environment for young children could be considered an educational motivation.

As our world grows increasingly more global, many children today faces the challenges of not only learning their native language, but also the need to learn multiple languages. Research states that if young children are exposed to optimal environments for language learning, multilingual children can acquire the same language skills in their second language as the native speakers [5, p. 14]. On a larger scale, teaching languages early may give multilingual children a voice to participate and engage in the society, no matter their cultural or social background, contributing to a multicultural diversity [15, p. 31]. Finding ways to create learning environments that also suits the needs of young multilingual children could be considered not only an educational motivation, but also motivation for the society.

My choice for the thesis subject build on my experiences from teaching at a primary school level. In addition to my bachelor in Computer Sciences I have also studied pedagogy and child psychology. By combining the disciplines computer science and pedagogy, I believe technology can contribute greatly to creating language learning environments.

1.2 RESEARCH QUESTION

As mentioned earlier, language acquisition early on is considered crucial for a child's academic development. However, in an increasingly globalized world, early education might face a challenge in creating learning environments supporting the different languages of multilingual children. This thesis therefore looks to explore how technology can contribute to create

an environment sustaining and stimulating language acquisition in an early age. The first research question is as follows:

RQ 1: How can technology contribute to an environment for language learning for a young user group?

Additionally, as technology has become an ubiquitous part of peoples lives, today's generation starts to interact with a technological environment early on. As these generations are *tomorrow's power users* [10] of technology they might therefore be suited to co-create this technology. Sub research questions on including the users of the technology in the design process are presented below:

RQ 1.1: How can creating an environment for co-creation be facilitated?

RQ 1.2: How can children and adults together design a tangible artifact for exploring languages?

RQ 1.3: What are the potentials for making second language learning fun and motivational in the co-creation and the use of a tangible artifact?

The third sub research question is based on early education literature stating that when creating an environment for learning intended for preschoolers, this should be based on play [25, p. 28][5, p. 41-42].

1.3 REPORT OUTLINE

In the following chapter relevant theories on learning and language acquisition are presented, followed by reviews of literature discussing the benefits of including children in the development process. Additionally Chapter 2 includes literature on the combination of technology and education.

As the intention is to create an environment for language acquisition used by the children, it is only natural that the children are a part of creating this environment. Therefore, methods borrowed from Participatory Design is described in Chapter 3. Further, methods for collecting and analyzing data are also presented.

Chapter 4 describes the iterations for co-creating a tangible artifact intended for exploring languages. Following is a description of the developed artifacts presented in Chapter 5. The results from evaluating the artifacts, and the development process is then presented in Chapter 6, and later discussed in Chapter 7. Finally, the project's conclusion is presented in Chapter 8.

2 BACKGROUND AND RELATED WORK

In this chapter relevant literature from different disciplines are presented. First, literature regarding the combination of technology and education is presented in Section 2.1. Following is a presentation of literature and theories concerning learning and language acquisition, which is presented in Section 2.2. Literature on including children in the design process is then described in Section 2.3. Finally, related work is presented in Section 2.4

2.1 EDUCATION AND TECHNOLOGY

Combining technology and education is not novel. Through time, the classroom has contained different tools to suit the different didactic methods used, from blackboards and chalk to computers and tablets. Today emerging trends of using mobile devices and Apps for educational use are becoming prominent. In 2012, 80 percent of the top selling apps in the Education category in the iTunes Store targeted children. Early learning apps for toddlers and preschoolers were particularly prominent [38].

2.1.1 Apps and Early Education

According to research made by *The Norwegian Centre for ICT in Education* in 2013 around 30 percent of all Norwegian kindergartens had access to mobile devices such as tablets. The center also experienced high demand from kindergarten staff that request instructions on how to use and integrate technology into their learning environments [20].

However, these apps created for educational purposes might not necessarily provide a suitable learning environment for young children. In his dissertation *Positive Technological Development for Young Children in the Context of Children's Mobile Apps*, Clement L. Chau examined the extent to which mobile tablet software applications produced for preschool children are designed in accordance with developmentally appropriate practices [7]. His work revealed that only a non significant majority of apps were meaningfully designed for preschool children. Further, Chau found that the content of these apps tended to cluster around school skills, and rarely engaged the children in activities beyond anything more than drill and practice exercises. Further, he found that these apps often ignored important aspects of children's development, such as social, emotional and physical aspects.

Cori M. More and Jason C. Travers point out in their work that poorly designed educational software is very commonplace, and simply handing a device loaded with supposedly educational apps does not ensure educational benefit [26]. Furthermore, the researchers explain that educational research will likely never be able to keep up with technological innovations, e.g. the App market. However, some research does manage to keep up, such as the games *Bobo and Apples* and *Martha Speaks*, which are later presented in Section 2.4.1.

2.1.2 Criticism of Technology and Education

Even though technology is becoming increasingly integrated in our everyday life, indications show that the public debate is somewhat dominated with fear with regards to children and technology. In the fall of 2014, the Norwegian press released a series of articles discussing children's use of media, receiving both positive and negative feedback from their audience [29][30].

Too many children has been ruined by tablets. It is not good for the eyes. Children becomes addicts. It is immoral. It is disgusting. It is child neglect. Somebody should contact child services. (Asker [4])

The quote above presents just some of the feedback a journalist received when she wrote in a Norwegian newspaper that she had bought a tablet to her 2 year old daughter [4].

In an interview with the Norwegian newspaper *Aftenposten*, director for *ICT-Norway*, Torgeir Waterhouse describes the audience behavior as *classical moralism*. He continues by pointing out fact that all new media has been followed by a wave of panic and moral condemnation [28]. Waterhouse draws parallels to different types of media that did once create fear and panic when introduced to children, teenagers and young adults.

The term moral panic is recurrent in the science of media. Already in the 1700's people were worried about how love novels and plays would poison the soul and destroy the moral of the youth. In the 1930's it was believed that youth became criminals by reading comics.. (Nipen [28])

However, when looking back at statistics, reality does not check out with the accusations. When comic books were accused of turning teenagers into criminals in the 1930's, crime was in fact falling to a record low. Coincidentally, in the 1990s when video games were deemed harmful, America had its lowest decline in crime. Despite music videos, television and video games, media that all met criticism, these are decades where IQ scores continued to rise [28]. A professor of psychology at Harvard, Steven Pinker, explains in an article posted in the *New York Times*, that if electronic media is hazardous to our intelligence, the quality of science should also have plummeted. But somehow it has not [32]

The increase seen in intelligence test scores measured in many parts of the world from roughly the 1930s, especially the increase in problem solving, abstract reasoning, pattern recognition and spatial logic is known as the Flynn Effect. In his book, Steven Johnson presents a hypothesis regarding the increase of IQ by drawing a link between the Flynn Effect and popular media. Believing that the increase in IQ over the past fifty years is affected by environmental factors, Johnson explains that the most influential factor seems to be media and technology. Johnson continues this train of thought with the idea of the Sleeper Curve in his book *Everything bad is good for you*. Johnson presents the notion that mass culture is growing more sophisticated, demanding more cognitive engagement, thus making our minds sharper [21, p. 139-156].

2.1.3 Motivating for Learning with Technology

While Johnson [21, p. 139-156] suggests that new media is making our minds sharper, other suggest that this creates new obstacles with regard to learning. American writer Mark Prensky explains that we need to design, and use games for learning *real world* content because the learners has changed radically, and that these learners need to be motivated in other ways than before. When growing up with technology, how the younger generations think and process information has changed. The author explains that the things that were motivating learners in the past does not necessarily motivate learners today [35].

The author finds it interesting that so few have observed that the students are no longer the people the educational system was designed to teach. He talks about a large discontinuity that has happened, so big and drastic that Prensky calls it a singularity. He talks about how today's generation has changed from those of the past, and that the singularity is the arrival of digital technology in the last decades of the twentieth century [35].

Author James Paul Gee suggest that new ways of learning is a foot in the world, and is not necessarily connected to traditional education and academics. In one of his books, Gee critiques traditional schooling, and suggest that a new kind of learning will take its place. He explains that these may be just as special, technical and complex as academic ways, but may be motivating in ways school does not. Believing that games and game technology for learning content in school and skills in the workplace will be pervasive, Gee argues that schools, workplaces, families and academic researchers have a lot to learn from computer and video games [13, p. 2]. Gee further explains that games incorporates a set of fundamentally sound learning principles, all strongly supported by contemporary research in cognitive science, which is as Gee describes it *the study of how humans learn the best* [12].

2.1.4 Designing Educational Technology

In the *Human-Computer Interaction Handbook*, Julie A. Jacko states that when designing educational technology it is necessary to select an appropriate pedagogy - an approach to learning. She presents three perspectives: behaviorism, constructionivism and social-constructionivism. Behaviorism explains learning as a process of stimulus and reinforcement, while constructionists sees learning as an active construction of knowledge through experience. A social-constructionist perspective emphasizes learning as a social process [19, p. 852]. A more detailed description of learning theories are presented later in Section 2.2.1.

Additionally, when developing technology for educational purposes, assessment strategies must also be developed to make sure the learning design is successful. Naturally, an evaluation of the technology's usability must also be assessed; if the student can not use the technology, certainly he will not learn from it either [19, p. 853].

Moreover, as learning typically takes place over longer time periods, making the need for evaluation and trials to also take place over longer time periods. Further, educational research also needs to fit in with the school year and the curriculum. For example, if the technology aims to teach about genetics, you often have to wait until it is covered in the curriculum [19, p. 853].

2.1.5 Summary

Presented in this section has been the emergent use of Apps in early education, and how pedagogical research seems to fall behind the considerable growth of educational Apps. Further, negative and positive views regarding young children's use of this media has been described. Additionally, views on how to motivate for learning through the use of video games has been presented, highlighting that today's youth needs to be motivated differently than previous generations. Furthermore, guidelines for designing educational technology has been presented, emphasizing the need for selecting an pedagogical perspective, and assessing the technology's usability in addition to its educational value.

However, as this thesis also concerns language acquisition, the following section presents theories regarding learning and second language acquisition.

2.2 LANGUAGE AND LEARNING

Research on how language is acquired is a divided field consisting of contrasting views. Some emphasizes the human biological ability, while others emphasizes on the social interactions between humans. But all seem to agree that a child's ability for learning languages is remarkable.

Section 2.2.1 presents a selection of theories regarding learning and second language acquisition. Additionally, the importance of supporting young multilinguals are presented. Further, Section 2.2.2 describes legislation regarding language learning, and supporting multilingual children.

2.2.1 Learning Theories

This section is dedicated to theories regarding how children generally learn through actively partaking in the learning process. Professor in Applied Linguistics Anna Maria Pinter explains that learning is an active process, and that children learn through exploration and play [33, p. 5].

Constructionivism

Psychologist and philosopher Jean Piaget referred to this active learning as *constructionivism*, suggesting that children learn by constructing knowledge for themselves by actively trying to make sense of their environments [33, p. 5].

In 1923, Piaget published the book *The Language and the Thought of the Child* where he discussed how a child's learning was a process of acquiring the principles of formal logic¹. He refers to these logical abilities as operations, and suggested that each child follows these stages in the exact same order as a process of the child's biological development. These operations are known as the *Piagetian stages of development*. Pinter [33, p. 6-7] explains these stages as:

- **Sensori-motor stage** (from birth to two years of age) The young child learns to interact with the environment by interacting with objects.
- **Pre-operational stage** (from two to seven years of age) The child's thinking is mostly dependent on perception, but gradually becomes more able of logical thinking. This stage is also characterized by ego centricism.
- **Concrete operational stage** (from seven to eleven years of age) According to Piaget, year seven is the critical juncture where the child's thinking starts to resemble adult-like thinking.

¹ Logic is generally considered formal when it analyzes and represents the form of any valid argument type.
<http://en.wikipedia.org/wiki/Logic>

- **Formal operational stage** (from eleven years and up) In this stage the children are able to think in more abstract terms, and are able to achieve formal logic.

However, in his theories, Piaget left out the social side to learning. Pointing out the important role of the social environment in learning was a contemporary of Piaget, Lev Vygotsky.

Social Constructionism

Social constructionism is associated with the ideas of Russian psychologist Lev Vygotsky. Sharing some of the same beliefs as Piaget, Vygotsky also believed that the social environment played an important role. He was interested in the learning potential of the individual child, and what they could achieve with the help of a more knowledgeable partner [33, p. 10].

Accordingly, the concept of the *Zone of Proximal Development* (ZPD) was created. This concept describes the different zones between the child's current knowledge, and the potential knowledge the child can acquire with the aid of a more knowledgeable peer [33, p. 10].

Constructionism

Constructionism is an educational theory inspired by the ideas of Piaget, developed by Seymour Papert. This theory shares the constructivism's view of learning but also adds the idea that this occurs in a context.

Professor of Developmental Psychology, Edith Ackermann describes that to Papert, knowledge remains grounded in contexts, and projecting our ideas is key to learning. Expressing our ideas makes them tangible and shareable, which in turn shapes and sharpens these ideas. Papert stresses the importance of externalization through the use of tools such as digital media and computer-based technologies [2].

2.2.2 Learning a Language

This section presents views on second language learning and young children. Additionally, a theory on how humans process second language learning is described, followed by a section presenting the importance of supporting young multilingual children. Finally is a description of Norwegian legislation on language learning and supporting multilingual children in a kindergarten setting.

Children Learning a Second Language

With regard to language learning it is not uncommon to hear that children learn languages effortlessly. Additionally, the belief that a second language develops simply by letting children play with other children speaking a different language is also not uncommon [15].

However, research based on the advantages of early second language are not all conclusive. When exploring how to introduce English into a kindergarten curriculum, authors Maagerø and Simonsen looked at the works of American scientist David Singleton. Singleton stresses that it is very difficult to come to a general conclusion in the field of children and second language acquisition. Furthermore, Singleton emphasizes that there are many additional factors that may have an impact on the child's life, thus affecting the acquisition of the new language. This includes the child's general life situation, psychological factors, both the parents' and the child's motivation, physical environment of the learning situation, the methods used when interacting with the new language, social and cognitive background and so forth. This makes the age factor only one of many when a child is introduced to a new language [25, p. 24].

However, Singleton does claim that young children obtains a much better realization of the language's phonological level compared to older learners. Additionally, young learners seem to embrace the languages prosody² as well. To possess a good pronunciation of a second language may have a positive communicative effect later in life, as how good one is perceived to know second language is often based on the phonic realizations [25, p. 25]. This might be an explanation for why it is not uncommon to believe that as with native language, second language acquisition is child's play, for children that is. It is easy to be fooled by a "perfect" pronunciation. Authors Trude Hoel, Helen Oxborough and Åse Kari Wagner explains, building comprehension and understanding in a language requires effort and time [15, p. 43].

However, the idea that there is an age factor seem to be supported in the research area of second language acquisition. In the *Annual Review of Applied Linguistics* from 2006, Nicolov and Djigunovi presents different research on the *Critical Period Hypothesis* (CPH) and age related studies. The authors explain that the role of the age factor and the existence of a critical period is a key research area in second language acquisition (SLA). The Critical Period Hypothesis claims that natural language acquisition is available to young children, and is limited to older adolescents and adults [27]. Tracey Tokuhama-Espinosa, a researcher within the field of second language acquisition describes the age 4-7 as the second window of opportunity for second language learning [42, p. 27]. In her book *Raising Multilingual Children: Foreign Language Acquisition and Children* Tokuhama-Espinosa expresses:

Generally speaking, children under the age of seven (unless extremely shy to begin with) are not inhibited by making mistakes in public. Language is a game, a code, to be played with. When children make a mistake in pronunciation or do not know the right word in a situation, they ask, or make it up, or use something close to what they need. If and when they are corrected they accept it as part of the rules to the game and move on; no ego-bruising, no blushing or hiding or closing

² Prosody is the rhythm, stress, and intonation of speech.
[http://en.wikipedia.org/wiki/Prosody_\(linguistics\)](http://en.wikipedia.org/wiki/Prosody_(linguistics))

their mouths for the rest of the afternoon just because someone had to help them. At this young age, children's egos do not get in the way of speaking (or many other areas of their lives, as a matter of fact).
(Tokuhamma-Espinosa [42, p. 27])

Although the researchers does not seem to agree whether young children has an advantage when it comes to second language learning, research does indicate the importance of facilitating for language learning early on. Hoel et al. explains that the process of learning languages has an important effect on a child's performance later in life. In their work they present a theory titled the *Matthew Effect*. This theory claims that a three year old's vocabulary is directly connected to the child's reading skills all the way up to their teenage years. Meaning if a child has an underdeveloped vocabulary in the end of preschool, the child could potentially remain a weak reader throughout their school years. On the contrary, if a child has a well developed vocabulary at early age, the theory suggest that the child's vocabulary might increase considerably during the coming years [15, p. 48].

Processability Theory

One theory trying to explain how human processes second language learning is the *Processability Theory* (PT). PT primarily deals with the nature of how these processes and routines becomes available for the learner. In her work, Gisela Håkanson further developed the idea of PT, and argues that language acquisition incorporates a gradual acquisition of these routines [18].

These procedures are arranged according to their sequence, and each procedure is a necessary prerequisite for the following procedure. The very first step of learning is to identify the words of the target language. The next step is to categorize the word together with the diacritic features - Tense suffixes for verbs and number suffixes, e.g "car" and "cars". In the third stage, the learner learns to unify the head and modifiers in a phrase, e.g a "red car", and "many red cars". In the next stage, the learner will start to use the grammatical functions of the word, e.g "The car is red". The final stage implies that the learner can apply different word order rules for main and subordinate clauses in the language [18].

Supporting Bilingual Children

In her book *Supporting Multilingual Learners in the Early Years*, Sandra Smidt starts by explaining the importance of language learning through the views of Piaget and Vygotsky. She explains that Piaget viewed that language structures and controls the process of thinking. For Vygotsky language was the social means of thinking, meaning that the young children learn language from others in their culture and that this helps the children develop concepts about the world [40, p. 14].

Maagerø and Simonsen presents similar views concerning second language learning through the works of American socio-linguist Dell Hymes. He describes that language acquisition is not solely based on learning a vocabulary and grammar, but is realized through oral conversations in everyday life situations. And when we think about it, this is exactly how we learn our native language too, through interaction, context and different situations. Hymes explains that this also applies for learning a second language [25, p. 60]. In contrast to the the communicative perspective presented by Hymes, Maagerø and Simonsen presents the story of little Marius in Alexander Kielland's novel *Poison*. He studied Latin grammar so intensively that he became ill and died [25, p. 56-57].

Smidt further explains that language learning is closely connected to context, as language is acquired through communication with others. She explains that young children does not learn languages through grammar and vocabulary, but through being social.

Children learn a huge amount from their peers and they do this through play, in meaningful activities such as eating lunch, in different contexts like in the playground and so on. (Smidt [40, p. 25])

She further explains that belonging is an important incentive for young children when learning a second language. She suggest letting young children act as peer tutors to other children, as they most likely will know a great deal about their language and can be a resource for other children [40, p. 25].

Furthermore she describes the importance of supporting young multilingual children, as their mother tongues are fragile, and can easily be lost in the early years. She mentions the importance of facilitating for an environment in early education where their native language is not only used, but respected and recognized [40, p. 136].

Further, she explains the significance of giving each child an equal chance to communicate. Language is crucial to our experience as human beings as it plays an important role in establishing and maintaining social contact [40, p. 90].

Legislation, Kindergartens and Language Learning

The importance of supporting multilingual children is also recognized by Norwegian legislation. The *National Curriculum for Norwegian Kindergartens* and requires that early language stimulation is a part of the kindergartens content. The legislation clearly specifies that the children should be able to use their language to express themselves. This means that the employees need to create an environment to stimulate the children's language acquisition and respects the children's native language [34].

In part 2 of the *National Curriculum for Norwegian Kindergartens*, it is recognized that toddlers are in the fundamental period for developing language.

The framework specifies that it is important that children with a different native language other than Norwegian is understood, and is given the possibility to express themselves. The kindergarten should support the child to use their native language, simultaneously as they are improving the child's Norwegian language skills [34].

Furthermore, the parliamentary report *St.Meld 6* from 2013 states that all children in Norway shall have the same possibilities for education. Additionally, the white paper states that all children should be provided with an equal and tailored education [1].

2.2.3 Summary

This section has presented different perspectives on how children acquire knowledge through active learning. Further, views regarding young children's ability to learn a second language has been presented. Although researchers does not agree if younger children learn languages easier than older learners, researchers implies the importance for facilitating for language learning early nonetheless.

Furthermore, research regarding how humans processes second language learning has been presented. This research indicates that second language learning follows a set of fixed steps starting with learning the words of the language.

Additionally, this project does not only aim to explore how technology can facilitate for an environment supporting language learning, but also aims to include the user group in creating this environment. The following section therefore presents relevant background on how to include children in the design process.

2.3 CHILDREN AS CO-DESIGNERS

In the Human-Computer Interaction community, there is a short but rich history of developing shared paths for communication between a diverse user group and the ones creating the technology. Once only found in one or two conference papers a year, today's HCI conferences now also include a growing body of literature that discusses children, technology and HCI-issues [10]. So is also the literature discussing how and why to include children in the development process of technology.

As this thesis project aims to include both children and adults in the design process, it is necessary to explore how to facilitate for this partnership. The following section therefore presents literature discussing how and why children should be included in the design process of technology, presented under Allison Druin's four roles [10].

2.3.1 The Child as User

Based on analysis of relevant work, and her own research, Druin have defined four roles that children can play in the technology design process. In the first role, as in the role of user, Druin explains that children can contribute to the development by using the technology while adults observe. This may be a way to understand the impact existing technologies have on children [10].

Druin explains that this method might use methods similar to project's involving adult users. However, these methods needs to be adapted to the children's ages, cognitive and social abilities. Typically researchers might use methods of observation, especially when working with young children. Further, data concerning the users impressions of the technology can be collected through surveys and interviews. Druin emphasizes that the language used in the surveys need to be appropriate and easy to understand [10].

2.3.2 The Child as Tester

In the second role, the child users can test prototypes of new technology. Druin explains that the goal of this role is for the children to help the researchers create new technology. As in the previous role, the child can be observed with the technology, but the researcher might also ask the children for direct feedback. However, Druin points out that children do not get to give feedback before initial prototypes have been created by the adults [10].

When including children as testers, Druin explains that the methods used can be quite diverse. Differing from the earlier role, the researchers also aim to find issues with the technology's usability. Further, she suggest keeping the children busy while they are not being testes with craft tables and cookies [10].

Usability designers at Microsoft has through extensive research designed and developed guidelines for how to tailor traditional software usability testing to allow children to participate.

In *User Interfaces for Young and Old*, Libby Hanna, Kirsten Ridsen and Kirsten Alexander presents guidelines developed by usability designers at Microsoft for tailoring traditional software usability testing for children. They explain that testing the usability will most likely not be an important factor in the evaluation. As mentioned by the authors, designing for children means designing for fun. Designers are often trained to focus on usability, but for children, product satisfaction easily overshadows product effectiveness and efficiency [14].

When working with preschoolers ages 2 to 5 years, Hanna et al. have experience that this age group require the most extensive adaptations of preferred methods. It is recommended that children in this age range should be allowed to explore the technology in their own pace and their own interests instead of a set of tasks which is more common in usability testing [14].

2.3.3 The Child as Informant

In the role as an informant, children may play a part in the design process at different stages, providing input and feedback. In this role, the children can be observed with existing technologies before the researchers has started the design process. When new technology has been created, the children can offer their input and feedback on the solution [10].

According to Druin, there are numerous ways to include children as informants in the design process. In the beginning of a project, researcher can observe the children with existing technologies, where the children can give design directions through their interactions with the technology. However, Druin stresses that children as informants can be included in the design process at different stages of a design process [10].

2.3.4 The Child as Design Partner

The final role described by Druin is the role of design partner where children are viewed as equal stakeholders in the design process. Jacko explains that the methods of including children as design partners borrow from the tradition of participatory design. She describes this design as an *"approach toward computer systems design in which the people destined to use the system also plays a critical role in designing it"*. She further mentions that with children, this idea is even more important since they are physically and cognitively different from adults. Their participation in the design process may offer significant insight [19, p. 847-848].

Druin explains that while children cannot do everything adults can do, as design partners they should have equal opportunity to contribute in any way appropriate. According to Druin, the most important goal of this partnership between adults and children is something she calls *idea elaboration*. This is when one participants build on the idea from another in the design group. She further expresses that this process is difficult when working with young children. To support idea elaboration, Druin suggest setting the participants' expectations regarding the design process, adapting the process of brainstorming, and how they reflect as a team [10].

She has found that expectations needs to be defined so that the participants can understand the their roles. Further, Druin explains that the participants will need time for negotiate a new *power structure* where the participants feel equal. This is also supported by Jacko, as seen in the quote below.

Empowering children in this way is way and including them in the design process can be difficult due to the traditionally unequal power relationships between kids and adults. (Jacko [19, p. 848])

Druin have in her work developed certain practices for negotiating the power structure between the participants, such as *no raising hands* and *use first name not last*.

Druin has also found that collaborating on design activities as soon as possible might help the participants build respect for each other [10]. Furthermore, Druin suggest including informal parts such as snack time, where the participants can discuss anything that comes to mind. She has also found that working with low-tech tools gives equal footing to both adults and children since using basic art supplies comes naturally to most people. Concerning collecting data, Druin suggest combining journal writing and video recording. Further, she suggest letting the young children use the camera as this might make the younger participants feel less self-conscious when they are being filmed by their peers and not by an unfamiliar researcher [10].

2.3.5 Summary

In this section I have presented the different roles children may take in the design process, and how methods could be adapted to be appropriate for the different roles, the children's ages, cognitive and social abilities.

Related work in form of projects with either educational technology, or projects on including second language learning into kindergarten curriculum or projects including children in the design process is presented in the following section.

2.4 RELATED WORK

This section is dedicated to related work. However, as this thesis project combines three disciplines, finding similar projects that includes second language learning that supports young multilingual children, educational technology, and including the users in the design process proved difficult. Therefore, presented in the following sections are relevant work from each of the three disciplines.

2.4.1 Related Work and Educational Technology

This section presents related work concerning the combination of technology and education. The two first projects present games for language learning, while the third project explores how technology can be used as tools in a kindergarten setting.

Martha Speaks

In the report *Learning, is there an app for that?*, Cynthia Chiong and Carly Schuler presents the results of studies that explores the feasibility and ef-

fectiveness of using apps for educational purposes for preschool and early elementary aged children. The authors presents a study where researchers gave 90 young children between the ages 3-7 a tablet on which to play two apps over two weeks, one which was *Martha Speaks: Dog Party*. Found in the study was evidence that the Martha Speaks application shows promise for vocabulary learning through introducing new vocabulary words through mini games [8].

Bobo and Apples

Bobo and Apples is a prototype for a multi-language and multi purpose games for young children between the ages of three to five. The game is designed to teach multiple languages and single math within a frame of a virtual environment, using mainly visual images, animation and sound. H. Holmen and F. Nielsen explains that increasingly many families today find themselves in situations that requires multiple languages. However, traditional language educational tools are often for learning one language at a time, and does not cover the need for learning multiple languages simultaneously [16].

Bobo and Apples mixes multiple languages automatically and simultaneously. The player controls Bobo a host character, and is given tasks focusing on the different aspects of a language, e.g selecting the correct fruit when the instructions are given that Bobo wants an apple.

The games was created in collaboration in two kindergartens. In the first kindergarten, 99 percent of the children were monolingual, while the other consist of largely multilingual children. The caretakers of the first group of children expected that this might be a tool that can inspire the children for second language learning. In the second group, caretakers and parents were interested in the game as a tool for translation.

As this is only a prototype and is in its early stages, how effective this kind of game will be still remains. However, the prototype had been received with much enthusiasms, indicating a need for such a tool in early education [16].

Creative use of Digital Tools

In a project exploring how the kindergarten can provide preschoolers with knowledge and skills connected to digital tools, author Catherine Fraggel Darre explores how technology can be a natural part of activities and projects. She empathizes that even though young children are big consumers of digital media, this does not necessarily mean the same as having digital competence [9, p. 10].

In her book, Darre presents the use of apps and games for educational purposes, but also how to use digital tools for creating an environment for learning. She describes projects where the children takes an active role in creating stop motion movies. Here the children take on the responsibility of taking the pictures and creating the content and later help putting the

images together to a stop motion movie together with an adult [9, p. 110-114].

In addition to describing different projects for combining technology with the different subjects taught in kindergarten, she has also dedicated a section to overcoming resistance from colleges and how to change the attitude of those critical to including technology in the kindergarten curriculum. Darre suggest by increasing the personnel's technological competence this might help these coworkers to overcome this disapproval [9, p. 57].

2.4.2 Related Work and Language Learning

This section presents projects that have explored how second language learning can be integrated into a kindergarten curriculum, and how second language teaching can be tailored for preschoolers.

Polly Put the Kettle On

In the book *Polly put the kettle on*, Eva Maagerø and Birte Simonsen presents a project that aimed to create a language stimulating environment by teaching the children English in a Norwegian kindergarten. In weekly sessions, the preschool children encountered English rhymes, songs and games [p. 95-100].

In the beginning of the project, the team members were met with negative reactions and disapproving glances from other employees - Accused of imposing school curriculum onto young children. This presents a common view that there should be a separation between kindergarten and school [25, p. 45].

Maagerø and Simonsen explains that learning through play should be the foundation when a young child is to encounter curriculum in kindergarten. This perspective build upon a general belief that young children learn through games and play, and that all variety of play is stimulating for the child. There is a strong conviction in the Norwegian society that play is important for the child to have a good upbringing, believing that play is the young child's most important learning arena [25, p. 28].

As with including technology into education, the authors stresses that it is crucial that the adults facilitating the children's encounter with unfamiliar languages are enthusiastic, motivated and happy to work with languages. Maagerø and Simonsen explain that this enthusiasm is critical for creating an environment for second language learning [25, p. 87].

English in the Kindergarten

English in the Kindergarten is a project where close to 30 kindergartens in one Norwegian municipality participated with the goal of developing environments for second language in the kindergarten by introducing English to preschool children [5, p. 9].

Results from the project showed that learning a new language can help the young children develop linguistic awareness, which is considered a crucial step before learning how to read and write [5, p. 24]. Further, the project refers to the National Curriculum for Norwegian Kindergartens, which has previously been described in Section 2.2.2. The Curriculum states that all children should experience a rich and diverse language environment in the kindergarten.

The authors of the book *Play with English in the Kindergarten*, Åse Bakken, Gro Ingunn Kaasa, Davina Talén, and Elena Tkachenko, gathered the experiences from the project that they believed could provide insight to how kindergartens can fulfill the requirements set by the national curriculum [5, p. 10].

Similar to the project *Polly put the kettle on*, this project also met opposition to including second language curriculum into a kindergarten setting. The authors stresses that the sessions with English was based on play, exploration and meaningful communication, and not traditional and formal teaching [5, p. 55].

Further, the project is based on Vygotsky's theories that learning happens when the child actively participates in the learning process, and through social interactions. The authors emphasizes for making learning happen, the children need to take an active role. Facilitating for this, Bakken et al. suggest letting the children explore English by working on projects together [5, p. 75].

2.4.3 Related Work and Co-creation

This final session presents the projects *KidPad*, *RHYME* and *SID*, three projects that explored how to include children as design partners in the development of new technology.

The KidPad

During the development of an expressive digital medium to support a learning environment for elementary school children, researchers Allison Druin, Jason Stewart, David Proft, Ben Bederson and Jim Hollan chose to establish a collaboration with members of the potential user group at the onset of the research [11].

Believing that children should have a say about the world we live in, and the technologies they use, Druin et al. steered away from traditional user testing with children. Traditionally, researchers have observed children using technology, and when appropriate asked them to participate in tests. Druin et al. explains that this may be well suited for testing the specific technology and its impact on the child, but does not really tell researchers what new technology should be created for the future. Even though chil-

dren may not be technology or pedagogy experts, they are experts in what they want and how they want it [11].

During the development of KidPad, the researchers combined participant observation techniques with participatory design experiences to better understand what children may want to do with the technology. In the project, Druin et al. included both computer scientists and educators as they believed both groups could contribute significantly to the development of educational technology. Further, by working in small groups both adults and children slowly seemed to become comfortable with each other and the technology. Druin et al. points out that as the children eventually felt more comfortable, they started giving design suggestions and pointed out problems with the software [11].

Through their experiences of working with the KidPad, Druin et al. discovered that when collaborating with children, they must be given opportunities for communication either through experiences with technology or through participatory design exercises as children often are not verbal about their needs. Further, the authors stresses that the children will be unequal partners in the beginning, and that equality needs to be facilitated by the adults. By giving the children time, experience and confidence, Druin et al. have found that children can grow to become full fledged designers [11].

Three Tensions for Participation

In their paper Harald Holone and Jo Herstad presents some of the challenges in involving children with severe disabilities as co-designers. The authors present experiences from the RHYME project that aimed to develop experiences for children with severe disabilities, their families and helpers. Drawing on existing literature on co-design with children, and their own experiences, the authors present three tensions for design principles for inclusion [17].

The first tensions is presented as the need of extra time versus rapid development highlights the need for patience and time. The authors explain that rapid prototyping is an important part of participatory design as it enables the participants to contribute with and discuss design ideas early in the design process. Further, the authors mention that the participants will need time to arrive at the same *starting line* e.g finding a common vocabulary to talk about what is going to be made in the process. When working with children with disabilities, the authors stress that the time needed will increase in order to arrive at this starting line [17].

Furthermore, more time might also be needed during the design process as the participants most likely will need to get accustomed to taking an active role. The authors point out that the role as decision maker is for many of these children unfamiliar, and suggest that care must be taken to make the roles adjusted in the early stages of the project. The authors suggest taking the familiar as a starting point, so both children and other participants can learn from each other in order to establish a platform for co-

creation. Further, as this group of children might have difficulties reflecting on abstract concepts, the authors suggest keeping the ideas discussed at a concrete level [17].

Finally, the third tension concerns the need for helpers to facilitate communication between the children and the co-designers has potential drawbacks that needs to be considered. The authors explain that children with severe disabilities have assistants who help them with communication, and that this mediated communication presents a challenge to the participation. The child's input on the design process might be simplified or misunderstood by the mediator. Furthermore, the assistants preconceptions might influence how the child's feedback is interpreted by the helper [17].

Ideation and Ability

By using a set of interactive yet basic tangible artifacts, Henrik Svarrer Larsen and Per-Olof Hedvall tackled the challenge of communicating with children with severe disabilities in a design process. In the paper *Ideation and ability: when actions speak louder than words*, the authors present an approach on how these design artifacts can facilitate the participation of children with profound disabilities in the design process. Taking the children's actions with these artifacts as input for ideation, Larsen and Hedvall sheds lights on including participants that cannot take part in cooperation that often requires actions like pretending, abstract thinking and dialogues [24].

In their design experiments, Larson and Hedvall built tangible artifacts that were easy to rebuild and alter, intended as tools for ideation. These designs were not aimed at creating a finished product, but rather functioned as explorative sketches that opened up for ways of engagement. Larson and Hedvall present these continuously reshaped artifacts as questions, hunches and understandings relating to the design, giving a tangible form to the design dialogue between the children and designers [24].

2.4.4 Summary

In this section related work regarding education and technology, second language as kindergarten curriculum, and how to include children in the design process has been presented.

From the related work on combining second language learning and kindergarten curriculum, learning through play is presented as a common denominator in the projects [25, p. 28][5, p. 10].

A common factor regarding related work on including children in the design process was facilitating for communication either through observing the child's actions or if possible through participatory design exercises such as co-creating a tangible low tech prototype [11][24][17].

2.5 SUMMARY OF THE CHAPTER

To find inspiration and to gather knowledge of the different disciplines that could be defined as significant to this thesis, relevant theories and relevant work has been described.

This chapter commenced with presenting literature regarding combining technology and early education. Following was a section presenting relevant theories on the learning theories, and theories on how we acquire our second language. A third section presents literature on including children in the design process and the different roles children can take during the process. Lastly, a section presenting related work on the three different disciplines was presented.

Furthermore, the literature presented in this chapter has influenced the choice of methods and tools selected for answering the thesis's research questions, which is presented in the following chapter.

3 METHOD

The focus of this thesis is how technology can contribute to creating an environment for language learning in an early age. The research question of this paper consists of one main question and three sub-questions. The research questions are respectively:

RQ 1: How can technology contribute to an environment for language learning for a young user group?

RQ 1.1: How can creating an environment for co-creation be facilitated?

RQ 1.2: How can children and adults together design a tangible artifact for exploring languages?

RQ 1.3: What are the potentials for making second language learning fun and motivational in the co-creation and the use of a tangible artifact?

This Chapter presents methods and tools selected for answering the research questions. Presentation Section 3.1 is methods suited for creating an environment for co-creating Succeeding is a presentation of the tangible artifact created in cooperation with the project's participants, see Section 3.2.

Following in Section 3.3 a section of the different methods and tools for creating and collecting data are presented. Succeeding is a section describing methods for analyzing the corresponding data, see Section 3.4. Subsequent is the presentation of a framework for evaluating the collected data, see Section 3.5. Lastly follows a description of ethical considerations concerning the project's young participants, see Section 3.6.

3.1 PARTICIPATORY DESIGN

As this report focused on including the potential user group throughout the development process, using methods and tools from a suitable methodology was therefore considered crucial for the project. The methodology should preferably support the children, kindergarten employees and technologists to cooperate as equals, and give the young children and non-technological a voice in designing new technology. The belief of directly involving users in the shaping of future artifacts found in the methodology of Participatory Design was therefore considered suitable for this projects aspirations [39, p. 2].

At the heart of Participatory design is the adamant commitment to ensuring that those who will use the technology also plays a crucial role in the design. The Participatory Design tradition is further defined by a perspective that consistently looks forward to the shaping of future technology [39, p. 2].

One fundamental aspect of Participatory Design is seeking to enable those who will use the technology to have a voice in the design, without needing to speak the language of a developer or designer. This is achieved by interactions with prototypes, and other tools that can represent developing systems [39, p. 2]. Another important aspect is the belief that people who are not professional technology designers or developers may not be able to define what they want from the designers. A process of mutual learning for all members, both technological experts and users, can aid the participants' ability to envision future technologies and how they can be used [39, p. 6].

In her paper, Druin defines participatory design as *"hearing what children have to say directly by collaborating on the development of low tech prototypes"* [10]. Additionally, hearing and speaking the same language as the children are essential, considering as adults our memories of our own childhood are influenced by the experiences we had since, and are understood in light of how we understand the world as adults. Even if we could remember our childhood exactly and purely as we understood it as children, we cannot escape the fact that our childhood took place in a different era.

One robust and relatively simple method created to enhance and expand the dialogue between designers and participants is the technique Future Workshop. By introducing a change in perspective, shedding new light on the well known, the participants and designers find a balance between what is, and what can be [39, p. 152]. The method is described in more detail in Section 3.3.1.

3.2 THE INTERACTIVE PAINTING

As this thesis project aimed to include a both young children and adults in the design process, it was necessary to explore how to facilitate for this cooperation. Taking inspiration from Participatory Design, participation was facilitated through the co-creation of a tangible artifact with familiar elements, through the phases of a Future Workshop. The implementation of the different phases can be found in Chapter 4. The tangible artifacts eventually became the two interactive paintings which are presented in more detail in Chapter 5.

Taking inspiration from the works of Larsen and Hedvall [24], and Holone and Herstad [17] the interactive paintings in this project were not only intended as tools for exploring languages, but additionally functioned as a tangible artifact for ideation. Due to the participants considerably young age, there was a need for the use of tangibles to replace the need for abstract

thinking, e.g how to teach and learn a language. As described by Pinter in Section 2.2.1 children’s thinking does not resemble adult-like thinking before the ages of seven and up [33, p. 33].

3.3 DATA COLLECTION

As this project aimed to involve its participants throughout the design process, data were naturally collected throughout the whole development process. The data collection is gathered from both the development process of the interactive paintings, and the subsequent interaction with the interactive paintings.

By Druin’s recommendations, the project included a combination methods for collecting data, such as observations, journal writing, recording of the sessions, interviews, and adult debriefing when collecting data [10]. The sessions for developing the interactive paintings followed the structure of a Future Workshop. The design sessions can be found in Chapter 4.

3.3.1 Future Workshop

Originally developed as a tool in the political fight for civil action groups to create a better future and to have a say in the decision making process getting there, Future Workshop has become a method for encouraging creative development by participants. The classic future workshop found in Participatory Design, consists of five phases, however modern future workshops may differ noticeably from the original [3]. The original phases are as follows:

1. Preparation phase
2. Critique phase
3. Fantasy phase
4. Implementation
5. Realization phase

The method according to the founders Jungk and Müellert, begins with the Preparation phase where rules and schedules are introduced to the participants. Following is the Critique phase where the participants brainstorm and visualizes questions concerning the problem that they are there to solve. Here, quantity has priority. The results are written on cards and grouped together according to topics that emerges from the cards [3].

After working with the problem, the participants work on creating an utopia and imagine future possibilities. As in the previous phase, all ideas should be collected. In the Implementation phase however, the ideas are

evaluated with regard to their feasibility. If a solution is found, an action plan for implementation is created. Then the concept and solution from the previous phase is realized in the Realization phase.

A modified version of the Future Workshop was used during the development process of creating the interactive paintings. Considering the participants' young age, the different phases of the workshop were spanned out over several days.

3.3.2 Observations

Hanna et al. explains that when assessing engagement, the focus should be on assessing the child's behavior as young children might have difficulty expressing their likes and dislikes orally. Observations were therefore used both during development and when the participants interacted with the interactive paintings. Furthermore, Hanna et al. suggest using observation as a means to gauge how much children like the solution, as behavioral signs are much more reliable than the children's responses to questions [14]. Additionally, while the adult participants observed the sessions, Druin suggests letting the children use the video camera, so the younger members may feel less self-conscious about being filmed as it is done by their peers [10].

3.3.3 Semi-Structured Interview

A semi-structured interview is a form of interview that allows the researcher to gather defined answers to defined questions, while it still leaves room for further development of these answers [43, p. 285]. The choice to use this kind of interview form related to the participant's young age. As they might have difficulties answering the questions, follow-up questions would most likely occur.

To gather the participants' ideas during the design and development of the interactive paintings, semi-structured interviews were executed during the process. After the implementations of the interactive paintings the participants were interviewed on how they experienced taking part in the development process, and what they felt about using the interactive paintings. According to Druin, interviews can be applied after the use of technology concerning their likes, dislikes, difficulties and motivation [10].

3.3.4 Participant journals

In her projects, Druin has used journal writing in order to keep track of project ideas and to evaluate the design process [10]. Considering the children's young age, and the fact that they have not yet learned to read and write, the young participants were asked to draw their reflections during the development of the interactive paintings. The children were asked about

what they had drawn and annotations were made by the adults regarding the children's thoughts and ideas.

3.3.5 Adult Debriefing

As one of the research questions focusing on how the user group could participate in the creation of the interactive paintings, reviewing the development process was also a crucial part in the data collection. The adult participants were engaged in short debriefings after the design sessions. According to Druin, this allows the adult team members to reflect on the design process, and how they can create better ways to help the children understand the concept or a difficult task for the next iterations. Druin explains that this allows the adult group members to take a step back, and look at the big picture [10].

3.4 DATA ANALYSIS

After data has been collected, analyzing the data comes as a natural step after the accumulation as little sense can be made just out of huge collections of data. Considering the qualitative disposition of the collected data, the methods for analyzing are naturally of the same nature. To analyze the qualitative data, I focused on using methods for extracting concepts and categories. The approaches selected for analyzing the data are presented in the following sections, respectively Section 3.4.1 and Section 3.4.2.

3.4.1 Transcribing

The interviews and audio recordings were transcribed using a denaturalized mode where idiosyncratic elements of speech was be removed. These elements include stutters, pauses, non verbal sound, and involuntary vocalization. Further, sensitive data such as names was be altered and replaced by pseudonyms. This particular method was chosen as the substance of the conversations was of more interest than depicting accents and involuntary vocalization often found in the naturalized mode [31]. As the observations the child's behavior was considered as equally important as the child's comments, the transcription was structured as dramatic scripts.

3.4.2 Open Coding

After the data has been collected and transcribed, the material underwent the process of Open Coding. As described by Khandkar, to be able to build concepts from a data source, the meanings, ideas and thoughts found in the

source must be exposed. Open Coding is suited to analyze qualitative data, and is often found in many Qualitative Data Analysis methodologies [22].

The first step in open coding is to break the data into pieces, that will be compared for relations, similarities and dissimilarities. One way to do this is analyzing the data line by line to find single concepts. The concepts that can be structured together will be marked with appropriate labels. The name of the labels can be taken from the content, or be decided by the analyzer. The concepts can be *in-vivo* meaning they were words used by the participants, or *constructed codes*, concepts named by the author [22]. The concepts from this process can be found in Chapter 6.

3.5 EVALUATION

As mentioned earlier by Hoel et al. building comprehension and understanding of a language requires effort and time [15, p. 43]. Furthermore, Jacko explains that as learning takes place over longer time periods, evaluation also needs to take place over longer time period [19, p.853]. Evaluating whether or not learning took place during this thesis project was therefore not possible. Nonetheless, the *Positive Technological Development Framework* was used for categorizing observations and feedback from the different sessions in order to examine if the participation in the design process, and the use of the interactive painting could encourage behavior that supports a positive development for the young users.

3.5.1 Positive Technological Development Framework

The Positive Technological Development framework (PTD), also known as the *six by six C's*, examines the developmental task of a child growing up in a digital era. PTD seeks to mentor children in the positive uses of technology, enabling the youth to live more fulfilling lives. PTD is influenced by the theories of *constructionism* by Seymour Papert and research on Positive Youth Development (PYD) [6].

Constructionism is rooted in the works of Piaget, and builds on the idea that children learn better when they explore and develop their own theories. It suggests that by creating an external object, individuals are more likely to construct internal knowledge [6]. Constructionism is described in detail in Section 2.2.1.

PYD research focuses on the relations between individuals, and aims to emphasize individuals strengths and assets, promoting valued characteristics and developmental assets that can lead a young individual towards a good developmental trajectory [6]. These developmental assets are presented in the list below.

- **Caring** - The willingness to use the technology to respond to the needs of others.
- **Connection** - The capacity to create and maintain positive bonds and relationships through technology, and promoting collaboration.
- **Contribution** - Contributing to society by using technology to solve problems engages in community building.
- **Competence** - The ability to use computers to create content or to problem solve.
- **Confidence** - A sense of confidence in oneself as one who can act successfully in a technology rich world.
- **Character** - A moral compass that guides the use of technology in responsible ways.

PTD aims to design and evaluate technology-based educational technology that can help children use the technology to learn, to express themselves creatively, to communicate, to care for themselves and others and to contribute to a community, while developing a sense of identity. To help children acquire these developmental assets, PTD focuses on encouraging positive behaviors supported by technology. The behaviors are: *Content Creation, Creativity, Collaboration, Communication, Community-building* and *Choice of conduct* [6].

3.6 ETHICAL CONSIDERATIONS

Guy Roberts-Holmes stresses that researchers need to be reflective throughout the project to ensure that the impact of participating is beneficial and not causing the child participants unnecessary stress and anxiety [36, p. 43]. Through the design process, I took certain measures regarding the ethical considerations when co-creating with young participants.

3.6.1 Informed Consent

Before starting the design process, consent forms was provided to the children's parents/guardians for them to sign. Robert-Holmes expresses that the parents should be informed about the research. In addition, Robert-Holmes stresses that if possible to gain the consent from the children themselves [36, p. 56]. The consent forms can be found in Appendix A.

In the beginning of the sessions, the children was given information about what was going to happen during the session, information concerning their role, and that it was voluntary to help the researcher and participate in the design process. The children was also told that their opinions and ideas

were highly regarded, and that the participation was voluntary, and if a child did not want to participate this would be respected. Roberts-Holmes expresses that the right to *not* participate has to be respected [36, p. 56].

3.6.2 Confidentially and Child Protection

Additional measures was also be taken in order to maintain the participants confidentiality. This included changing all the names of the participants into pseudonyms. Furthermore, images used in the report does not reveal anything that can expose the participants' identity. Further, the location and the name of the kindergarten and associated employees is not revealed in the report.

3.7 SUMMARY OF THE CHAPTER

The methods and tools selected for answering this thesis' research questions has been presented in this chapter. This has included the choice of Participatory Design, a methodology that could support the co-creation a tangible artifact as equals. Further, the method Future Workshop was described, presenting a method suited for encouraging active and creative development. Succeeding, different methods for gathering and analyzing data was presented. Subsequently, a framework for evaluating the technology was mentioned. Finally, ethical considerations for working with young participants were described.

4 DESIGN

This chapter presents how the participants co-created a tangible artifact intended for exploring languages through the phases of a Future Workshop. A description of the participants that participated in the design process is described in Section 4.2. The first session of the Future Workshop is presented in Section 4.3, followed by the second session that included a brainstorming session for finding solutions for the project, and is described in Section 4.4. The third and fourth phases concerned taking the ideas from the previous phase and transforming them into a tangible artifact, see Section 4.5 and Section 4.6. However, some preparations were needed before commencing the design process, which is presented in Section 4.1.

4.1 PRELIMINARY INTERVIEW

Before the workshop and prototyping could commence, a semi-structured interview was conducted together with a kindergarten manager at a kindergarten in Norway. The main goal for the interview was to find participants, both adults and children who could participate in creating the tangible artifact. In addition, finding possible themes and constraints for the artifact were also discussed during the interview. The interview was transcribed by using a denaturalized transcription mode, and later categorized into concepts by using the method of Open Coding, see Section 3.4.1 and Section 3.4.2.

The first concept that emerged from the interview was the use of concretes when teaching languages. The manager explained that the use of tangible elements were used to help the children understand the new word they were learning. Storytelling with concretes was one of the method used in the kindergarten. When telling the story, the story is supplemented with toys representing the different elements in the story. As an illustration, in the story of the Three Billy Goat Gruff, the story is supplemented with toy goats, a stuffed toy troll, a tiny wooden bridge and different colored felts representing the river and the grass at the mountain farm. A similar approach is also presented by Smidt. *"Props are essential to enable children to be able to talk and think about what they have said and done"* (Smidt [40, p. 86]). Another important focus when teaching languages was a focus on the social aspect of learning. The manager pointed out that to become a part of a community, language is key. This is also supported by Smidt:

The context in which children acquire a new language matters. Language is acquired when the learner understands messages. It is not grammar or vocabulary that is learned, but meanings and messages that are exchanged. So learning is social. (Smidt [40, p. 25])

After discussing the methods used for language learning in the kindergarten, the next concept focused on the use of technology by the children and the kindergarten's employees. The manager expressed that they wanted to use available technology not only to keep the children occupied, but wanted the resources to provide additional pedagogical content to the children's time in the kindergarten. The Kindergarten also intended to include the children as creators of the learning environment together with the adult employees. However, the manager mentioned that the current use of technology does not support this ambition. The present solution is a computer in a common area with pre-installed games selected by the ICT-employees, not by staff with pedagogical background.

After the interview was finished, the dates for the Future Workshop was set. Concerning the participants' young age, the different phases of a Future Workshop were spread out on different days and were planned to have a duration of approximately 30 minutes. A consent form was also provided to the participant's legal guardians, supplying information on the project, see Appendix A.

4.2 PARTICIPANTS

The participants in the design process consisted of five bilingual preschoolers between the ages of four and five, that had been selected to participate by the kindergartens manager. The following list presents the child participants with corresponding pseudonyms:

- Owen
- Oscar
- Sarah
- Lara
- Martin

Furthermore, two of the kindergartens pedagogical leaders volunteered to participate in the design process, Ingrid and Mary.

4.3 FIRST ITERATION – PREPARATION PHASE

Taking into consideration the children's young age, and the introduction of an unfamiliar adult, the first session focused on getting to know each other,

and becoming familiar with the project. Further, considering the participants young age it was important to ensure that the children's first experience with the project were enjoyable. The session therefore consisted of playing with technology, storytelling, drawing and snack time.

The session started with me introducing myself, and the project. After getting to know the children, a demonstration of technology that could be used followed. The technology that was demonstrated was the Bare Conductive Touch Board, an micro circuit board that can be connected to different objects, and when interacted with, the objects would trigger the Bare Conductive to play different sounds, as presented in Figure 1. The different objects were a banana, a pipe cleaner, and a drawing, and the sound produced by the Bare Conductive were different piano tones. When the child interacted with the different elements, they experienced the different sounds. The children were told that these objects and the sounds could be replaced by other objects and sounds later in the project.

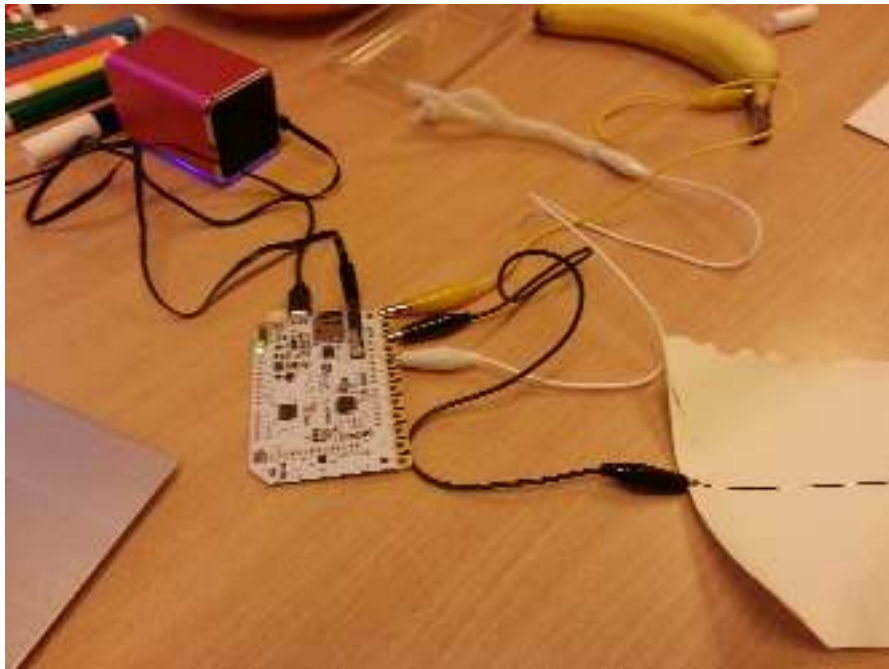


Figure 1.: Elements connected to a Bare Conductive circuit board, used to present possible technology that could be used to enhance the fairy tale.

After the children had tested and played with the technology, the session continued with telling the story of the Three Billy Goat Gruff^[41], see Appendix B. As this was set as a theme for the workshop, it seemed natural to brush up on the story for the children who already knew the story, and introducing it to the children who had not yet heard the traditional Norwegian fairy tale.

During the session, the children were seated around a round table, and were provided their own participant journals and drawing utensils, for documenting their ideas during the process, as seen in Figure 2. The use of participant journals is based on Druin's experience when documenting her

projects, presented in Section 3.3.4. As this phase solely focused on introducing the project for the participants, there were no ideas yet to document. The children therefore practiced using their journals by drawing scenes from the fairy tale, see Figure 3b and Figure 3a.



Figure 2.: Image from the first session where the children practiced on documenting the session.

As this was mostly to get familiar with the project, minimal recording devices were included in the session. This was to ease the children into being recorded. A camera was placed on the table, and the children were encouraged to use it during the session to document with photos, as suggested by Druin [10]. The session was further documented by photos taken by one of the adult participants.

After the session and snack time was finished, the children were thanked for their participation. The adult participants stayed behind for a debriefing, a method described earlier in 3.3.5. During the debriefing, the adult participant reflected on the session. Based on the feedback from the adult participants, the younger participants seemed to enjoy taking part in the session. Further, the adults seemed very interested in the use of technology, and expressed excitement of the possibilities the technology could provide. For the next session, one of the adult participants pointed out that the children should be introduced to the technology again with even more art supplies available to the children.



(a) Drawing of the troll after being defeated by the biggest Billy Goat Gruff from the fairy tale. (b) Drawing of the three Billy Goat Gruff walking over the bridge with the troll beneath.

Figure 3.: The children documented the session in their own journals.

4.4 SECOND ITERATION - IMPROVEMENT AND FANTASY PHASE

After greeting the children, the second session started with recalling collectively what the participants remembered about the project. This was not only necessary for creating a focus for the children, but also an introduction for the project for a new participant. Following the ideas of participatory design, letting the children participate when possible was vital. The children were therefore asked to share what they remembered instead of an adult repeating the focus of the project. The following section is a segment of the conversation from the session.

Ingrid: *"Do you remember what we are going to do in this project?"*

Lara: *"Make something".*

Ingrid: *"Yes, make something. What is it that we are going to make?"*

Lara: *"Flags!"*

Ingrid: *"Flags? No. What are we going to make for this project?"*

Lara: *"A fairy tale!"*

Ingrid: *"Which fairy tale?"*

Lara: *"Three Billy Goat Gruff!"*

The children was also encouraged to explain how the technology worked to the new participant. An addition to some of the same elements as last time, the children were presented with new conductive materials that could be used to enhance the fairy tale. The elements were tin foil, wire thread, modeling clay, and conductive sewing thread. While the new participant got the chance to play with the technology, the other children were given the opportunity to play with modeling clay or draw to keep the other chil-

dren already familiar with the technology busy, as suggested by Druin in Section 2.3

After the new child participant had interacted some with the technology, we proceeded with re-telling the story of the Three Billy Goat Gruff. Continuing with the idea of letting the children partake when possible, the children cooperated in telling the story together with an adult participant.

Following the structure of a classic Future Workshop, the Critique phase was the next stage in the workshop. Originally, a general and critical question concerning the problem is created in this phase, see Section 3.3.1. However, regarding the participants young age, amassing critique regarding storytelling was replaced with a brainstorming session focusing on collecting ideas on how storytelling could instead be improved. The participants were told that all ideas were welcome.

When brainstorming, the participants discussed what we could make with the different materials. After testing if wool and modeling clay were conductive and if they produced a sound when interacted with, one participant suggested the use of wool to represent the three Billy Goat Gruff. While another child suggested the goats should be made with something white. Another participant proposed using green felt to represent the grass at the mountain farm.

Ingrid: *"Maybe we could make the Billy Goats out of...?"*

Owen: *"Wool!"*

Further, the children suggested making the different parts of the story move on their own. The participants also discussed which sounds should be played when touching the different elements.

Ingrid: *"Maybe we could replace the sounds the computer plays with something else? What do you think the tiny Billy Goat Gruff should say?"*

Owen: *"Baaaah! or vaaaargh!"*

Caroline: *"Maybe the troll could say something like that?"*

Owen: *"Yeah.. or who is walking across my bridge!"*

The session was recorded with a film camera, and an audio recorder. As last time, the children were also offered to use a camera to document the session. However, the children seemed to take little notice of the different recording devices in the room.

The repetition of the project scope, repetition of the technology, the storytelling and the brainstorming ended up taking all the allocated time for the session, and snack-time and the documentation were therefore skipped. However, as most of the ideas were created collaboratively together with the participants, it is uncertain if the participants felt ownership to the different ideas, and therefore might have diminished the need for individual journal participation from this session.

After the children had been thanked for their participation, they were presented shortly with the plans for the next phase. The adult participant stayed back for a debriefing for discussing and reflecting on how the session had proceeded.

4.5 THIRD ITERATION - REALIZATION PHASE

The third iteration was recorded with an audio recorder, and documented with pictures taken by the adult participants. Further, the child participants were offered to use a camera to document the session. Due to illness, only one child, and one adult participant were present when the session started. A second child participant joined the session halfway through the session.

The focus of this iteration was to create a tangible artifact based on the concepts imagined in the previous iterations of the workshop. However, the goal was not only to create the tangible artifact, but also to create a tool for discussing with the younger participants how languages like their own could be integrated in the project. The idea of using the creation of the artifact as a tool for aiding engagement and dialogue in the design process was inspired by the works of Larsen and Hedvall [24], see Section 3.2.

After greeting each other, the participants started recalling what the project was about, and the fairy tale of the Three Billy Goat Gruff. Based on the belief that the children should participate when possible, they were asked to talk about what they remembered instead of an adult participant retelling the fairy tale and the project. After we had discussed the fairy tale and the project, the participants were given information on what was going to happen in this session.

As mentioned earlier, one of this iteration's goals were to create a tangible artifact. The artifact would present the different elements from the fairy tale painted on a canvas, with the corresponding words on different languages, emitted from a speaker when the child interacted through touching the different elements. The child participant painted the different elements from the fairy tale on a canvas. Which elements were completely up to the child participant's imagination, as seen in the short excerpt below. Later, the child also helped put thumbtacks on the canvas, that were later used to connect the elements to the Bare Conductive Touch Board.

Caroline: *"Is there anything from the fairy tale you would want to paint?"*

Owen: *"Yeah."*

Caroline: *"What's that?"*

Owen: *"The troll!"*

After the child had finished, he helped document the session by taking pictures of the canvas, see Figure 4. This is based on the idea of letting the child participate when possible, following the ideals of Participatory Design.



Figure 4.: Child participant documenting the finished interactive painting.

While the participant cleaned up, I connected the painting to the Bare Conductive circuit board to the canvas, by attaching spring clip wires to the circuit board at one end, and to the thumbnails in the canvas on the other. By connecting the two elements, sound could be triggered from the speaker connected to the circuit board when someone interacted with the canvas. More information on the interactive painting can be found in Chapter 5.

After the canvas and the technology were connected, the two child participants played with it while the adult participants observed, see Section 3.3.2. The results from the observation was later transcribed using the denaturalized mode, and processed using the method of Open Coding, see Sections 3.4.1 and 3.4.2. The results from the observation are presented in Chapter 6.

The reason for observing the participants use of the interactive painting so rapidly after it was created, was inspired by the works of Larsen and Hedvall [24]. They created basic interactive artifacts representing hunches, questions and dialogue between the participants and designers. The artifacts provided a tangible form to the design dialogue, and could easily be reshaped and redesigned to encourage engagement. This way, the interactive painting is not only a product of the session, but also a tool for discussion, ideation and cooperation.

Further, by letting the children interact with an example of how the language could be integrated, it could make it easier for the younger par-

ticipants to envision how it could be done differently. Thus, acting as a medium for discussing how language could be integrated in the next interactive painting.

Additionally, the participants' considerably young age was also a motive for choosing this method of rapid prototyping [17] and use of tangible artifacts [24]. By connecting the technological part the child participant had created together, the children could perhaps see the connection between his work and the technology.

After the children had tested the interactive painting, they participated in snack-time and a discussion on how other languages besides Norwegian and English could be integrated. When asked if they would like to draw their ideas, they seemed not interested in drawing in their journals.

When snack-time was over, the child participants were thanked for their participation, and shortly presented with the plans for next session. In the next session, the children would together as a group create a new interactive painting by painting, and gluing different types of craft supplies to a canvas. The participants were also told that next time, more languages would be added to the canvas.

This was followed by a semi-structured interview with the adult participants as presented in Section 3.3.3. The data collected from the interview was then transcribed using a denaturalized mode, and later processed using the method of Open Coding, see Section 3.4.1 and Section 3.4.2. The results from the interview is presented in Chapter 6.

4.6 FOURTH ITERATION - REALIZATION PHASE

As in previous iterations, the fourth session was recorded with an audio device, and documented with pictures taken by the adult and child participants. Two adult participants, and five child participants engaged in the session. One child showed up early and by herself to the session. The participant was supplied with drawing utensils and modeling clay while she waited for the others. After ten minutes, the other child participants came in. Some of the participants noticed the flags on the canvas, see Figure 5 and started talking about flags, especially their own flags.

Sarah: *"German flag!"*

Sarah: *"My flag!"* [Points to the German flag on the canvas]

Owen: *"This is my flag. Kosovo has two flags."*

As in previous sessions, we started by greeting each other, and continued by discussing the project, and the fairy tale. To encourage as much participation as possible, the children were asked to what they remembered about the project, and the last session. The children that had participated in the previous session were asked to share what we did in the last session. We then proceeded to talk about what we were going to do in this session.



Figure 5.: The flags on the canvas. Documented by one of the child participants.

The children were then presented with an almost empty canvas, and told that we were going to paint elements from the fairy tale on it. The children was given the possibility to explore the canvas on their own before they started to paint on the canvas.

Sarah: *"I want to press my flag!"*

Sarah tries to press the different buttons

Lara: *"Can I also press the buttons?"*

Caroline: *"Yes."*

Lara starts pressing the different buttons together with Sarah.

Before the session, the canvas had been prepared by adding buttons and flags to the surface, as seen in Figure 5. The Bare Conductive Touch Board had also been connected to the different buttons. This was necessary as this iteration of the interactive painting would include more languages than the previous iteration. The interactive paintings' functionality is presented in detail in Chapter 5.

Before painting, the children could choose which element they wanted to paint as long as it had a sound counterpart. We also discussed to place the paintings near the small buttons that could trigger the sound. The canvas before the children painted the elements from the fairy tale is presented in Figure 6.

One of the adult participants used a children's counting rhyme to decide who would start and who would be next to paint as they were eager to start painting. The children used the buttons on the canvas to hear what they could paint, and to find out where they could paint. While one child

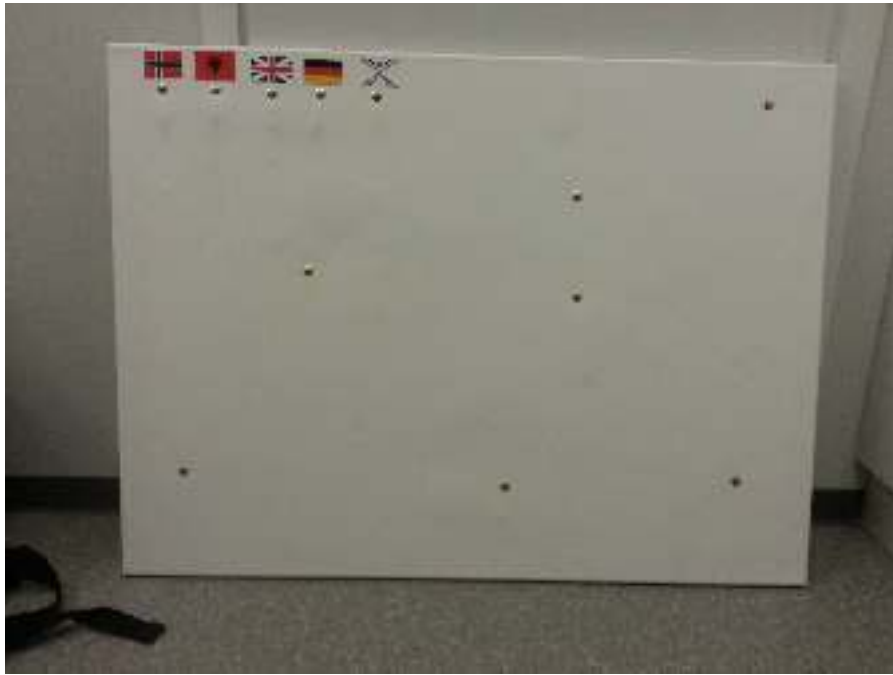


Figure 6.: The canvas before the participant added the content.

painted, the other child participants were provided with different art supplies so they would not get bored, as suggested by Druin [10].

After all the elements had been painted on the canvas, the children took a short break from the session to wash paint of their hands. As the interactive painting were assembled beforehand, and the files containing the language files had been prepared earlier, the children could test out the interactive painting as soon as they came back.

After we had finished the interactive painting, and the participants had tested it, we continued with an interview with the child participants, combined with snack time. The questions from the interview can be found in Appendix D. The interview consisted of questions created before the session, but as the interview followed the design of a semi-structured interview, the participants were allowed to digress and elaborate further if they pleased. The interview type is described in more detail in 3.3.3.

After the children had been thanked for their participation and left the room¹, the adults participated in a similar interview. The questions were similar, but had greater focus on educational benefits, assessing learning and the educational value of the technology. The questions can be found in Appendix D.

After the session was finished, the child participants got to present the interactive painting, and show how it worked to the other children at the kindergarten. Data was collected through observation, as suggested by Hanna et al [14].

¹ This did not happen immediately as the children stayed back to play with the prototype and to talk with the adult participants.

4.7 SUMMARY OF THE CHAPTER

Presented in this section was a description of the four sessions for co-creating a tangible artifact. The first session focused on preparing the participants for the co-creation by getting familiar with the project, an unfamiliar adult and new technology. The second phase included a brainstorming session for gathering ideas for how an artifact for exploring and learning languages could be created. In the third and fourth session, the ideas from the previous session was implemented as an interactive painting. The following Chapter presents a detailed description of the interactive canvases that was created in the third and fourth session.

5 THE INTERACTIVE PAINTING

This section presents the implementation of the interactive paintings that were created in the third and fourth design session. Section 5.1 presents the Bare Conductive Touch Board, the micro controller responsible for making the artifact interactive. Following is a section presents the implementation from the third iteration, see Section 5.2. Finally, is a section describing the implementation from the fourth iteration, see Section 5.3.

5.1 THE BARE CONDUCTIVE TOUCH BOARD

The Bare Conductive Touch Board is a micro controller that can be used to make projects interactive and responsive. The board has twelve dedicated touch electrodes¹, that when touched, triggers a sound via its on-board MP3 player. Figure 7 presents the micro controller used in this project.

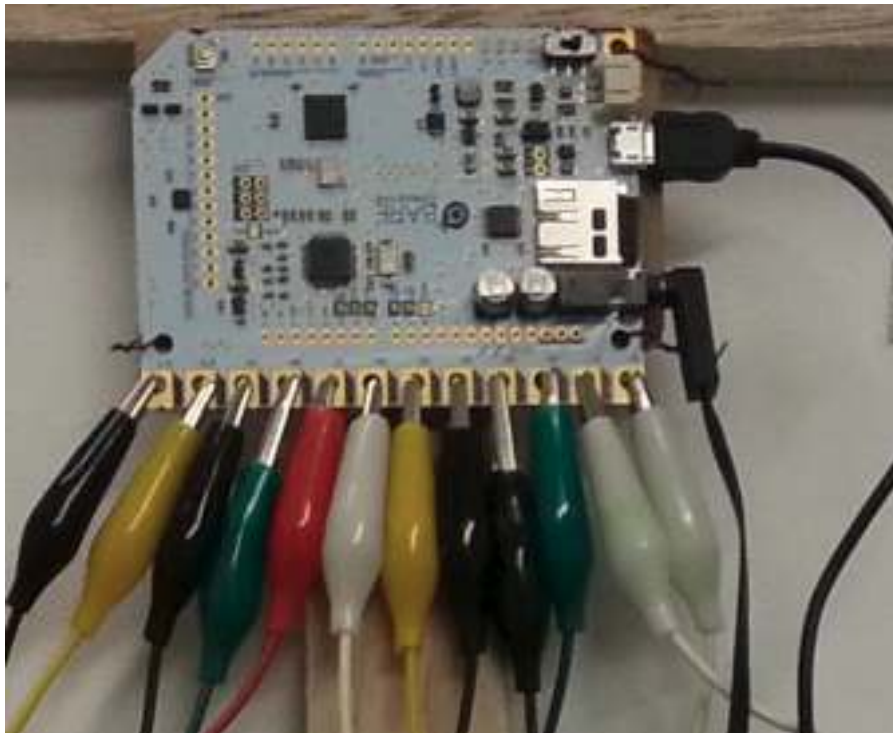


Figure 7.: The Bare Conductive Touch Board with Spring clip wires connected to each of the twelve touch electrodes.

¹ http://www.bareconductive.com/wp-content/uploads/2015/01/TouchBoard_TechDataSheet.pdf

5.2 FIRST INTERACTIVE PAINTING

The first interactive painting was created in the third session, see Section 4.5. Illustrations from the fairy tale *The Three Billy Goat Gruff* was painted by a child participant. The illustrations are presented in Figure 8. The child participant also helped put on two thumbtacks next to the different illustrations. The thumbtacks acted as buttons for triggering sound from the Touch Board.



Figure 8.: The canvas filled with elements from the fairy tale, painted by one of the participants.

Spring clip wires were then connected to each of the thumbtacks on the back of the canvas, as seen in Figure 9, and connected to the Touch Board. When pressed, the buttons would trigger a sound from the Touch Board's on-board MP3 player. Sound files in both English and Norwegian had been prepared before the session, and the ones that matched the illustrations selected by the child participants were added to the Touch Board. The English words included in this interactive painting are presented in the list below:

- Bridge
- Troll
- The biggest billy goat Gruff

- The medium billy goat Gruff
- The smallest billy goat Gruff
- Waterfall

This interactive painting used the Touch Boards existing code, which can be found in Appendix E. In this code, each touch electrode corresponds to a sound file on the Touch Board's SD card. This means that if the first touch electrode is triggered, then the first sound file would be played. However, this limited the interactive painting to only have twelve sound files. In the second interactive painting the source code of the Touch Board was edited to support additional sound files.

5.3 SECOND INTERACTIVE PAINTING

In this version of the interactive painting, the buttons and the Touch board were already added to the canvas before the children added the illustrations to the canvas, as seen in Figure 9.

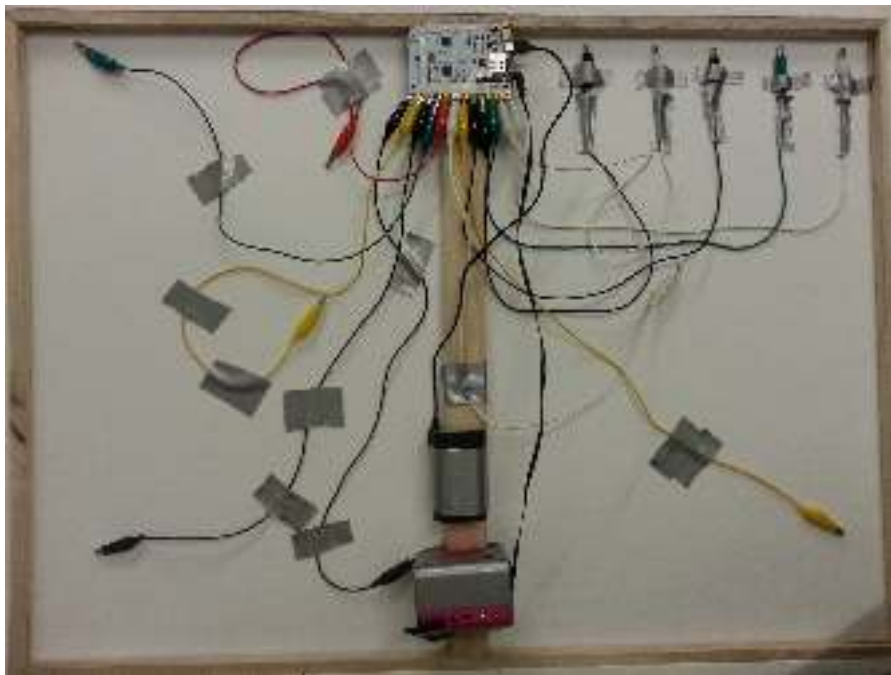


Figure 9.: The setup

By making some changes in the Touch Board source code, see Appendix F, this version of the interactive painting included 40 sound files instead of being limited to only twelve as seen in the previous version. This painting included the words presented in the list below in the languages Albanian, Arabian, German, English and Norwegian ².

- Bridge
- Saeter
- Grass
- The smallest goat
- The medium goat
- The largest goat
- Troll
- Waterfall

The participants could choose the desired language by pressing a button dedicated for selecting language, as seen in Figure 10.



Figure 10.: The interactive painting made by the participants in the fourth iteration.

For instance, if a participant pressed the button next to the British flag, and then pressed the button next to the illustration of the smallest billy goat, the words *"The smallest goat"*, would be played by the Touch Board. If the

² The Bosnian language was intended as a final language, but unfortunately this was not possible due.

participants choose e.g. the German flag and then pressed the button next to the smallest billy goat the words "*die kleineste Ziege*" would be played.

5.4 SUMMARY OF THE THE CHAPTER

This chapter has presented the Bare Conductive Touch Board, a micro controller used to make the paintings created by the participants interactive. Furthermore, this chapter presented the implementations from the third and fourth design sessions. The first implementation concerned an interactive painting that contained illustrations from the fairy tale *The Three Billy Goat Gruff*, and corresponding sounds to the illustrations in Norwegian and English. The second interactive painting also included illustrations created by the young participants. However, this version also included the languages Albanian, Arabian, German in addition to English and Norwegian.

Presented in the following chapter is results from observing the participants in the process of designing and creating the interactive paintings. Furthermore, Chapter 6 presents results concerning the children's interaction with the interactive paintings.

6 RESULTS

This chapter presents the data collected through observing the participants in process of developing and using the interactive painting. Further data is collected from interviews with both adult and child participants.

To make sense of the collected data, I applied an Open Coding process to the transcribed data. The findings from this process is described further in 6.1. The concepts found in the Open Coding process are presented with the help of the framework for Positive Technological Development (PTD), and are presented in Section 6.2.

6.1 OPEN CODING

The transcribed audio and notes from observations were processed using the method of Open Coding. The theories behind the transcription method, and the Open Coding process has been previously described in Chapter 3, and can be found in Section 3.4.2 and Section 3.4.1

The transcribed data were analyzed line by line for finding concepts. This resulted in paragraphs that were given one or more codes. The process of finding concepts that classified the data, would make it possible for analyzing the data later. The codes were either *in-vivo*, meaning the word was taken from the text, or constructed by the author. The following excerpt presents an example of the Open Coding Process, using both types of codes.

Owen: *"Can I press a button?"* ["Engaged"] ["Participating"] ["Voluntary"].

Child participant Owen presses the button below the Albanian flag, then a second button. The words for "The smallest goat" is played in Albanian from the interactive painting's speaker.

Ingrid: *"Wow!" "What did it say?"*

Owen presses the button again to listen one more time. ["Listen"]

Owen: *"Chapi"* ["Overcoming language barriers"]

Owen: *"Little"* ["Translating"]

The codes obtained from the Open Coding Process are presented in Table 1.

Co-designer	Funnier together	Teaching each other
Familiarity	Recognition of languages	Translating
Co-technicians	Context	Curious
Engaged	Shapeable technology	Voluntary
Repetition	Nationality	Cooperation
Discussion	Challenges	Tell, do not ask
Pride	Ownership	Sentiments
Single words	Monolingual	Multilingual
Opportunity	Alienated	Control
Co-creators	Social competence	Achievable
Globalized world	Patience	Relate
Sharing	Participating	Native language
Overcoming barriers	Passive to active	Remembering
Designer	New words	listening
Successful	Choice	Creators, not only consumers
Learning	Diversity	Insight
Need time to adjust	inclusion	interactive painting as a tool
Gentle introduction	Tangible	

Table 1.: The concept from the Open Coding Process

6.2 FINDINGS

In this section, I present the findings collected throughout the development process, and from observing the participants with the two interactive paintings by using the codes presented in Table 1. The findings are further classified by using the model "six by six C's" presented in the PTD framework, which has previously been described in Section 3.5.1.

As learning typically takes place over longer time periods [15], the need for evaluation naturally also take place over longer time periods [19, p. 853]. However this project's relatively limited time span makes it impossible to assess whether the participants have learned from creating and playing with the interactive painting. Nonetheless, I have chosen to use the PTD framework to categorize findings from the development process and the testing of the interactive painting. Even though the results of language learning can not be included in this report, the findings can be categorized to see if participation in the process and the use of the interactive paintings encourages behavior that supports a positive development for the children.

6.2.1 Content Creation - Competence

Presented in this section are concepts that adhere to promoting competence through content creation by participating in the development process. Furthermore, this section presents concepts promoting competence by using the interactive painting through play.

Through the Open Coding process, a total of twenty concepts was found that could arguably be interpreted as promoters of competence. In the following sections are three categories containing the concepts. The first category concerns competence as co-developers acquired through participation in the development process. The second concerns concepts that adhered to language competence through play, and the final regards social competence through both play and participating in the development process.

Competence Through Participation

Presented in this section are the following concepts: *co-designers*, *co-creators*, *interactive painting as a tool*, *co-technicians*, *from consumers to creators*, *remembering*, *shapeable technology*, *challenge*, and *familiarity*.

When asked about their role in the process, the first concept *co-designers* appeared. The children expressed that they had been given the chance to decide in the design process. This was further supported in the interviews with the adult participants. One of the adult participants pointed out that the children had been given the possibility to participate in the the different parts of the process, from decision making, to documenting the session with journals and pictures and also creating the interactive painting.

"I think the process has been successful. They've got the opportunity to do research, they have been given the opportunity to try out different things ... You have given them the opportunity to do the things they wanted, and that is important." (Ingrid)

Further, the adult participant mentioned that the children had the possibility to shape the sessions. They were not forced to do anything, but rather asked if they would like to participate and help the researcher with the project. The children were also allowed to decide what to do in the sessions. If they wanted playtime between the different tasks, this was granted to the children.

With regard to creating the content for the first interactive painting, a child participant took the role as content creator, both deciding on which elements from the fairy tale should go on the canvas and where he wanted to paint them. The participants also helped place the buttons on the canvas and helped with connecting the wires between the buttons and the micro-controller.

When we creating the second interactive painting, the elements that needed to be added to the canvas had already been chosen. However, the children seized the role as content creators by choosing which of the elements they wanted to paint, as long as they could find a corresponding sound on the canvas. The children needed little encouragement from the adult participants to actively seize the role as creators. Based on the child participants actions, the concept *co-creators* emerged.

A common denominator that emerged from watching the child participants creating the content, was the use of the buttons on the canvas for finding out what to paint and where. When creating the content, the children needed little instruction, and instead of asking the adults, they found out by themselves by using the interactive painting. This resulted in the concept *interactive painting as a tool*. An additional common factor emerged as the child participants all listened to the other languages as well as the ones they knew when finding out what and where to paint. An example of this behavior is presented in the following excerpt:

Lara is busy painting the waterfall in the fairy tale. When she has finished painting she presses the button next to the waterfall. The Norwegian word for waterfall sounds from the interactive painting's speaker. She changes the language to Albanian, and listens to what the word for waterfall is now. She continues doing this for all the languages.

With regard to the concept *co-technicians*, the children voluntarily helped debug the interactive painting when two of the wires were connected to the wrong drawing in the first version of the painting, resulting in the wrong sound being played. The children helped find the two wires that had been connected to the wrong button, and tested the sound after the wires had been switched to make sure the right sounds were played.

When asked in an interview if they saw other uses for the technology, one child mentioned a banana. This might seem like an odd answer, but in fact the child remembered from earlier sessions that everything that can conduct electricity can be used with the interactive painting to trigger sound, and a banana would work. When playing with it, one of the other children asked if we could connect other things, like an apple to the circuit board, further showing that they remembered how the technology could be used. The concept *remembering* arose from these observations.

Competence regarding the technology used to create the interactive painting might not have been the only technological competence the children acquired through participating in the development process. Knowing that technology is not just a finished product, but something that can be shaped and created was mentioned as one of the benefits the children had from participating in the project. In an interview, the adult participants discussed the differences between the interactive painting and educational apps on an iPad.

Although they were unaware of the results from studies such as Chau's [7], the adult participant mentioned a concern regarding apps for preschoolers. They expressed that it was difficult to know if the children could learn from the app, and mentioned that they usually played the games before installing it on the kindergartens iPad.

Further, she expressed concern regarding the children using only a finished technological product such as a tablet. She explained that the children became consumers when they should be creators as well.

Ingrid: *"They have that iPad, and they just expect that this is how things are."*

Mary: *"On the iPad, you touch the screen, and things happen, but they don't know how. It is so important [understanding how technology works], and so educational, and I believe that they [the child participants] have gotten such an ... an advantage on being a part of this [the development process]."*

The adult explained that participating in the project acted as a gentle introduction to the world of technology, and expressed that this was something they felt was crucial for the children's development. Additionally, the adult explained that the tangible solution could be easier to understand than apps. This reflection created the concept *tangible*. Furthermore, one adult participant pointed out that by being part of the process, the children got a better understanding of how technology can be created, and could become creators of technology and not only consumers. From these observations, three concepts emerged; *gentle introduction*, *shapeable technology*, and *creators not consumers*.

"Those who are young now are growing up in a very technological environment, and it is important to consider that these children should not only grow up to become consumers, but also creators." (Ingrid)

Before they interacted with the painting, the child participants were not told how it worked, but was left to explore the canvas on their own. The young participants had some experience with the micro controller before, while the other children in the kindergarten had not previously been introduced to the technology. However, there seemed to be little difference between the two groups. Both groups seemed not to need encouragement from the adults to find out how to interact with the painting. The combination of familiar elements such as the canvas, the thumbtacks and the paint with new technology such as the micro controller seem to make the children familiar with the new functions of the canvas. Based on these observations, the concept *familiarity* emerged.

Even though the children seemed to easily adapt to- and enjoy playing with the technology, integrating technology into a kindergartens curriculum does rely on the employees. One of the adult participants explained that introducing technology into kindergarten curriculum could be a *challenge*. She explained that the use of technology usually depends on the employees interests. She further argued that it was difficult for the less tech savvy users to keep up with the current technology suitable for young children.

"That's the challenge for us working in a kindergarten, we have to keep up with it [technology], and depends on own interests." (Ingrid)

However, the adult participants seemed eager to engage the technology as a part of the curriculum at the kindergarten, as expressed in the excerpt below.

"It has been really fun! I have looked forward to each session. I think this has been so incredibly fun, and you have really made me excited to continue with the project."(Ingrid)

When asked if they thought the use of technology such as the micro controller in the kindergarten could be achieved, the adults seemed positive to less tech savvy users integrating the technology into curriculum. Although the adults saw introducing technology as a challenge, they mentioned several times during the development process that this was a project they could see themselves continuing. Realizing the need for enhancing their expertise in using and understanding the technology the participants suggested creating a workshop with the other employees and me to learn how to use the technology in future projects. Based on this, the concept *achievable* was discovered.

Competence Regarding Language Acquisition

Another competence acquired through participating in the development process and the use of the interactive painting was linguistic competence. This is based on the following concepts: *language learning, single words, repetition, translating, context, insight, and new words.*

Linguistic competence was observed through the children repeating the words, creating the concept *repetition*. Further, this ability was seen when the children translated words from one language to another, creating the concept *translation*. The children also used this to help other children understand the meaning of the word. While one child pressed the buttons, another child with Albanian as native language translated the Albanian words played by the interactive painting to corresponding words in Norwegian. One child even translated from German to Norwegian, even though he had not had much experience with German before.

Sarah: *"Can hear it in German?"*

Ingrid: [To another child participant currently playing with the interactive painting] *"Sarah wants to try German"*.

Owen: *"German!"*

Owen changes the language to German by pressing the button under the German flag. Sarah presses the button next to the drawing of the smallest Billy Goat Gruff. The interactive painting plays the German words for "The smallest goat".

Canvas: *"Die kleinste Ziege"*.

Owen: [Translates from German to Norwegian] *"Lille bukkene Bruse. (English: Smallest Billy Goat Gruff.)"*

Further, the children expressed that they felt they had learned new words after playing with the interactive painting. This indication of learning was supported by the adult participants. They explained that it facilitated an environment for language learning through the possibility of exploring the different words in different languages. Based on these observations the concept *new words* emerged. Further, the adult participant mentioned that the process of getting to know the other children's languages was the start of a new insight for the children, creating the concept *insight*.

Ingrid: *"It is that they feel, with several languages, that one can choose Norwegian, and one can choose ones own native language, and check out other languages if you want."*

Mary: *"And this whole thing, they have been given the insight of something. And we too, not at least. It is quite true."*

Furthermore, some of the children were also observed reflecting on that some of the words was the same in the different languages. When discussing the facilitation of second language learning with the interactive painting, one of the pedagogical leaders of the kindergarten suggested focusing on the presentation of *single words* in the different languages instead of full sentences or full stories.

"I think you should focus on using single words. They are much easier to learn." (Ingrid)

Beyond translating and repeating the words from the interactive painting, the children were also able to put the words from the canvas into context of the fairy tale. The concept *context* emerged from this observation. When one of the participants pressed the button for the biggest billy goat gruff, he continued telling the rest of the sentence he knew from the story in Norwegian. An example of this behavior is presented in the excerpt below:

Canvas: "*The biggest Billy Goat Gruff!*"
 Owen: "*Som skulle til sæters for å gjøre seg fet.*" (English: "That was going to the mountain farm to make himself fat").

This is only one of several situations where the children managed to put the words into context. During playtime with other children that had not participated in the development, several of the children realized that the words played by the interactive painting was from the fairy tale of the three Billy Goat Gruff.

Social Competence

One of the adult participants pointed out that participating in the process and playing with the interactive painting did not only increase the children's linguistic and technological competence, but also could contribute to the children's *social competence* and social skills. Presented in this section are the concepts supporting social competence: *respect*, *cooperation*, *patience*, *relate* and *listening*.

Me: "*If we for a second now look away from the language learning aspect of the project, do you think the children have learned other things?*"

Ingrid: "*Yes, social competence. This is also a priority in the municipality. And cooperating is the highest level of social competence. ... It is important, very very important.*"

Cooperate was a concept that emerged quite often in the transcripts. And by participating in the process the children had to cooperate in order to create the interactive painting. Further, in the design process the child participants needed to *listen* to the other children's ideas and thoughts. *Listen* was also a concept that was discovered several times during observations.

When we created the interactive painting's content, the child participants was required to be patient and wait for their turn to paint. They also needed to relate to the other participants in the group and make room so the others also could paint on the canvas. Further, the participants needed to paint only the selected element. Based on this, the concepts *patience* and *relate* was discovered.

Respect is also a concept that is relevant to social competence. When playing with the interactive painting later, the participants had to let the other children use the interactive painting in turns. Both the participants and the other children needed to respect the other children's wish to play with it.

6.2.2 Creativity - Confidence

This section presents the concepts *pride*, *breaking language barriers*, *sharing*, *control*, *time to adjust*, and *unfamiliar*. The first three concepts relate to the participants obtaining confidence by providing them with a forum for experiencing and sharing languages. The last three concepts are related to providing the participants with confidence as co-developers, obtained through participation in the process of creating the interactive painting.

Confidence by Sharing and Experiencing Languages

Pride was a concept that emerged quite often from observing the children's behavior. They seemed not only proud of the solution we had created together, but also seemed to take pride in showing others what the different words meant in their languages. Whenever a kindergarten employee was curious about what the children had created, the child participants immediately wanted to show them how it worked. A short example from this behavior is presented below:

An employee drops by to see what the children are doing. Owen drops everything and quickly gets in front of the interactive painting. He changes the language to Albanian and starts pressing the buttons on the canvas. Owen translates the words from Albanian to Norwegian.

Canvas: "*Chapi më vogël.*"

Owen: "*The smallest Billy Goat Gruff.*"

Employee: *So cool!*

Canvas: "*Chapi të mesem.*"

Owen: "*The medium Billy Goat Gruff*"

Owen shows the employee how the interactive painting works for a couple of minutes before Sarah approaches the canvas and wants to show the employee the German words.

Sarah: "*Hear it in German?*"

The concept of pride also appeared in the interviews with the adult participants. The following excerpt present one of the many times pride was mentioned during the interview in the fourth session.

Ingrid: "*Yeah, they get a kind of ownership .. not ownership, but pride. Their own language, and being able to teach it to the others without having to say the words themselves.*"

Mary: "*And with Sarah, I felt.. Pride! She is very proud of her language, and when.. I felt that she.. This was something that belonged to her.*"

The participants seemed proud of sharing their native language and the interactive painting, establishing the concept of *sharing*. Earlier, Ingrid and

Mary both expressed that encouraging the children to use a different language other than Norwegian was difficult. The adult participants described it as a cultural *barrier*. In the kindergarten the children typically spoke Norwegian, and at home they used their native language. The following excerpt is taken from one of the discussions of this barrier.

When the children are in the kindergarten, there is a barrier to use their native language, and to teach us adults what the different words are in their language. They can talk with other children that also speak the same language, sometimes, but not always. They usually speak Norwegian.(Ingrid)

Nonetheless, this barrier seemed to disappear both for the *monolingual* native Norwegian children, and the *multilingual* children when playing with the interactive painting. When playing with the interactive painting, the monolingual children repeated the sounds from the different languages. One child even systematically went through all the elements in all the languages, and later showed that she could translate the English words to Norwegian on her own initiative.

The disappearance of the barrier was also noticed by the adult participants. When one of the child participants, Owen, started to translate from Albanian to Norwegian on his own without any encouragement from the adult participants, Ingrid expressed that she felt the project was quite successful. This was further supported by the adult participants in an interview. The following text is an excerpt from the interview.

Mary: *"You saw that Owen dared to say the things on his language. I have never experienced Owen doing something like that before."*

Ingrid: *"No, he has always been very careful not to."*

The children were seen breaking the language barrier in several occasions during both playtime and when creating the interactive painting.

Confidence through Participating in the Process

Due to their new role as co-designer, the concepts *unfamiliar*, *needing time to adjust*, and *control* emerged. When discussing the child participant's roles in the project the adults explained that it was important that the adults took some *control* in the beginning of the project. One of the adult explained that since the technology and participating in such a project was new to the child participants, it was necessary to steer the project in the beginning. From statements like these, and the statement below, the concept of control emerged.

"You kinda have to go through the plans and give them some ideas, and steer them a little. This is all new to them."(Ingrid)

Further, the children needed not only *time to adjust* to the role as co-developer, but they also had to get used to me.

Ingrid: *"They were a little cautious in the beginning, needed some help to start thinking."*

Mary: *"This has all been a little new to them. If we had worked with this some more, then they would have come up with even more ideas and thoughts. But, this is all very new, so I believe [the children's] fantasy will flourish if we start using it."* [refers to the technology]

However, the adult participants explained that the children seemed much more comfortable in the role as designers in the end, and would probably be much more engaged from the beginning next time around. This change in behavior was also seen during observations. In the third and fourth iteration the children seemed much more comfortable participating in the co-creation, sharing their ideas and languages.

6.2.3 Collaboration - Connection

This section presents the concepts supporting connection and collaboration between the participants. The concepts presented in this section are: *Tell, don't ask, translating, teaching each other, and ownership.*

Collaborating and learning

It was not only the child or adult participants' behavior that ended up as concepts. My way of asking questions sometimes created extra obstacles when trying to motivate the children into participating, resulting in *telling, not asking* appearing as a concept. The following excerpt presents one of several situations where asking the younger participants if they would like to do a certain task resulted in a simple no:

Me: *"Owen and Oscar, last time it was only us four here [third iteration], do you want to tell the others what we did at that time?"*

Owen: *"No"*

Although we encountered some obstacles when communicating, the children seemed to have little problem understanding the words played by the interactive painting. When interacting with the first interactive painting, the children managed on their own to translate the English words into Norwegian when interacting with the canvas. For example, when the button for the bridge was pressed, and the English word was played, the children quickly translated, and shouted in unison the Norwegian word. This is presented in the short example below:

Ingrid presses the button closest to the bridge painting.

Canvas: *"Bridge."*

Child participants unison in Norwegian: *"Brua!"*(English: "The Bridge")

However, the children seemed to translate not only for their own sake, but also to help the other participants. As described previously in section 6.2.1, the child participants helped each other understand the words played by the interactive painting by translating them into Norwegian. From this behavior the concept *teaching each other* was established. The following excerpt presents one of the situations where the children helped translate for each other.

Lara presses the buttons on the interactive painting. Owen is next to her and is so eager to get to press the buttons that he falls of his chair. Owen gets up, and starts pressing the buttons, but then lets Lara try again. Lara listens to the different languages. She changes the language to Albanian and starts pressing the other buttons. Owen starts translating the words so Lara will understand.

This cooperation between the children seemed to occur completely naturally without any suggestions from the adult participants. On their own initiative, the children started helping each other by translating and explaining, becoming a resource for the other participants.

However, the participants were not only eager to help each other when playing with the interactive painting, they were also eager to present the interactive painting to the other adult employees in the kindergarten. After some playtime, the participants naturally got bored playing with the it, and started playing with a camera, taking pictures of the canvas, the room and themselves.

However, as another kindergarten employee was curious about the prototype and wanted to try, then the child participants immediately wanted to show her how it worked. This initiated more playtime with the interactive painting. From this emerged the concept of feeling *ownership* of the prototype. This was something they had made, and they wanted to show the adult how it worked. This behavior was also noticed by the adult participants as well, as presented in the excerpt below:

"As soon as someone new entered the room, the children were immediately ready to show them the interactive painting." (Ingrid)

However, this sense of ownership had a different effect on one of the participants with regard to cooperation. The participants with languages included in the interactive painting were eager to show the other children in the kindergarten the interactive painting, and let the other play with it. However, this participant did not have her native language included in the interactive painting, and seemed less interested in sharing the prototype with the other children. She even expressed that this was hers to play with and rather ignored the other children that wanted to play with the painting.

6.2.4 Communication - Caring

This section presents the concepts that helps establish positive relationships and encourages the children to play together. The concepts found in this section are: *funnier together*, *inclusion*, *alienated*, *monolinguals*, and *multilinguals*.

Playing and Learning Together

Presented in the section above were results on how the children used the interactive painting to translate words for other participants unfamiliar with the currently selected language. The children who knew the language helped the others understand, encouraging children who did not understand the words to play nonetheless. The platform for exchanging words in different languages seemed to create both communication and play.

The participant's that knew a language also seemed inclusive, helping other participate in the play and be a part of the environment. This created the concept *inclusion*. When creating the interactive painting in the third iteration, one of the participants mentioned that he believed it would have been funnier to paint on the canvas as a group instead of by himself. Based on this, the concept *funnier together* was discovered.

However, one child stayed behind watching the other children play with the interactive painting during playtime. Not even invitations from the adults or the other children seem to make her change her mind. The child was told to come closer and to try the interactive painting if she wanted to. After a little while she came closer, but still continued only to watch the other children. After some time she carefully asked why her language was not included. Based on her reaction to the interactive painting, the concept *alienated* emerged. Although one child seemed alienated by the fact that her native language was not included, many other multilingual children seemed to enjoy playing with it and exploring the different languages even though their native language was not included in the interactive painting.

As the co-designers of the interactive painting were multilingual children, the observations have naturally been affected by this. However, the monolingual children seemed as interested in the interactive paintings as much the others. Additionally, the length of the playtime did not differ between the groups of monolingual and multilingual children. An additional observation regarding the monolingual children was that they seemed to be amused by hearing new types of sound, and easily repeated the words from the interactive painting. One Norwegian child seemed to prefer the Arabic language, listening closely and repeating the sounds while smiling.

6.2.5 Community Building - Contribution

The concepts found in this section are *a globalized world*, *diversity*, *nationality* and *challenges*, concepts that engages the participants in the society. These

concepts also adheres to community building, strengthening the kindergarten's bond to an increasingly globalized world, and to the children's families.

Community Building

The importance of including second language learning in kindergarten was often mentioned during discussions and in several of the interviews. The adult participant pointed out that in an increasingly globalized world, the kindergarten is also becoming more globalized, establishing the concept of *a globalized world*. The adult participants saw a need for including learning foreign languages in the kindergarten's curriculum.

About half the children in this particular kindergarten had a different native language than the country's spoken language. However, when discussing the kindergarten's current program for teaching the children a second language, it became evident that this type of program was relatively non-existing, apart from certain situations. If a child approaching school age started in the kindergarten with poor Norwegian language skills, the kindergarten employees will learn words from the child's everyday language from their parents.

However, the adult participants explained that communicating with the children's parents could be a challenge due to the lack of a common language. To strengthen the connection between the kindergarten and the parents, the adult participants foresaw the use of the technology as a way for including the parents more than before. The adult participants expressed interest in continuing the project on their own, explaining that the project we had created together was very suitable for another larger project currently taking place in the kindergarten focusing on second language learning. Based on this, the concept *opportunity* emerged.

"This is really exciting, and I see it as a great opportunity as a tool for working with languages." (Ingrid)

The project *Competence for Diversity* is based on a white paper for integration politics presented to the Norwegian Parliament issued by the government [1]. A presentation of the document can be found in Section 2.2.2. The paper states that all children shall be given an equitable and adapted education in both kindergarten and school.

"And we are becoming an increasingly more globalized kindergarten. And we are cooperating on a project with the county governor, and we could transfer the ideas from this project. ... We will first focus on cooperating with the children's parents." (Ingrid)

The kindergarten's first priority in the project is to involve the parents of multilingual children to a greater extent than before. One of the adult participant mentioned that projects such as the one we created together could

be a way of involving the parents. This was mentioned several time during the different sessions, and created the concept of "Including the parents". She further explained that this could strengthen the connection between the kindergarten and the children's families.

Due to the fact that the children immediately started talking among themselves about the flags that they recognized on the canvas when they entered the room, the concept of *nationality* emerged. Owen was very enthusiastic on telling the others that his language had two different flags. Sarah that had been very quiet during the previous sessions was the first to start talking about the flags when she recognized the German flag on the canvas.

Sarah: "*German flag!*"

Sarah: "*My flag!*" [Points to the German flag on the canvas]

Owen: "*This is my flag. Kosovo has two flags.*"

The children were naturally very interested in their own flag, but they also seemed to start recognizing the other participant's flags. When Sarah wanted to listen to the words in German, Owen helped by changing the language for her. He did this without anyone telling him which flag to press.

Further, the children seemed very aware that they all had different nationalities. When we discussed why the interactive painting had so many different languages, one child explained that this was because the participants in the group spoke different languages.

Although the participants seemed to have few problems selecting languages, one of the adult participant explained that some of the other children in the kindergarten might not have recognized the different languages solely by looking at the flags. She suggested adding sound that explained which language was chosen as well as the flag. This was also suggested by one of the children during playtime.

6.2.6 Choice of Conduct - Character

This section presents the concept relating to encouraging a sense of character. The concept presented in this section are: *developers, passive to active, choice, laughter, recognition of languages, sentiments, and engaged.*

In the role as designers

When discussing the children's roles in the project, the adult participants described the process as successful, and felt the children had been given the opportunity to participate. She also pointed out that the children had been given the possibility to participate in the the different parts of the process, from decision making, to documenting the session with journals and pictures, in addition to creating the interactive painting. Based on the role the child participants had in the development process, the concept of *designers* emerged.

"I think they have been given the opportunity to contribute, and allowed to provide input, and been heard." (Ingrid)

Further, the adult participant mentioned that the children had the possibility to shape the sessions. They were not forced to do anything, but rather asked if they would like to participate and help the researcher with the project. The children were also allowed to decide what to do in the sessions. Based on these observations, the concept *choice* emerged.

The child participants seemed to enjoy their role as designers, and needed little prompting to participate, except one participant. Discovered through observations, and again mentioned in an interview with the adult participants, one child seemed to prefer a passive role during the different sessions. The child seemed not very interested in sharing his ideas for the artifact, or participating in creating the interactive painting. He even explicitly said that he felt that the sessions were "too difficult", and that he rather do something else. This was a participant with poorer Norwegian language skills than the other participants in the group.

However, when the second interactive painting was introduced in the fourth session, the child started to take notice of what the other participants were doing. The child voluntarily took an active role after he heard a familiar language coming from the interactive painting's speaker. Even though the participant did not want to paint the different elements, he did play with it for quite some time. The adult participants also noticed this behavior, and expressed delight over his participation. From his behavior, the concept *from passive to active* appeared. This is one of the situations where the concept *recognition* of languages emerged.

"Yeah, you saw how his eyes just lit up when he got to play with the canvas in his own language. It was really fun to see, he became just so.." [She draws a deep breath, smiles and holds her hand over her chest] *"just.. yeah."* (Mary)

The situation described above created much enthusiasm and joy from the adult participants. However, this was not the only time where positive sentiments and laughter was observed. During both the development process and during playtime, one behavior that were especially prominent when the participants interacted with the interactive painting was laughter. Both adult and child participants seemed to have fun. This was further backed up through the interviews after the sessions.

Me: *"What did you guys think about using the canvas?"*

Oscar: *"Good!"*

Owen: *"It was fun."*

When talking about the interactive painting, the adults expressed positive sentiments, as shown in the excerpt below.

Ingrid: *"I am really impressed."*

Mary: *"Me too."*

Ingrid: *"Fantastic"*

Positive sentiments like cool, fantastic, successful were some of the words used by the participants and others during both playtime and the development process, creating the concept of *sentiments*. Additionally, the participants seemed to enjoy the development process as well. The concept *engaged* emerged based on the participants eager to create the content on the canvas. When asked who would want to paint the first element, one child exclaimed that she was going first, while three others raised their hands to show their interest.

The children needed little prompting from adult participants to play with the interactive painting. The children voluntarily played with it, listened to the different languages, and by themselves started to translate the words from one language to another.

Mary: *"I feel the children had a great time. "We actually had to throw them out [when the session was finished], you saw that yourself."*

Ingrid: *"And that pride they had, and the joy! Like, and they were so eager to hear the different languages. They were so eager, and there was such joy, I feel that it was fun. They were engaged."*

The participation in the process and playtime with the interactive painting seemed to engage the child participants. As previously mentioned one child even fell off his chair as he was so intent to press the buttons on the canvas¹. However, it was noted that not only the child participants seemed to enjoy participating, the adult participants also seemed engaged. Additionally, it was not unusual for other employees to drop by to see what the participants had created.

6.3 SUMMARY OF THE CHAPTER

In this section I have presented the findings from the Open Coding process, based on data collected from observations and interviews, previously described in Chapter 3. The findings has been classified by the PTD framework, see Section 3.5.1.

In the first category, concepts relating to promoting different types of competence was presented. Competence as co-designers was the first competence that emerged based on the children's roles in the development process. Both supported by observations and statements by the participants suggest that the children obtained competence as co-developers by participating in the process. Competence regarding language acquisition was also

¹ Do not worry, the participant was unharmed from the fall.

presented in this section, focusing on language learning by participating in the design process and during playtime. The last competence focused on the interaction between the participants, suggesting that the process and playtime with the interactive painting could foster social competence.

The second category focused on concepts correlating to promoting confidence. This section consists of two parts, confidence obtained through sharing and experiencing languages, and obtaining confidence as co-developers. The following section presented concepts supporting collaboration between the participants. During playtime, the participants collaborated easily and voluntarily without needing encouragement from adult participants. Furthermore, the children seemed to use the interactive painting as an environment for teaching each other words from their native language.

The next section presented concepts describing how the interactive painting could encourage the participants to play together. The participants were mostly inclusive, and wanted to show others how it worked. However, one child seemed alienated because her language was not included in the interactive painting. The following section presented concepts describing how to engage the participants in contributing to society, and concepts that adheres to community building. With regard to community building, the need for integrating second language teaching in kindergarten was presented. Integrating the use of technology was also seen as important for a modern kindergarten. The adult participants saw the technology as a tool for language learning, but also as an environment for cooperating with the parents of multilingual children.

The final section presented concepts that might encourage a sense of character. The adult participants explained that the younger participants had been given through the development process the possibility to act as designers.

The following chapter presents a discussion of the results presented in this chapter.

7 DISCUSSION

In this chapter I discuss my research questions in light of the findings presented in Chapter 6. I also discuss my findings in view of relevant theories and similar work presented in Chapter 2. The research questions are respectively:

RQ 1: How can technology contribute to an environment for language learning for a young user group?

RQ 1.1: How can creating an environment for co-creation be facilitated?

RQ 1.2: How can children and adults together design a tangible artifact for exploring languages?

RQ 1.3: What are the potentials for making second language learning fun and motivational in the co-creation and the use of a tangible artifact?

Firstly, I discuss research question 1.1, which involves discussing the prerequisites for making the co-creation possible, see Section 7.1. Successively, I discuss research question 1.2, highlighting my experiences of co-creating with young participants and the process of co-creating an artifact for exploring languages, see Section 7.2.

Subsequently, I shed a light on the potentials of language learning through co-creation by discussing research question 1.3. Additionally, I discuss how the artifact, the interactive painting, might facilitate for fun and motivational language learning, see Section 7.3. A summarizing discussion of the three sub research questions are then presented in Chapter 8

7.1 CREATING AN ENVIRONMENT FOR CO-CREATION

Based on reviews of projects involving young participants in the design process, and insight on how to work with children accumulated from the projects presented in Chapter 2, I discuss in this section how I choose to adapt methods from Participatory Design, facilitating for co-creation with preschoolers. Additionally, the restrictions that were necessary in this project for creating an environment for co-creation is presented.

7.1.1 Adapting the Methodology

I choose the methodology Participatory Design as it is defined by a perspective that constantly looks forward to the shaping of future technology. And as today's generations are growing up in an increasingly technological world, enabling those who starts to interact with this environment so early on might have potentials for creating novel solutions. Traditionally researchers have included children in the evaluation of technology to understand the impact specific technology might have on children. However, it does not tell the researchers what new technologies could be created for the future. Further, Druin et al. explains that if children can be heard before the technology has begun to be developed, more profound technology innovations might be possible [11].

Participatory Design is also committed to ensuring that the ones using the technology also plays an important role in the development process [39, p. 2]. It is therefore critical to find methodologies that support children's role in the whole design process [11]. However, even though the methodology is quite adamant in making sure the users have a voice in the development of new technology, not all user groups are able to voice their opinion. Hanna et al. explains that preschoolers especially might have problems expressing themselves orally [14]. This is also supported by Druin, see quote below.

.. as we know, young children have a more difficult time verbalizing their thoughts, especially when it concerns abstract concepts and actions. (Druin [10])

Nonetheless, researchers such as Druin have previously tackled the challenge of giving young participants a voice in the design process. She defines participatory design as *hearing what children have to say directly by collaborating on the development of low tech prototypes.* [10]. The approach of using artifacts and prototypes in order to generate co-creation is also seen in projects involving young children with severe disabilities, children that might not have the ability to vocally or cognitively contribute with their ideas [24][17].

Taking inspiration from Druin et al. [11] work on the KidPad, Holone and Herstad's [17] work on the RHYME project, and Larsen and Hedvall's [24] work on the SID project, this project aimed to create an environment for co-creation of a tangible artifact.

Reshaping The Future Workshop

To facilitate for co-creation through the creation of a tangible artifact, I choose Future Workshop, a method from Participatory design that consist of five phases, and aims to encourage creative development by the participants through the creation of prototypes [3]. The method is described in detail in Section 3.3.1.

A traditional Future Workshop begins with a preparation phase where the participants get introduced to the rules of the workshop, which is fol-

lowed with a Critique phase where the participants brainstorm in order to visualize questions regarding the problem they are trying to solve. Which then is followed by a fantasy phase where they imagine an Utopian situation, and an implementation phase where ideas are evaluated according to their feasibility, and are later realized in a final phases [3].

However, instead of following the structure of a traditional Future Workshop I decided to drop the second phase. This was a deliberate choice as the problem concerned abstract elements such as technology and language learning, and would possibly very challenging for the children to brainstorm about. Additionally, as the tangible artifact were not meant to improve or replace an existing solution, brainstorming how this could be improved also seemed difficult.

Further alterations were made with the Future Workshop. When working with adult participants, a Future Workshop often takes place in one session. However, taking the participants young age into consideration, the different phases were distributed over several days and was planned to last a half hour so not to tire or bore the children. Hanna et al. explains that preschoolers will last on average about 30 minutes in the role as testers. They further explain that preschoolers will need extra time for play and exploration, and suggest scheduling for the session to last an hour [14].

The sessions usually took longer, usually from 45 minutes to 1 hour and 30 minutes instead of the estimated time. This was often due to play time that took place during the sessions, e.g after we had told the fairy tale, some of the children wanted to play with the toys from the story. In some cases the children did not leave the session after it was finished, but staying back talking with each other and the adults.

"I feel the children had a great time. We actually had to throw them out. You saw that yourself." (Mary)

There is a strong conviction that play should be the foundation when a young child is to encounter something that resembles curriculum in kindergarten [25, p. 28]. And as co-creators with a say in what happens in the design sessions, it seemed wrong to deny the children the play time that regularly occurred during the sessions.

After the first session, it became evident that I needed to incorporate the possibility for free play when planning the sessions. Holone and Herstad highlights the need for extra time and patience when working with young co-creators, and expresses that all design partners must have respect for the amount of time needed. This is considered crucial by the authors, so the child participants might be able to give their perspective, take initiative and reflect on the other participants' ideas [17].

7.1.2 Getting ready for the Role as Co-Designer

As a consequence of distributing the phases of the Future Workshop on separate days demanded that each session included an introduction, and in some cases a repetition of the fairy tale *The Three Billy Goat Gruff*. In the introduction the children were reminded about their roles in the project and what we were going to do in that session.

Druin found in her work that expectations must be defined so all members of the design team understand the roles they play in the design process. She also mentions that it is hard for both children and adults to believe that they are truly equal partners. She expresses that the children need to learn that their ideas are valuable and will be heard by the adult participants [10].

Although this introduction, and retelling of the fairy tale seized time from the time allocated for the design process, I believe it gave the participants the opportunity to settle into the role as co-creator. As explained by Holone and Herstad, the role as decision maker might be unfamiliar for children, and suggest taking care to make the roles adjusted in the early stages of the project [17].

In her work, Druin has developed practices to help set the expectations in the beginning of a project, attempting to support a feeling of equality among the different members of the design team. In order to change the *power structure* between adults and children, Druin suggest the processes of *no raising hands* and *use first names not last* [10]. However, from observing the participants in this project, these practices were already a natural part of the children's environment in the kindergarten, and were not a challenge in this project.

Making the unfamiliar familiar

Additional measures were taken to ensure that the children were given the possibility to become equal co-designers before commencing the co-creation. The children were given the opportunity to play with and explore the technology before any brainstorming on how we could use the technology. This was based on experiences shared by Hanna et al. suggesting preschool participants be given the possibility to explore the technology in their own pace [14].

In addition, the combination of new technology with something familiar was the starting point in the design process.

By taking the familiar as a starting point, both children and other participants can learn from each other to establish a good platform for co-creation. (Holone and Herstad [17])

When Holone and Herstad discusses familiarity, it concerns finding areas in children's life's where they are used to make decisions and take initiative to inspire the design environment in order to aid the children take the role as contributor in the design process.

As mentioned earlier, the children Holone and Herstad targeted were children with severe disabilities. They describe these children as unaccustomed to taking the role as an active participant and are more familiar with having other people making decisions for them [17]. Druin explains that this might also apply for children without disabilities as well.

... where young people are dependent on their parents and teachers for everything from food and shelter to educational experiences. At times these relationships may make it difficult for children to voice their opinions when it comes to deciding what technologies should be in schools or at home. (Druin[10])

Taking inspiration from this, the unfamiliar technology used in this project was combined with familiar elements to help the young participants seize the role as co-creator.

Getting to know a new adult

In addition to settling into the role as co-designer, the young participants also needed to get to know a new and unfamiliar adult, me. An additional reason for dividing the Future Workshop into separate sessions was that I hoped it would give the children time to not only get used to their new roles, but also used to working with me. This was further facilitated by choosing a small group of participants so I could get the chance to get to know the participants, and so that they could get used to me.

One technique that seemed to put both adults and children at ease was that researchers worked in small groups with students (e.g., one researcher to two or three children). Slowly, both adults and children began to feel more comfortable with the technology and each other. (Druin et al. [11])

This approach was also used by Druin et al. as seen in the quote above. In the same paper, Druin et al. refers to the CHI'95, where 50 attendees worked with 25 children in small design groups to prototype multimedia environments for children.

7.1.3 Restrictions

Although I aspired to give the children the possibility to seize the role as equal design partners in the design process, some restrictions to the participants' role had to be made regardless. Before starting the design process, the kindergartens manager suggested creating some restrictions for the process by selecting a theme, which ultimately ended up being the fairy tale of *The Three Billy Goats Gruff*, see Section 4.1.

When looking to my peers, their project usually have some theme or starting point for ideation and creation, e.g the KidPad project started with an

already existing product [11]. Creating some restraints were also supported by the adult participants in the first session. The adult participants also supported this, and explained that it was justified by the unfamiliar nature of role the children were to take on as co-creators. Further, as mention by Holone and Herstad, full participation might not always be the ultimate goal for all team members, and suggest finding the right balance for the participants to participate in the process [17]

Technology

In this project I choose the *Bare Conductive Touch Board*, together with the kindergarten's manager before commencing the design process as she suggested that creating some constraints on the project would make it easier for the children to participate. This choice was also supported by the adult participants, as seen in the expert below.

"You kinda have to go through the plans and give them some ideas, and steer them a little. This is all new to them." (Ingrid)

However in an Utopian situation the workshop could have started with the exploration of other types of technology that could be shaped by the participants. Druin et al. suggest that if children can be heard before starting the design process, technology innovations may be possible [11]. And in an ideal setting, the participants could have a say in what kind of technology to be used.

Sound

It was not only the technological aspect that fell victim to restrictions. Although I aspired to give the children the chance to create both the visual and auditory content, the adult participants explained that the children were less likely to use their native language in the kindergarten, see quote below.

"When the children are in the kindergarten, there is a barrier to use their native language, and to teach us adults what the different words are in their language. They can talk with other children that also speak the same language, sometimes, but not always. They usually speak Norwegian." (Ingrid)

Smidt explains that this is about belonging. Children want to be the same as other children. Which means speaking the same language of the other children [40, p. 25]. The auditory content was therefore collected through the cooperation with language teachers.

7.1.4 Summary

In the previous section I have presented how the children were given a voice in the development process through co-creating a tangible artifact. I have

also discussed my choices for tailoring the Future Workshop to better suit the needs of the young participants. Not to tire the children, I have found that to separate the different phases of the workshop, and having them last no longer than one hour seem to suit the young children's attention span. Further, this separation of the sessions might also have given the children the needed time to get used to an unfamiliar adult. I also discovered that the flexibility to include free play during the sessions was necessary when planning the different sessions.

By dividing the Future Workshop into different sessions, the children were introduced to their roles, the project and what we were going to do in each session. I believe this might have given the children additional time to settle into the role as co-designer. The children were also given several opportunities to play with the project's technology in order to make something as unfamiliar as a micro controller familiar.

I also discussed restrictions that was be necessary for the children to participate in the development process, such as deciding on a theme for the design sessions in order to make the process a little less abstract for the young participants.

7.2 THE PROCESS OF CO-CREATION

In this section I discuss the process of co-creating the interactive painting. First, I discuss experiences from a brainstorming process with the young participants. Following is a discussion of my experiences of creating the interactive painting in cooperation with the participants. In this discussion I look at the outcome of the chosen methodology, and the different roles the participants in the design process. Lastly, I discuss how the participants were given the chance to reflect on the process of co-creation.

7.2.1 Brainstorming for Ideas

The story of *The Three Billy Goats Gruff* acted as the starting point for ideation in the two earliest session. This was a fairy tale the children knew by heart. As described earlier, I wanted to take the familiar as a starting point, so that the participants could learn from each other [17]. By basing the co-creation on something the children knew very well, then they would have an expertise which they could contribute to the project with. In addition to being experts on being children, and what they want as a user group [11].

When we brainstormed how to create an artifact for language learning with the technology we had at hand the children were eager to share their ideas. However, this was only the case when they could envision a solution by combining the technology, and the fairy tale with familiar tangible elements such as paint, crayons, paper, wool, pipe cleaners, canvas and

modeling clay, e.g one child and adult participant envisioned a troll made of modeling clay with glowing eyes that sounded scary.

However, when I asked the children on what they imagined we could do with the technology alone, they seemed hesitant to answer. One suggestion for why this is can be found in Druin's works, as presented in the quote below.

... as we know, young children have a more difficult time verbalizing their thoughts, especially when it concerns abstract concepts and actions. (Druin [10])

Another explanation might be that the familiar tangible elements created a common ground for the vocabulary used when the children explained their ideas, see quote below.

In all such processes, time is needed to get to the "starting line", for example to find common vocabularies to talk about the artifacts being designed. (Holone and Herstad [17])

For brainstorming, Druin has a similar approach to mine. However, Druin suggest starting by observing the children with current technology through the use of the method contextual inquiry. This way researchers can understand what children want [10]. However, in this project, the kindergarten did not have anything similar to the technology we ended up using for the tangible artifact.

Observing the participants with current technology could have given the children a voice in selecting the technology as previously discussed in Section 7.1.3, in addition to contribute with an understanding of what children want. After the first session, Druin takes the insight gathered from the contextual inquiry into a Participatory Design session where the children could use low-tech materials for creating prototypes [10].

7.2.2 Creating the interactive painting

The interactive painting was not only created as a tangible artifact for language learning, it also functioned as a tool for engaging the young participants in the design dialogue [17][24], which is an important aspect of the Participatory Design approach.

... two principle roles reflect two fundamental aspects of Participatory Design. The first is that it seeks to enable those who will use the technology to have a voice in its design without needing to speak the language of professional technology design. This is achieved through interactions with prototypes, mock-ups and other tools that can represent developing systems and future practices. (Simonsen and Robertson [39, p. 2])

Differing from the projects of Druin where she aims to include young participants to evaluate and test solutions for creating better design for children, this project never intended to create a finished product. - The process of creating the artifact held the same value as the artifact itself [11].

Furthermore the creation of the interactive canvas took something abstract as language learning and technology, and made it easier to understand by making it tangible for the young participants. The children also used the technology behind the interactive painting as a tool for adding content to the canvas.

Additionally, the process of creating the interactive painting was inspired by the notion of *Rapid Prototyping* as presented in the quote below.

Rapid prototyping and quick and dirty design is an important part of participatory design processes. This enables participants to contribute with and discuss design ideas at an early stage and throughout the project, bringing their own understandings and desires to the table.
(Holone and Herstad [17])

The goal on the third and fourth iteration was to take ideas from the previous sessions, and create the interactive painting in cooperation with the participants. This meant that in the end of the session, the interactive painting would be finished and ready to be used. As mentioned by Holone and Herstad in the quote above, rapid prototyping could enable participants to discuss ideas throughout the project, and by finishing the interactive painting in the session meant that the children could contribute with not only their ideas on how it worked, but I could also observe the children interacting with the artifact.

This approach was also based on inspiration from Larsen and Hedvall [24]. They used interactive, yet basic tangible artifacts for looking at the interaction between children with disabilities and the artifacts as a pivotal point for ideation. These artifacts could easily be altered, and are accordingly to the authors constantly being reshaped as they learn from the children's actions.

Assuming the Role as Co-Designer

As co-designers, the young participants took on the different roles including decision makers, content creators, and technicians. When describing the role as a design partner for younger participants, Druin suggest giving the children the possibility to participate whenever appropriate, see quote below.

With this role, children are considered to be equal stakeholders in the design of new technologies. While children cannot do everything that an adult can do, as partners children can have an equal opportunity to contribute in any way that is appropriate for the design process.
(Druin [10])

In Chapter 6, the younger participants expressed that they felt they had the possibility to make decisions during the design process. However, this was mentioned during an interview discussing the design process, and as presented in the following quote, children might be inclined to please adults and it might therefore be wise to look at behavioral signs instead.

.. behavioral signs are much more reliable than children's responses to questions about whether or not they like something, particularly for younger children. Children are eager to please adults.. (Hanna et al. [14])

However, the adult participants described the design process as a success as the children had been given the possibility to be decision makers, and that they had the possibility to shape the sessions. The adults also pointed out that the younger participants had been given the opportunity to participate in the different parts of the design process, from ideation to help document the sessions with journals and pictures¹ and by creating the interactive painting, giving them the role as co-creators. The following quote is from Section 6.2.6.

"I think they have been given the opportunity to contribute, and allowed to provide input, and been heard." (Ingrid)

However, even though they had been heard as mentioned in the quote above, it was always a surprise what the children chose to answer.

Me: *"Thank you for helping me today, it was very nice of you."*
Owen: *"COOKIES!"*

And giving them the role as decision maker also meant that they could say no. As explained by Druin, children may not want to do the different tasks [10], like the task of updating their journals, as seen in the case presented below.

Me: *"Do guys want to draw what we have done today?"*
Owen: *"No!"*

Hanna et al. suggest using phrases such as "Now I need you to..." or "Let's do this..." or "It's time to..." to avoid situations where the children have the opportunity to say no [14]). However, aspiring to let the younger participants be as equal as possible it is debatable if this is a good solution. In the following quote Druin discusses this issue.

A challenge that is unique to working with children in the role of design partner, is that adults are not in charge, but neither are children. Design partners must negotiate team decisions. This is no easy task when children are accustomed to following what adults say, and adults are

¹ Although I did end up with a lot of great photos, I also ended up with over 200 of the children's selfies.

accustomed to being in charge. Methods of communication, collaboration and partnership must be developed that can accommodate children and adults. (Druin [10])

The children needed little encouragement to help document the sessions by taking pictures of what the other participants were doing, or taking pictures of what they had made. Giving the camera to the younger participants was originally to help make the children less self-conscious about being filmed as it was done by one of their peers [10]. However, the child participants seem to take absolute no notice of the adult participants taking photos of them to put on the Kindergartens web page. I therefore decided to add a video camera to the third and fourth sessions. In this case the young participants took some notice of the recording devices, however they seemed more interested in using the device. Prensky explains this might be because children today grow up surrounded by technology, they are fundamentally different than previous generations [35].

An additional observation that occurred when the children took pictures of the sessions, was the children that used the camera seemed to really embrace their responsibilities of documenting the design process. I believe this ended up as an additional way for the child participants to feel that they contributed to the design process.

.. there must be the freedom for children to accomplish a task that is meaningful for them. (Druin [10])

The child participants also voluntarily seized the role as co-technicians whenever the interactive painting did not work as expected.

Ingrid: "They were a little cautious in the beginning, needed some help to start thinking."

Mary: "This has all been a little new to them. If we had worked with this some more, then they would have come up with even more ideas and thoughts. But, this is all very new, so I believe [the children's] fantasy will flourish if we start using it." [refers to the technology]

The adult participants also saw how familiar the children became with the technology as presented in the expert above. I wonder if they were able to seize the role as co-technicians on their own initiative because the children seemed not only to be comfortable in their new role, and the new adult, but also with the technology behind the interactive painting.

But what about the adults?

Considerations were taken to make the younger participants equal design partners. However, this did not stop the adult participants from enjoying participating in the development process. The adults expressed that they often looked forward to the sessions, and that they really enjoyed participating.

"It has been really fun! I have looked forward to each session. I think this has been so incredibly fun, and you have really made me excited to continue with the project."(Ingrid)

Which came as a relief, as I did have some concerns about the employees mindset on adding both technology and second language learning to the kindergarten's curriculum. In a project to create a language stimulating environment by teaching the children English in a Norwegian kindergarten, Maagerø and Simonsens explains that project members were met with negative reactions and disapproving glances from the other employees; accused of imposing curriculum onto young children [25, p. 45].

Furthermore, while writing this thesis many have in the media raised a critical voice on the matter of technology and preschoolers, believing that early use of technology could do harm to the young children, both mentally and physically[28][4].

So my concerns of combining technology and language learning in the curriculum for preschoolers were not unfounded. However this moral condemnation of new media or new technology is nothing new. For instance back in the 1930s, cartoons were deemed dangerous. However, as explained by Pinker, if new electronic media is hazardous to our intellect, the quality of science should have plummeted instead of increasing [32]. Believing that media and technology is the most influential factor for the increase in I.Q over the last fifty years [21, p. 139-156].

Luckily, the adult participants seemed to embrace the use of novel technology in the kindergarten. As expressed by the adult participant Ingrid earlier in this section, they wanted to continue the project on their own. Earlier they had also expressed concern regarding including technology in the curriculum.

"That's the challenge for us working in a kindergarten, we have to keep up with it [technology], and depends on own interests." (Ingrid)

Which leads me to believe that facilitating for the children are important, but also preparing the possibly less tech savvy to take on the role as the project's *technological experts* might be almost equally important. Druin also expresses a similar view:

When teachers are an active part of the design process, this too can be empowering. In both our KidStory research in Europe and our Digital Libraries research in the USA, teachers have come to realize that they too can have an impact on how technologies are changed. (Druin [10])

Without the employees to facilitate for the co-creation with the children with an pedagogical perspective in addition to the technological, including technology in the kindergarten will be difficult. In her book on using digital tools creatively in Norwegian kindergartens, Fragell Darre has dedicated a section solely to the challenges of changing the mindset of kindergarten employees [9, p. 57].

Including the Other Children in the Kindergarten

In her work, Druin expresses that testing with other children are crucial, as expressed in the quote below.

Another critically important way we reflect on the technologies is to ask other children to test what we have made. We have found that it is not enough to get the opinions of seven children in creating a technology. They are our design partners and have developed a deeper understanding of a particular technology than a typical child user. (Druin [10])

However, as mentioned earlier this project differs from many of Druin's projects as this project never intended evaluate and test how to create better design for children, as pointed out by Larsen and Hedvall [24]. The interactive painting created by the young participants were not only designed by them and, but also for them, and not a larger user group as often seen in Druin's projects, e.g the KidPad project [11].

Nonetheless, out of curiosity I let the children present the interactive painting to children that had not participated in the design process. This was based on observations during the design process, where whenever a curious adult stopped by, the children were eager to present the interactive painting for other non-participants.

As soon as someone new entered the room, the children were immediately ready to show them the interactive painting. (Ingrid)

This presentation of the interactive painting happened on the child participants' own initiative. Although this interaction can not be called a test setting, it gave the children the possibility to observe how other adults and children interacted with their creation.

7.2.3 Reflecting over the Process

After each session I aimed for leaving room for snack time where the participants could talk and reflect over the design process. This was inspired by Druin's projects, where she started by setting the design members expectations through snack time. Originally meant to replenish energy with food, Druin explains that she has come to see this time as a critical part of her design methodology [10].

During snack time, participants would informally discuss anything that comes to mind, getting to know each other as people with lives outside the design sessions. Following this discussion, the talk would concern the current session, finding goals and deciding on activities to be accomplished during the session [10].

However, I decided to placed the snack time in the end of each design session, to facilitate discussion concerning the participants experiences from the session. In some sessions the snack time also included short interviews.

This gave us the opportunity to get to know each other better, but also gave the participant the chance to reflect on their experiences.

However, in the first sessions, it might have been wiser to place the snack time in the beginning of the session. As mentioned earlier, the child participants needed to become acclimate to the role as co-creator, get used to new technology, but they also needed to get to know an unfamiliar adult. By placing the snack time in the beginning of the first sessions, it might have given the participants to get to know the unfamiliar adult, making the participants feel more comfortable. Druin explains that the informal part of snack time could be important for developing relationships between the participants, and is based on *Contact Theory*.

The intercultural communications literature discusses this type of informal socializing in "Contact Theory". This theory suggest that to get beyond prejudice and develop better working relationships there must be some social contact. (Druin [10])

In addition to snack time, time after the sessions also included *Adult Briefing*. This seemed to give the adult participants to take a step back and assume the role as a pedagogue and a teacher besides their role as the participants.

This is a time where adults can stand back and look at the big picture of things - sometimes more difficult to do when children are present. (Druin [10])

I believe this might have given the adult participants a chance to not only reflect on the design process, but also how it could be improved and how they could apply their own experiences to future projects.

7.2.4 Summary

In this session, I discussed the process of co-creating the interactive painting, starting with my reflections and experiences on brainstorming together with young children. When brainstorming, the children were eager to share their ideas. However, this was only when they could envision a solution combining new technology with familiar elements, proving a need for a common vocabulary.

One of this project's goal was to create a tangible artifact for language learning. The interactive painting also functioned as a tool for engaging the young participants in the design dialogue. Taking inspiration from Rapid Prototyping the children created the content, and than later in the session got the opportunity to test the solution together with non participants.

Further I discussed how the children seized different roles in the design process, including decision makers, content creators and technicians. Roles the children seemed to embrace with little encouragement from the adults.

However, making young children equal decision makers may also create situations where the child simply say no to an idea, or suggestion.

Reflections on the adult participants' roles and experiences was also discussed as the children were not the only one who seemed to embrace their roles in the design session, and the use of the technology.

Finally, I discussed how the participants were given the possibility to reflect on the design sessions at the end of each session through snack time. This gave me and the participants the chance to discuss and reflect on the current session. However, in the first sessions, I do believe placing the snack time in the beginning of the session could have facilitated for a quicker development of the relationships between me and the participants. I also saw the need for the adult participants to step away from their role as participant in order to reflect on the project's pedagogical value.

7.3 THE POTENTIAL FOR PLAYFUL LEARNING

In this section I discuss the potentials for learning through participating in the design process, and through the co-creation of a tangible artifact. Further, I discuss potential for learning through interaction with the interactive painting. Lastly I discuss if the participation in the process, and the interaction with the device supports what can be believed to be the most important motivator for learning in regard to preschoolers; that it was fun.

7.3.1 Potential for Learning Through Co-Creating the Interactive Painting

Although this project's focus was to examine how technology could contribute to language learning, potentials for developing social skills also emerged during the design process. Further, the children's hands on experience with technology might have provided the participants with technological insight.

Social competence

Based on both my own and the adult participants observations, the participation in the development process could possibly contribute to the children's social skills and social competence. During the development process, the children needed to adapt to the role as co-designer, and make decision, and present their ideas while also listening to the other participants. These observations are described in full in Section [6.2.1](#).

Me: "If we for a second now look away from the language learning aspect of the project, do you think the children have learned other things?"

Ingrid: *"Yes, social competence. This is also a priority in the municipality. And cooperating is the highest level of social competence. ... It is important, very very important."*

Participating in the development process also demanded the children cooperated with the other participants in order to create a common artifact, helping the children developing social skills that are crucial to develop during the preschool years.

The trajectory for academic and life success is established in the preschool and primary years, when children are developing new habits for learning and social development (Chiong and Shuler [8])

This cooperation that included respecting and listening to the others, having patience and relating to the others ideas, was accordingly to one of the adult participants the highest level of social competence. Druin mentions this as one of the strengths of including young participants in the design process, as seen in the quote below.

Children can also learn more about working with other people, and become more aware of their communication and collaboration skills. (Druin [10])

As mentioned earlier in Chapter 2, Constructionists sees learning as an active construction of knowledge through experience, and the *socio-constructionist* perspective believes that the social environment has an important part in how children construct knowledge [33, p. 10], see Section 2.2.1.

Looking through the eyes of a constructionist, arguably the children might have learned through the co-creation of the tangible artifact. However, a third learning theory might also be applicable for this project. *Constructionism* is rooted in the works of Piaget, and builds on Papert's idea that children learn better when they explore and develop their own theories [6]. Ackermann explains Papert perspective as:

He stresses the importance of tools, media, and context in human development. Integrating both perspectives illuminates the processes by which individuals come to make sense of their experience, gradually optimizing their interactions with the world. (Ackermann [2])

And if we look back at the chosen methodology of this project, see Section 3.1, directly involving the participants in the shaping of artifacts [39, p. 2] offers the children the opportunity to engage, create, experience and learn.

Technological insight

An additional competence that seemed to emerge during the design process was linked to the children's new knowledge of the project's technology.

And as today's generations are growing up in an increasingly technological world, this insight might be valuable. Just look at the app marked, in Chapter 2, I mentioned that 80 percent of the apps in the Education category on the iTunes Store targets children. And early learning apps for toddlers and preschoolers are very prominent. Many of which are games [38].

Arguably, this is a good thing if we look at pedagogues Maagerø and Simonsen that explains that young children should learn through fun and games [25, p. 28]. Supporting the ideas of using fun and games for learning are Gee and Prensky. Both shares the belief that today's generation has drastically changed due to their growing up surrounded by technology, and that traditional education does not motivate this generation [12][35].

According to research made by the Norwegian Centre for ICT in education in 2013, early education are seemingly embracing the use of mobile devices. The centre estimated that about 30 percent of all Norwegian kindergartens have access to mobile devices such as tablets [20]. Which might be a good thing, according to the Division for Early Childhood of the Council for Exceptional Children, the use of technology in early childhood years, in an educational setting may help improve children's quality of life [26]. And there is evidence that children can learn from apps, e.g the Martha Speaks application [8], see Section 2.4.1.

However, as apps are being created at an astounding and increasing speed, research might not be able to provide educators with guidance of how to use emerging technology [26]. More and Travers explains that education has historically been plagued with a lag between newly discovered findings of teaching and the use of these in an educational setting. They also stresses that educational technology, especially for young children are also victim to this [26].

However, the field is emerging so quickly that empirical studies on the effectiveness of apps for learning have lagged behind, and learning apps for mobile devices have become a hotly debated educational technology topic. (Shuler et al. [38])

in his dissertation, Chau [7] examines to which extent children's tablet software applications are designed to promote the optimal development of preschool children. In his research, he discovered that just more than half of the apps were developmentally meaningful for the target group. He also found that many of the current apps seemed to have limited content offering, and often failed to elicit the types of behaviors that researchers have found to promote optimal development.

On the contrary, the present study suggested that the current children's mobile apps space seemed to have limited content offering. Many apps were either developmentally not appropriate for young children or they failed to elicit the types of behaviors that researchers have found to promote optimal development. (Chau [7])

Although they were unaware of the results from studies such as Chau's, the adult participant mentioned a concern regarding apps for preschoolers. They expressed that it was difficult to know if the children could learn from the app, and mentioned that they usually played the games before installing it on the kindergartens iPad.

In addition to concern regarding the content of the applications on the iPad, the adults also seemed to worry that they facilitated for the children to become consumers of technology, when they should become creators.

Ingrid: "They have that iPad, and they just expect that this is how things are."

Mary: "On the iPad, you touch the screen, and things happen, but they don't know how. It is so important [understanding how technology works], and so educational, and I believe that they [the child participants] have gotten such an ... an advantage on being a part of this [the development process]."

In an interview, the adult participants expressed that through participating in the design process, the children had been introduced to a world of shapeable technology. Being a part of the process, the children could have been given an understanding of how technology could be created and shaped according to their ideas, and that they could be creators of technology. By exposing the children to the technology behind the solution, the pedagogues expressed that the children went from consumers to creators. The results concerning this is presented in detail in Section 6.2.1.

Those who are young now are growing up in a very technological environment, and it is important to consider that these children should not only grow up to become consumers, but also creators. (Ingrid)

When looking at similar projects presented in Chapter 2, the children helps shape new technology through interacting with art supplies to draw and write design suggestion for an existing product as seen in the KidPad project [11], or giving their input through interacting with tangible low fidelity prototypes as seen in the SID project [24]. Druin expresses that by including children in the development of technology, they can become to see themselves as creators, as expressed in the following quote.

Children can grow to see themselves as something more than users of technology. They can come to believe that they make a difference. (Druin [10])

Although the young participants helped shape new technology through art supplies to create a tangible artifact, similar to the projects described above, in this project the children also got to interact directly with the technology behind the interactive painting. When we created the first interactive painting, the children helped debug when the wires was connected to the

wrong painting, and helped place the wires to the correct part. And in the first sessions, the children interacted with different elements they saw were connected to the micro controller. Even though it is impossible to determine if this particular interaction had any effect on the children's technological insight, the adult participants seemed to believe this could be the case, and called the development process for a *gentle introduction* to technology.

During the sessions, the adult participants also seemed to accumulate knowledge of the technology used in the project. Although they had previously mentioned that it was difficult to keep up with technology, see Section 6.2.1, the adult participant seemed interested in continuing using the technology on their own.

It has been really fun! I have looked forward to each session. I think this has been so incredibly fun, and you have really made me excited to continue with the project. (Ingrid)

More and Travers expresses that it will become increasingly important that early childhood professionals learn to effectively evaluate and integrate emerging technology in their environment, as educational research will likely never be able to keep pace with technological innovation [26].

7.3.2 Potential for Learning Through the Interactive Painting

In the following section potential for learning through interacting with the interactive painting. I discuss how the artifact facilitated for language learning in light of language learning theories. Further, I discuss how the interactive painting assisted the children in breaking language barriers. Additionally, I discuss how exploring languages together might help both monolingual and multilingual children to open up to diversity. Lastly, I discuss how the young children can become bilingual peers, aiding each other in the process of language acquisition.

Language Learning

In Chapter 2 I presented a divided field of contrasting views concerning how we learn languages. When acquiring our first language some researchers emphasizes biological abilities, while others emphasizes social interactions as key. However, all seem to agree that a child's ability for language acquisition is remarkable.

It is not uncommon to hear that children learns other languages effortlessly as well [15, p. 43]. As with the acquisition of our first language, this is also a divided field. On one side, we have researchers such as Singleton that stresses that it is very difficult to come to a general conclusion regarding young children and second language learning [25, p. 24]. While there are researchers that seem to view that *younger is better*. Researcher Tokuhama-Espinosa describes the age 4-7 as the second window of opportunity for second language learning [42, p. 27].

Nevertheless which theory is correct, language learning at an early age is according to Hoel et al. extremely crucial. Several studies suggest that the process of learning languages early has an effect on a child's performance later in life. Labeled the *Matthew effect*, researchers believe that the vocabulary in three year old's directly corresponds to their reading skills as adolescents. [15, p. 48]. Similar theories for bilinguals are presented by Smidt:

The level of a child's mother tongue is a strong predictor for his or her second-language development. (Smidt [40, p.136])

Early language stimulation are also seen as an important part of the kindergartens content by Norwegian legislation. Further, this legislation also point out that toddlers are in the fundamental period for developing language, and that the kindergarten should support the child to use their native language simultaneously as they are improving their Norwegian language skills [34].

Further, as mentioned earlier in 6.2, the time span of this project is too limited to assess any real language acquisition among the children. As Hoel et al. explains, building comprehension and understanding in a language requires effort and time [15, p. 43].

TRANSLATION Nonetheless, the children stated that they had learned new words in other languages by interacting with the interactive painting. One example was when a child started translating the German words to Norwegian even though he did not know German, as previously presented in Section 6.2.1.

Sarah: *"Can hear it in German?"*

Ingrid: [To another child participant currently playing with the interactive painting] *"Sarah wants to try German"*.

Owen: *"German!"*

Owen changes the language to German by pressing the button under the German flag. Sarah presses the button next to the drawing of the smallest Billy Goat Gruff. The prototype plays the German words for "The smallest goat".

Canvas: *"Die kleinste Ziege"*.

Owen: [Translates from German to Norwegian] *"Lille bukkene Bruse. (English: Smallest Billy Goat Gruff.)"*

However, even though the participants felt they had learned new words, it might have been possible that the children simply remembered what the drawings represented, and could therefore translate to Norwegian. Although, making sense of the images can also be regarded as a type of learning, according to Druin, a new type of literacy is coming, with the advent of multimedia technologies, children must come to make sense of their world in words, pictures, sound and more [11].

Even so, the adult participants explained that the interactive painting facilitated an environment for language learning because it allowed the children to listen to words in different languages. An example presenting this is presented in the quote below.

Lara is busy painting the waterfall in the fairy tale. When she has finished painting she presses the button next to the waterfall. The Norwegian word for waterfall sounds from the prototype's speaker. She changes the language to Albanian, and listens to what the word for waterfall is now. She continues doing this for all the languages.

The adult participants explained that they were also given the possibility to explore languages, laying the foundation for an environment facilitating language learning.

It is that they feel, with several languages, that one can choose Norwegian, and one can choose ones own native language, and check out other languages if you want. (Ingrid)

As mentioned earlier in this discussion, and in Section 2.2.2, Norwegian legislation specifies that children should be able to use their language to express themselves, meaning the employees in the kindergarten needs to create an environment that facilitates language learning and at the same time respects the child's native language [34].

REPETITION When interacting with the canvas, the children often repeated the words played by the interactive painting out loud. And during playtime, it was just wonderful seeing a young Norwegian boy with blond curls intently listening to the Arabic words coming from the interactive painting, and repeating the sounds to himself, obviously amused.

According to Maagerø and Simonsen repetition is an important principle for second language acquisition. Further, Maagerø and Simonsen explains that the children relies on hearing the words repeatedly to make learning effective. The children were also observed playing and listening to the words repeatedly [25, p. 72-75].

According to Singleton [25, p. 25], the oral elements of a language is the same elements children seem to obtain much more easily than adults or teenagers. He claims that young children obtain much better realization of a language phonological elements compared to older learners. Additionally, Singleton suggest that young learners seem to more easily embrace the language prosody as well. By exposing the children to the different languages, they might according to Singleton learn pronunciation more easily, something that might make language learning later in life more motivational. How good one is perceived to know a second language is often based on the phonic realizations.

However, pronunciation does not necessarily mean understanding, as Hoel et al. explains, building comprehension and understanding in a language requires both effort and time [15, p. 43]. So just exposing the children

to the words might not be sufficient for language learning. However, if we look at the environment as a whole, the technology can help create an environment where the children can interact together in a context. According to socio-linguist Dell Hymes, language acquisition is not only about grammar and vocabulary, but is realized through oral conversations in everyday life situation [25, p. 60]

CONTEXT The interaction Hymes [25, p. 60] explained being the crucial part of language learning was often seen when the children, and even the adults interacted with the interactive painting. It seemed that the interactive painting created a context for discussing and learning new words in currently foreign languages.

Hoel et al. also believes that learning words in a new language are not just about learning that single word, but also the context surrounding that word. For example, imagine the word *jungle*. Most likely it will make you think of other thing you associate with the word, such as the animals living there, the foliage and the trees [15, p. 43].

However, when discussing how to facilitate language learning with the pedagogical leaders of the kindergarten, they suggested focusing on single words instead of full stories and full sentences, explaining that it would make it easier to learn. The interactive painting therefore only played mostly single words. This was also based on the Processability Theory, a theory trying to explain how the human processes languages. For a more detailed description of the theory, see Section 2.2.2. This theory explains that the first step of learning a language is to identify the words of the language [18]. The focus on teaching single words can also be found in the Martha Speaks App presented earlier in Section 2.4.1.

Beyond translating and repeating the words from the interactive painting, the children were observed putting the words from the canvas into context. When playing with the first interactive painting, one of the young participants pressed the button next to the biggest Billy Goat Gruff, and the interactive painting played the words "*The biggest Billy Goat Gruff*". The child then continued telling the rest of the sentence that normally followed when they told the fairy tale, as seen in the excerpt below.

Canvas: "*The biggest Billy Goat Gruff!*"

Owen: "*Som skulle til sæters for å gjøre seg fet.*" (English: "That was going to the mountain farm to make himself fat").

This was observed several times during, even with children who had not participated in the design process. When interacting with the second interactive painting, the children understood from the words and the paintings that this was about the fairy tale of the Three Billy Goat Gruff, even though their names nor the name of the fairy tale was mentioned.

Looking back at the learning theories presented in Section 2.2.1 and discussed in 6.2.1, context is an important part of how children construct knowledge according to the *Constructivism*.

To Papert, knowledge, even in adult experts, remains essentially grounded in contexts, and shaped by uses, and the use of external supports and mediation remains, in his mind, essential to expand the potentials of the human mind — at any level of their development. (Ackermann [2])

In the quote above, Ackermann explains the constructivistic view on context and learning.

META LINGUISTIC AWARENESS In addition to repeating and translating the words, there also occurred situations where the children started to reflect on the different words in the interactive painting. During playtime with the interactive painting, many of the children seemed to discover how the word *troll* was the same on many of the different languages. Bakken et al. [5, p. 24] explains that this gives the children insight into what is called the *meta linguistic awareness*. This insight was also observed by the adult participants.

And this whole thing, they have been given the insight of something. And we too, not at least. It is quite true. (Mary)

During the design process, the children also needed to reflect on languages, and how these could be integrated into the interactive painting. Bakken et al. explains that the reflection on the different part of languages means that they have entered a higher level of their language development. They also suggest that this consciousness might have a great impact on the first meeting with literacy [5, p. 25].

Breaking Language Barriers

As discussed in the previous session, the interactive painting seemed to facilitate for language learning where the children shared their languages and helped translate for each other, and got the possibility to explore the different languages. However, this might not have been possible if the children did not break their language barriers.

In Section 7.1.3, I discussed the challenge of including the children in creating the auditory content of the interactive painting. During the earlier sessions, the adult participants had pointed out that it was difficult to get the children to use their native language in the kindergarten, describing this as a barrier, as seen in the quote below.

When the children are in the kindergarten, there is a barrier to use their native language, and to teach us adults what the different words are in their language. They can talk with other children that also speak the same language, sometimes, but not always. They usually speak Norwegian. (Ingrid)

This is also supported by Sandra Smidt, which explains that this behavior is about belonging. Smidt explains that children want to be the same as other children, and this means also speaking the same language [40, p. 25]. So in a Norwegian kindergarten where most of the children speak Norwegian in common with most of the other children and employees, using a different language would mean being different than the majority. Bakken et al. also explains that bilingual children associate the different languages to different domains, and it can be emotionally wrong for them to use their native language in the kindergarten when this is a Norwegian speaking domain [5, p. 22].

However, when creating or playing with the interactive painting, this barrier seemed to disappear. In one situation, child participant Owen started to translate from Albanian to Norwegian on his own without any encouragement from the adult participants or the other participants. This was him sharing his knowledge willingly, a knowledge few other in the room possessed.

Mary: *"You saw that Owen dared to say the things on his language. I have never experienced Owen doing something like that before."*

Ingrid: *"No, he has always been very careful not to."*

Bakken et al explains that if the children in the kindergarten is genuinely interested in different languages, and that speaking more than one language has value in it self, then the multilingual children might be more motivated to share their native language without it seeming strange and exotic. They point out that this can help the multilingual children to use their language, feel pride and develop their identity [5, p. 23].

Ingrid: *"Yeah, they get a kind of ownership .. not ownership, but pride. Their own language, and being able to teach it to the others without having to say the words themselves."*

Mary: *"And with Sarah, I felt.. Pride! She is very proud of her language, and when.. I felt that she.. This was something that belonged to her."*

However, giving the multilingual children the opportunity to share their languages and helping them break language barriers preventing them from doing so, may also make the linguistic diversity in the kindergarten visible for the rest of the children.

Displaying some recognition of the languages in a class or a group is a small token of respect and goes some way to indicate to all children and all families a respect for linguistic diversity. (Smidt [40, p. 33])

This awakening to other languages and cultures might according to Maagerø and Simonsen, help the children develop positive attitude towards to the different languages, and the people speaking them [25, p. 38].

Bilingual Peers

During the development process, and during playtime with the interactive painting, the children were often observed translating the different words from a foreign language to Norwegian. However, these children did not always seem to translate only for themselves, but also for the other children.

Piaget called the years from two to seven as the *pre-operational stage*, a stage that is categorized by egocentrism [33, p. 7]. Nevertheless the self-centredness these children voluntarily helped the other participants by translating.

Lara presses the buttons on the interactive painting. Owen is next to her and is so eager to get to press the buttons that he falls of his chair. Owen gets up, and starts pressing the buttons, but then lets Lara try again. Lara listens to the different languages. She changes the language to Albanian and starts pressing the other buttons. Owen starts translating the words so Lara will understand.

After breaking the language barrier, the children seemed to become resources to the other children as bilingual peers. In her literature on supporting multilingual children, Smidt explains that children who gets a chance to show their knowledge and their expertise in for of their own language might find themselves in the position as a teacher, and in this role might be able to reveal their own understanding of the language. She expresses that adults working with young children should facilitate or even engineer situations to make this happen [40, p. 43].

Children know a great deal about their own language and when in situations where adults recognize and value this, can act as peer tutors to other children. (Smidt [40, p. 43])

Psychologist Vygotsky was a contemporary of Piaget, and shared some of the basic beliefs about child development. However, Vygotsky also pointed out the importance the social environment had for the learning process. He was interested in exploring what an individual child were capable to achieve with the help and support of a more knowledgeable partner, and created the concept *Zone of Proximal Development*. This concept describes the difference between the child's current knowledge, and what can be achieved with the help of from a more knowledgeable peer [33, p. 11].

Looking at Vygotsky's Zone of Proximal Development, I do see parallels to this project. Individually children might learn the words by interacting with the interactive painting, comparing the foreign words with the Norwegian counterpart. However, during playtime, some of the participants acted as resources for the other children and helped translate, helping the other children reach a higher level of the zones.

Maagerø and Simonsen explain that the employees competence is crucial when introducing English into the learning environment, and emphasizes that the employees needs to master the language [25, p. 87].

However, as explained by Holmen and Nielsen, just teaching one language does not necessarily cover multilingual children's need for learning several languages simultaneously [16]. As presented in Section 4.2, 24 out of 50 children in the kindergarten had a different native language than Norwegian. Facilitating for all these languages will demand much more of the employees than solely in the case of including English.

In this project I faced the challenge of gathering auditory content for several languages. Norwegian and English were simple enough, however Albanian, German, Bosnian and Assyrian which created the need for external dependencies in form of language teachers. During one of the interviews, the adult participants however imagined a different solution than using language teachers, as seen in the quote below.

And we are becoming an increasingly more globalized kindergarten. And we are cooperating on a project with the county governor, and we could transfer the ideas from this project. ... We will first focus on cooperating with the children's parents. (Ingrid)

The adult participants suggested including the children's parents and legal guardians to replace the need for external help to create the auditory content. She further explained that this might create a tighter bond between the children's families and the employees in the kindergarten. Smidt explains that engaging and working with participants is one of the most vital parts of providing children with excellent education, as these are the ones that knows the children the best [40, p. 109].

Exclusion and Alienation

In section 6.2.6, I describe observations regarding how the interactive painting encouraged a previously passive participant to explore theirs and the language of the other participants in the group. In Section 6.2.4 I presents results where the interactive painting seemed to create an environment for playing and learning foreign words together. In this section, However, I also observed how the interactive painting in one situation created a alienating environment for one child.

During playtime, one child watched from the back of the room instead of gathering in front of the painting like the other children. Even when asked by the adults and the other children, the young girl was hesitant to approach the canvas. However, she remained to watch the other children play with the interactive painting. After some time, she approached another girl playing with the canvas, and whispered something in her ear. She wanted to know why her native language was not included in the interactive painting. Smidt explains that by rejecting a child's language in the school or setting is to reject the child herself [40, p. 136].

By introducing the interactive painting to the other children in the kindergarten I had involuntarily alienated a child from the playtime. This might

be an indication that making some languages seem more important or considered superior to others by not including them in the kindergarten's curriculum might have unfortunate effects not only on the language learning, but also the children themselves.

Was it fun?

Making the learning fun might seem insignificant when it comes to learning in comparison of the language acquisition theories and learning theories previously discussed in this chapter. However, young children are not motivated to learn languages in order to read classical literature such as Shakespeare or Goethe. Rarely do young children put effort into language learning solely for the sake of perfect grammar. Just look at the story of little Marius in Alexander Kielland's novel *Poison* where he studied Latin grammar so intensively that he died. Children are not motivated to learn languages in order to communicate with others, and to have fun together, as explained by Maagerø and Simonsen [25, p. 56-57]. Considering this, I discuss in this section if the participation in the process, and the interaction with the tangible artifact motivated for playful learning.

When I asked the children about what they felt about playing with the interactive painting and participating in creating it, the young participants expressed that it had been a fun experience.

Me: *"What did you guys think about using the canvases?"*

Oscar: *"Good!"*

Owen: *"It was fun."*

However, relying on the children's spoken feedback might not be sufficient, as young children might be motivated to please adults, as described by Hanna et al. [14]. However, the adult participants seemed to support the children's statements.

Mary: *"I feel the children had a great time. We actually had to throw them out [when the session was finished], you saw that yourself."*

Ingrid: *"And that pride they had, and the joy! Like, and they were so eager to hear the different languages. They were so eager, and there was such joy, I feel that it was fun. They were engaged."*

The children needed little prompting from the adults to interact with the interactive painting, perhaps indicating that the participants enjoyed playing with the painting. Especially one child that had been passive through most of the sessions suddenly showed interest in playing with the interactive painting when he heard his own native language played from the prototype's speakers. The child's change in behavior created much enthusiasm with the adult participants.

Yeah, you saw how his eyes just lit up when he got to play with the canvas in his own language. It was really fun to see, he became just so.. [She draws a deep breath, smiles and holds her hand over her chest] just.. yeah. (Mary)

The child with poorer Norwegian skills suddenly became the expert of a language the others did not know. Maagerø and Simonsen explains that children with poorer language skills that of the country's spoken language might be given more confidence when they suddenly masters a language few others understand. Further, the children already mastering the country's spoken language will when meeting a new language understand the difficulties of learning a new language [25, p. 35].

The children's behavior before the sessions could be used as an indicator of interest. Some of the participants arrived early to the design sessions when they saw that I had arrived the kindergarten. This voluntary action by the young participants could suggest that the children enjoyed participating in the sessions. When talking about the interactive painting, the adults expressed positive sentiments, as shown in the excerpt below.

Ingrid: *"I am really impressed."*

Mary: *"Me too."*

Ingrid: *"Fantastic"*

The children seemed eager to show the others how the interactive painting worked, and seemed proud of the solution. This pride and eagerness were noticed by the adult participants as well as myself.

As soon as someone new entered the room, the children were immediately ready to show them the prototype. (Ingrid)

However, as preschoolers will often be happy to show what they know and what they can do [14], this alone might not be sufficient to gauge if the environment was fun and motivational. However, the children's behavior seemed to support the their statements about the interactive painting as laughter was very prominent during the design sessions and during play.

7.3.3 Summary

In this section I discussed how participating in the design process could contribute to the children's development of social skills as the co-creation demanded cooperation. I further discussed how participating in the design process could possibly provide the participants with new insight regarding technology as they got hands on experience with a micro controller. I also compared the project's technology with technology one can today find in Norwegian kindergartens. Mainly apps and tablets. My findings suggest

working with technology can give the children insight on the fact that technology is not only a finished product, but a tool for creation.

Further, I looked at how interacting with the interactive painting could facilitate for language learning in light of theories regarding language acquisition. By providing the children with the interactive painting, it seemed to provide an environment where the children could to explore different languages. At the children's own initiative they translated, repeated and put the words played by the interactive painting in context. Furthermore, when creating the canvas, and interacting with it later, the children were often observed reflecting on differences and similarities between the languages. This might introduce the children to meta linguistic awareness, a higher level of language learning which will become necessary in regards to literacy.

However, this might not have been possible if the interactive painting did not also seem to help the children to break language barriers. Supported by both the adult participants, and the background literature, bilingual children seem to associate different languages to different domains, and making the children involuntary change these associations might feel emotionally wrong for the young children. Even though, when interacting with the canvas, this barrier seemed to disappear.

Furthermore, with the disappearance of the language barrier, the bilingual children become resources for the other children, translating the words from their native language to a language they had in common. When observing the participants exploring the different languages, I also discovered how leaving some languages out of the prototype might make children feel excluded and alienated. Indicating the importance of not making some languages seem more important than others.

Lastly, I discussed how the participating in the co-creation, and the use of the interactive painting could make learning fun and motivational by looking at both the adults feedback and the children's behavior.

7.4 SUMMARY OF THE CHAPTER

In this chapter I have discussed the three sub research questions in light of the results presented in Chapter 6, and relevant theories and similar work presented in Chapter 2.

Concerning the first sub research question I discussed the prerequisites made for giving the young participants the chance to seize the role as co-designer, and my experiences in facilitating for co-creation with preschoolers.

In regard to the second sub research question, I discussed the results from the design process in light of similar projects involving young participants, and my reflections and experiences concerning this project's selected methods.

Regarding the third sub research question, I have discussed how both participating in the design process, and interacting with the interactive painting could motivate for learning. I have discussing the children's experiences from participating in the design process, and the use of the tangible artifact in light of theories concerning language acquisition and learning. In addition, I have discussed if the two facilitates for the most powerful motivator for young children. Making learning happen through fun and play.

A summarizing discussion, and a conclusion of my findings follows in the ensuing chapter, Chapter 8.

8 CONCLUSION

In this thesis project I have sought out to explore how technology can contribute to an environment for language learning intended for a young user group, through the co-creation of a tangible artifact together with children and adults. Drawing from my experiences from creating together with young children as co-designers, I present in this chapter my conclusions regarding each of the the project's three sub research questions, which can be found in Section 8.1, Section 8.2 and Section 8.3.

Conclusion concerning the overall research question is presented in Section 8.4, followed by a reflection regarding the process itself, and possible ideas for future work, see Section 8.5.

8.1 CREATING AN ENVIRONMENT FOR CO-CREATION

The first sub research question concerns how an environment for co-creation could be facilitated. Taking inspiration from Participatory Design and similar projects that included children in the co-creation of novel technology, the children were given a voice in the development process by co-creating a tangible artifact through the phases of a Future Workshop.

8.1.1 The Need for Familiarity

Furthermore, co-creation was made possible together with the young participants through the use of tangible and familiar elements. The tangible elements served as a starting point for discussing the project's unfamiliar technology. I discovered that the children were eager to share their ideas on what we could create by combining unfamiliar technology such as the micro controller with elements they were already accustomed to using in a kindergarten setting, such as paint, crayons, modeling clay etc.

Furthermore, as the children were less eager to share their ideas when we discussed the possibilities with the technology alone, indicates a need for creating a common vocabulary by using elements that are familiar to the participants early in the project's stages.

These discoveries regarding the success of facilitating co-creation by constructing a tangible artifact together, and by the use of familiarity, supports findings from similar projects including children as co-designers.

8.1.2 The Need for Time

Reshaping the method Future Workshop was intentionally meant not to tire and bore the children with too lengthy design sessions, as the phases of the workshop was divided and placed on different days. Fortunately, this seemed to give the children more time to adjust to the role as co-designer. During the first sessions, the children were cautious, but started to actively seize their role as co-designer in the later design sessions. Suggesting young children will need additional time to adjust to the role as decision maker. Furthermore, as the children were given the role as an equal design partners, one can expect free play to occur during the design sessions, and probably should plan the schedules accordingly.

The need for additional time needed for getting used to their role as co-designers, strengthen findings in similar projects. Further does the need making room for free play in the schedules.

8.1.3 The Need for Restrictions

Although I aspired to give the children the possibility to seize the role as equal design partners, I found that some restrictions needed to be made regardless. When looking to my peers, their projects usually have some kind of starting point for ideation and creation. Based on this, I therefore selected the project's technology before starting the design session.

Furthermore, another restriction included the use of a familiar fairy tale as a theme for the project. This was a story the children knew by heart, meaning the young participants possessed valuable expertise in addition to their expertise as the user group and their expertise on what it means to be a child.

These findings could suggest the need for some constraints and restrictions when working with young participants for facilitating for co-creation, and making the design process a little less abstract for young minds.

8.2 THE PROCESS OF CO-CREATION

The second sub research question concerns how children and adults together design a tangible artifact for exploring languages.

8.2.1 Creating

Through brainstorming with familiar and tangible elements, and the micro controller the participants conceptualized a solution of a tangible artifact. More specific an interactive painting. The familiar elements acted as tools for ideation, as the children were eager to share their ideas when brainstorm-

ing with familiar art supplies. Furthermore, the young participants were also observed using the technology behind the artifact in order to decide where paint the visual content on the canvas. Suggesting the familiarity of tangible elements seemed to cancel out the unfamiliarity of the technology.

Additionally, during the creation of the interactive painting the young participants actively and voluntarily seized different types of roles in the creation of the artifact, such as decision maker, content creators and technicians. Indicating that the participants might have been given the possibility to adjust to the role as co-designer. Whether this is through sufficient amounts of time, their familiarity with the elements of the artifact, or their expertise on the fairy tale is however debatable.

8.2.2 Reflection

Each session were concluded with time to reflect on the design process. For the young children this meant snack time that consisted of an informal discussion of the session's events. This informal part of the design process might have helped developed relationships between the participants in the group.

Additionally, the adult participants were given a chance to reflect on the sessions afterwards. This seemed to have provided them with the possibility to reflect on the artifact's pedagogical value. Which might be verified how the adult after one session bought their own micro controller, intending to continue the project on their own.

8.3 THE POTENTIAL FOR PLAYFUL LEARNING

The third sub research question concerns if the interaction with the artifact, and participating in the co-creation of the tangible artifact supports an important motivator for learning in regards to preschoolers. More specific, the potential for making second language learning fun. In this section I present different types of learning that emerged through the co-creation and interaction with the interactive painting.

8.3.1 Playful Learning

When asked about what they young participants felt when playing with, and creating the interactive painting, the children expressed that this had been a fun experience. This was further supported by statements made by the adult participants. The children's behavior was also an indicator as they needed little encouragement to both interact and take part in creating the interactive painting. That a child that had remained passive throughout the design process suddenly showed interest when he heard his native language

from the artifact's speakers could also be an indicator. Additionally that some of the participants arrived early and voluntarily to the design session could be a indicator that this was an amusing experience. Furthermore, laughter was always very prominent during the design sessions and during playtime.

8.3.2 Social Competence

By participating in the design process as an equal co-designer, the children needed to to make decisions and communicate their ideas, but at the same time listen and mind the other participants. Participating also meant the young children had to cooperate with the others in order to create the tangible artifact.

Supported by literature on early child development, by similar projects including children as co-designers and by the pedagogues that participated in this project, is the belief that cooperation is an important part of social competence. This indicate that by participating in the design process, young children can acquire social skills, skills which are essential to develop in the preschool years.

8.3.3 Technological Competence

The hands on experience with the micro controller might have given the children insight that technology can be shaped, making the groundwork for the children to grow up as creators of technology, not only consumers.

Further, by participating in the design process, the adult participants seemed to acquire insight on how they could integrate the technology into the kindergarten curriculum. This might be an indication of the importance of including the pedagogues when creating technology for educational purposes as well. Additionally, due to the rapid growth of educational technology some literature stresses the importance of early childhood professionals becoming competent to evaluate and integrate technology into the learning environment.

8.4 TECHNOLOGY AND LANGUAGE LEARNING

When looking at the potentials for language learning through interacting with the tangible artifact, actually assessing if the children learned from interacting with the artifact falls outside this project's scope. As learning takes time consequently does the assessments of learning as well.

However, there were indications that by providing the participants with the artifact created an environment where the children could explore different languages, and possibly could facilitate for language learning.

8.4.1 Interacting with Languages

At their own initiative when interacting with the tangible artifact, the preschoolers listened to foreign languages, translated the words from one language to another, repeated the sounds they heard, and put words played by the artifact into context. In some cases, bilingual children seemed to translate words played by the artifact in their language to a language they had in common with the other participants, becoming a resource for the other children, and actively seizing the role as teacher.

8.4.2 Breaking the Language Barriers

However, it is uncertain if the results had been the same if the artifact had not facilitated helping the young participants break what is known as the *language barrier*. As bilingual children associate different languages to different domains, it might feel wrong for the children to change these associations. This belief is supported by both literature and by the views of the pedagogues that participated in the design process. However, when interacting with the artifact, the children broke this barrier voluntarily and seemed quite proud to share their language with the other children, bilingual and monolingual alike. Indicating that the children were willing to break the language barriers as long as they were not the first to do it.

8.4.3 Creating an Environment for Bilinguals

Furthermore, by exploring the different languages in the kindergarten, and creating an environment where speaking more than one language has value in it self, the bilingual children might be motivated to share and use their native language with the other children. Possibly creating an environment where the bilingual can develop their identity and native language in addition to learning the country's spoken language. In addition, by leaving out a language spoken by one child in the kindergarten, I discovered that by excluding the language, I also involuntarily excluded a young child. This indicated the importance of never making some languages seem more important than others when creating a technical solution for supporting language learning with multilingual children.

8.4.4 Opening up for Diversity and Literacy

Furthermore, the children were often observed reflecting on the differences and similarities between the different languages. The ability to reflect on languages is known as meta linguistic awareness, and is considered an important step before learning to read and write.

Additionally, research suggest that being exposed to different languages and different cultures might help the young children open up to diversity. Meriting that the use of the artifact might not only be a tool for exploring languages but also a step for opening up to different languages and the ones that speak them.

Undeniably, we are currently living in a multilingual and multicultural world. Furthermore, the following generations will live in an even more diverse world, meaning these generation of children will need to relate to those with a different culture, and those who speak a different language.

8.5 REFLECTIONS AND IDEAS FOR THE FUTURE

In this project I have reflected on how young children can participate in co-creating a tangible artifact intended for language learning, and how they might learn from interacting with the tangible artifact. Accompanying these reflections are also thoughts regarding what I have learned throughout the design process.

I went into the design process with the mindset of a researcher, but quickly found that I also needed the mindset of a pedagogue and a care-giver. Each action or task meant for collection data in the design process needed to be carefully considered and evaluated if it was appropriate for the young participants.

This challenge of changing perspectives throughout the project has given me a change to grow as a researcher. As technology is becoming an increasingly larger part of everyone's lives, including nontraditional participants in the design process, such as young, old or those with disabilities, seem like a natural progression. I believe gaining insight on how to adjust and adapt traditional methods to suit these with different needs will be valuable for me in future projects.

8.5.1 Ideas for the Future

This section is dedicated to improvements to the design process, and ideas for future projects.

Replacing the Researcher

As mentioned in Section 7.1.3 I described certain restrictions made early in this project for facilitating the design process for the young participants. One of these restrictions regarded the type of technology used in this project. As the one with the technological background, I choose what we were going to use. Which is for better or worse, an aspect of Participatory Design, someone needs to define the project's restrictions.

I would have liked to see both the young and adult participants take a larger role in the design process by also deciding what kind of technology could be used for creating learning environments. This could be facilitated by including time for exploring different kinds of technology in the design process.

App versus Micro Controller

In Chapter 6, I discussed how learning Apps for young children are overflowing the App market, and that Norwegian kindergartens are embracing the use of apps. I also discussed how education often lagged behind technology, and certain studies suggest that not all apps for children necessarily accommodate for learning.

Although I can not say if the children have learned from participating in the development process, and by playing with the interactive painting without assessments, it would certainly have been interesting to test what the children learned from this project versus an app with similar content. If the assessments yielded positive results in favor of the tangible artifact, this could suggest that kindergartens could benefit from integrating other technologies in addition to the standard technology such as apps, tablets and computers one can find in kindergartens today.

Technological Insight to the People

As a consequence of participating in the design process, the adult participants bought similar equipment for continuing the project on their own. It would have been interesting to see the results of these projects, and how the children embraces the technology now that they have previous experience with it and the role as co-designers.

In addition, as our society is becoming increasingly more technological, giving everyone the prerequisites needed to shape and understand the technology that will surround them in their daily lives should not be reserved for the few with technological background. Technological insight should belong to everyone. And one way to provide this insight to most children may be to integrate technology into the learning environment in kindergarten and primary education.

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A CONSENT FORM

I am a student at Østfold University College, and I am currently writing on my master thesis. The focus of my thesis is to explore how technology can contribute to creating an environment for second language learning in kindergarten. I want to design, develop and implement a prototype together with the children, where the children will have equal roles as design partners. During the development, I will film, record audio and take pictures of the sessions and the prototypes created by the children. Further, information regarding the participants age and gender will also be collected. Information regarding the child's name will not be included in the final report. Images, film, audio recordings and other material will only be used for the thesis, and an eventual presentation of the thesis. It is voluntary to give your consent, and the consent may at any time be revoked if this is desired by the child's guardians.

Sincerely
Caroline Sofie Olsen

Child's name:

I/We give our consent to allow our child to participate in the project _____

I/We give our consent that images may be taken of our child _____

I/We give our consent that audio may be recorded of our child _____

I/We give our consent that our child's participation can be filmed _____

Date

Parent's signature

B THE THREE BILLY GOATS GRUFF

Once on a time there were three Billy-goats, who were to go up to the hill-side to make themselves fat, and the name of all three was "Gruff."

On the way up was a bridge over a burn they had to cross; and under the bridge lived a great ugly Troll, with eyes as big as saucers, and a nose as long as a poker.

So first of all came the youngest billy-goat Gruff to cross the bridge.

"Trip, trap! trip, trap!" went the bridge.

"Who's that tripping over my bridge?" roared the Troll.

"Oh! it is only I, the tiniest billy-goat Gruff; and I'm going up to the hill-side to make myself fat," said the billy-goat, with such a small voice.

"Now, I'm coming to gobble you up," said the Troll.

"Oh, no! pray don't take me. I'm too little, that I am," said the billy-goat; "wait a bit till the second billy-goat Gruff comes, he's much bigger."

"Well! be off with you," said the Troll.

A little while after came the second billy-goat Gruff to cross the bridge.

"Trip, trap! trip, trap! trip, trap!" went the bridge.

"WHO'S THAT tripping over my bridge?" roared the Troll.

"Oh! It's the second billy-goat Gruff, and I'm going up to the hill-side to make myself fat," said the billy-goat, who hadn't such a small voice.

"Now, I'm coming to gobble you up," said the Troll.

"Oh, no! don't take me, wait a little till the big billy-goat Gruff comes, he's much bigger."

"Very well! be off with you," said the Troll.

But just then up came the big billy-goat Gruff.

"TRIP, TRAP! TRIP, TRAP! TRIP, TRAP!" went the bridge, for the billy-goat was so heavy that the bridge creaked and groaned under him.

"WHO'S THAT tramping over my bridge?" roared the Troll.

"IT'S I! THE BIG BILLY-GOAT GRUFF," said the billy-goat, who had an ugly hoarse voice of his own.

"Now, I'm coming to gobble you up," roared the Troll.

"Well, come along! I've got two spears, And I'll poke your eyeballs out at your ears; I've got besides two curling-stones, And I'll crush you to bits, body and bones."

That was what the big billy-goat said; and so he flew at the Troll and poked his eyes out with his horns, and crushed him to bits, body and bones, and tossed him out into the burn, and after that he went up to the hill-side. There the billy-goats got so fat they were scarce able to walk home again; and if the fat hasn't fallen off them, why they're still fat; and so:

Snip, snap, snout, This tale's told out.

C THIRD ITERATION ADULT BRIEFING

1. In the aspect of language learning, do you think we should focus on using single words, or larger information units in the prototype?
2. Can you describe the kindergartens program for second language learning?
3. Which languages are represented in the group of participants?
4. What are your impression and thoughts on the process?
5. Do you think the technology used in the project could be used in the kindergarten by employees?

D FOURTH ITERATION INTERVIEW

D.1 ADULT PARTICIPANT

1. What are your thoughts on the children's participation in this project? How did you see the children's roles in the process of developing the prototype?
2. Do you think the children think differently about technology after this project after being exposed to different technology than technology they usually meet?
3. Do you see any benefits in regards to language learning in both the process of creating and playing with the prototype?
4. And if we look away from the language aspect, does the children learn other things by being involved in the process, and playing with the prototype? Such as cooperation, creativity?
5. How do you think the children could be motivated to learn languages by interacting with the prototype?
6. What were your impression when seeing the children play with the prototype? Do you think the children had fun using the prototype?
7. Do you think the children benefited from participating in creating a technological solution?
8. Do you think the children can become motivated to learn more after participating in such a process, and after playing with the prototype? E.g children wanting to learn more words on another language after learning new words through the prototype?

D.2 CHILD PARTICIPANT

1. How did you like participate in the project?
2. Did you feel like you could also decide what we were going to do in this project?
3. How did you feel about using the prototype we made?
4. Did you learn any new words after playing with the prototype?

CHILD PARTICIPANT

5. What did you think about hearing your own language in the prototype?
6. What did you think about hearing the other children's languages in the prototype?
7. Why do you think I added more languages in the prototype?
8. Can you think about other ways we could use the technology?

E BARE CONDUCTIVE TOUCH SOURCE CODE

/*****

Bare Conductive Touch MP3 player

Touch_MP3.ino - touch triggered MP3 playback

Based on code by Jim Lindblom and plenty of inspiration from the Freescale Semiconductor datasheets and application notes.

Bare Conductive code written by Stefan Dzisiewski-Smith and Peter Krige.

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*****/

```
// compiler error handling
#include "Compiler_Errors.h"
```

```
// touch includes
#include <MPR121.h>
#include <Wire.h>
#define MPR121_ADDR 0x5C
#define MPR121_INT 4
```

```
// mp3 includes
#include <SPI.h>
#include <SdFat.h>
#include <SdFatUtil.h>
#include <SFEMP3Shield.h>
```

```
// mp3 variables
SFEMP3Shield MP3player;
byte result;
int lastPlayed = 0;
```

```
// touch behaviour definitions
#define firstPin 0
#define lastPin 11
```

```
// sd card instantiation
SdFat sd;
```

```
// define LED_BUILTIN for older versions of Arduino
#ifndef LED_BUILTIN
#define LED_BUILTIN 13
#endif
```

```
void setup(){
  Serial.begin(57600);
```

```

pinMode(LED_BUILTIN, OUTPUT);

//while (!Serial) ; {} //uncomment when using the serial monitor
Serial.println("Bare Conductive Touch MP3 player");

if(!sd.begin(SD_SEL, SPI_HALF_SPEED)) sd.initErrorHalt();

if(!MPR121.begin(MPR121_ADDR)) Serial.println("error setting up MPR121");
MPR121.setInterruptPin(MPR121_INT);

result = MP3player.begin();
MP3player.setVolume(10,10);

if(result != 0) {
  Serial.print("Error code: ");
  Serial.print(result);
  Serial.println(" when trying to start MP3 player");
}

}

void loop(){
  readTouchInputs();
}

void readTouchInputs(){
  if(MPR121.touchStatusChanged()){

    MPR121.updateTouchData();

    // only make an action if we have one or fewer pins touched
    // ignore multiple touches

    if(MPR121.getNumTouches()<=1){
      for (int i=0; i < 12; i++){ // Check which electrodes were pressed
        if(MPR121.isNewTouch(i)){

          //pin i was just touched
          Serial.print("pin ");
          Serial.print(i);
          Serial.println(" was just touched");
          digitalWrite(LED_BUILTIN, HIGH);

          if(i<=lastPin && i>=firstPin){
            if(MP3player.isPlaying()){
              if(lastPlayed==i){
                // if we're already playing the requested track, stop it
                MP3player.stopTrack();
                Serial.print("stopping track ");
                Serial.println(i-firstPin);
              } else {
                // if we're already playing a different track, stop that
                // one and play the newly requested one
                MP3player.stopTrack();
                MP3player.playTrack(i-firstPin);
                Serial.print("playing track ");

```

```
        Serial.println(i-firstPin);

        // don't forget to update lastPlayed - without it we don't
        // have a history
        lastPlayed = i;
    }
} else {
    // if we're playing nothing, play the requested track
    // and update lastplayed
    MP3player.playTrack(i-firstPin);
    Serial.print("playing track ");
    Serial.println(i-firstPin);
    lastPlayed = i;
}
}
} else{
    if(MPR121.isNewRelease(i)){
        Serial.print("pin ");
        Serial.print(i);
        Serial.println(" is no longer being touched");
        digitalWrite(LED_BUILTIN, LOW);
    }
}
}
}
}
}
```

F BARE CONDUCTIVE TOUCH EDITED SOURCE CODE

```
/*  
Bare Conductive Touch MP3 player  
-----
```

Touch_MP3.ino - touch triggered MP3 playback

Based on code by Jim Lindblom and plenty of inspiration from the Freescale Semiconductor datasheets and application notes.

Bare Conductive code written by Stefan Dzisiewski-Smith and Peter Krige.

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```
*/
```

```
#include "Compiler_Errors.h"  
#include <MPR121.h>  
#include <Wire.h>  
#define MPR121_ADDR 0x5C  
#define MPR121_INT 4
```

```
#include <SPI.h>  
#include <SdFat.h>  
#include <SdFatUtil.h>  
#include <SFEMP3Shield.h>
```

```
SFEMP3Shield MP3player;  
byte result;  
int lastPlayed = 0;
```

```
#define firstPin 0  
#define lastPin 11
```

```
SdFat sd;  
SdFile file;
```

```
#ifndef LED_BUILTIN  
#define LED_BUILTIN 13  
#endif
```

```
void setup() {  
  Serial.begin(57600);
```

```
  pinMode(LED_BUILTIN, OUTPUT);
```

```
  //while (!Serial) ; {} //uncomment when using the serial monitor  
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```

```
  if (!sd.begin(SD_SEL, SPI_HALF_SPEED)) sd.initErrorHalt();
```



```

if (!MPR121.begin(MPR121_ADDR)) Serial.println("error setting up MPR121");
MPR121.setInterruptPin(MPR121_INT);

result = MP3player.begin();
MP3player.setVolume(10, 10);

if (result != 0) {
  Serial.print("Error code: ");
  Serial.print(result);
  Serial.println(" when trying to start MP3 player");
}
}

void loop() {
  readTouchInputs();
}

void readTouchInputs() {
  if (MPR121.touchStatusChanged()) {
    MPR121.updateTouchData();
    if (MPR121.getNumTouches() <= 1) {
      for (int i = 0; i < 12; i++) {

        if (MPR121.isNewTouch(i)) {
          if (i < 5) {
            lastPlayed = i;

            Serial.print("last played ");
            Serial.println(lastPlayed);

            MP3player.playMP3("TRACK001.mp3");
            sd.chdir();
            Serial.print("chdir");
          }
          else if (i >= 5) {
            if (lastPlayed == 0) {
              sd.chdir("E000");
              //Serial.print("chdir");
              //Serial.println(sd.chdir());

              if(i==5){
                MP3player.playMP3("TRACK005.mp3");
              }
              else if(i==6){
                MP3player.playMP3("TRACK006.mp3");
              }
              else if(i==7){
                MP3player.playMP3("TRACK007.mp3");
              }
              else if(i==8){
                MP3player.playMP3("TRACK008.mp3");
              }
              else if(i==9){
                MP3player.playMP3("TRACK009.mp3");
              }
              else if(i==10){
                MP3player.playMP3("TRACK010.mp3");
              }
            }
          }
        }
      }
    }
  }
}

```

```

        else if(i==11){
            MP3player.playMP3("TRACK011.mp3");
        }
    }
else if (lastPlayed == 1) {
    sd.chdir("E001");

    if(i==5){
        MP3player.playMP3("TRACK005.mp3");
    }
    else if(i==6){
        MP3player.playMP3("TRACK006.mp3");
    }
    else if(i==7){
        MP3player.playMP3("TRACK007.mp3");
    }
    else if(i==8){
        MP3player.playMP3("TRACK008.mp3");
    }
    else if(i==9){
        MP3player.playMP3("TRACK009.mp3");
    }
    else if(i==10){
        MP3player.playMP3("TRACK010.mp3");
    }
    else if(i==11){
        MP3player.playMP3("TRACK011.mp3");
    }
}
else if (lastPlayed == 2) {
    sd.chdir("E002");

    if(i==5){
        MP3player.playMP3("TRACK005.mp3");
    }
    else if(i==6){
        MP3player.playMP3("TRACK006.mp3");
    }
    else if(i==7){
        MP3player.playMP3("TRACK007.mp3");
    }
    else if(i==8){
        MP3player.playMP3("TRACK008.mp3");
    }
    else if(i==9){
        MP3player.playMP3("TRACK009.mp3");
    }
    else if(i==10){
        MP3player.playMP3("TRACK010.mp3");
    }
    else if(i==11){
        MP3player.playMP3("TRACK011.mp3");
    }
}
else if (lastPlayed == 3) {
    sd.chdir("E003");

    if(i==5){

```

```

    MP3player.playMP3("TRACK005.mp3");
}
else if(i==6){
    MP3player.playMP3("TRACK006.mp3");
}
else if(i==7){
    MP3player.playMP3("TRACK007.mp3");
}
else if(i==8){
    MP3player.playMP3("TRACK008.mp3");
}
else if(i==9){
    MP3player.playMP3("TRACK009.mp3");
}
else if(i==10){
    MP3player.playMP3("TRACK010.mp3");
}
else if(i==11){
    MP3player.playMP3("TRACK011.mp3");
}
}
else if (lastPlayed == 4) {
    sd.chdir("E004");

    if(i==5){
        MP3player.playMP3("TRACK005.mp3");
    }
    else if(i==6){
        MP3player.playMP3("TRACK006.mp3");
    }
    else if(i==7){
        MP3player.playMP3("TRACK007.mp3");
    }
    else if(i==8){
        MP3player.playMP3("TRACK008.mp3");
    }
    else if(i==9){
        MP3player.playMP3("TRACK009.mp3");
    }
    else if(i==10){
        MP3player.playMP3("TRACK010.mp3");
    }
    else if(i==11){
        MP3player.playMP3("TRACK011.mp3");
    }
}
else if (lastPlayed == 5) {
    sd.chdir("E004");

    if(i==5){
        MP3player.playMP3("TRACK005.mp3");
    }
    else if(i==6){
        MP3player.playMP3("TRACK006.mp3");
    }
    else if(i==7){
        MP3player.playMP3("TRACK007.mp3");
    }
}

```

```
else if(i==8){
    MP3player.playMP3("TRACK008.mp3");
}
else if(i==9){
    MP3player.playMP3("TRACK009.mp3");
}
else if(i==10){
    MP3player.playMP3("TRACK010.mp3");
}
else if(i==11){
    MP3player.playMP3("TRACK011.mp3");
}
}
```

```
}
}
}
}
}
```