

University of Applied Sciences and Arts of Southern Switzerland
Master of Advanced Studies in Interaction Design

SUPSI

Talki

Learning language through play in early childhood



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1 Definition

1.1 Research Topic

The early childhood years are a vital and productive time for language learning. Research shows that infants and toddlers can easily learn additional languages due to their heightened neuroplasticity, the brain's capacity to form new neural connections and new brain cells throughout life.

What science tells us is that reaching the potential we do have is strongly determined by what happens to us when our brains are being developed, from birth through about three years of age.

Dr. Susan Curtiss, Professor of Linguistics at UCLA, who studies the way children learn languages, notes that ...the power to learn language is so great in the young child that it doesn't seem to matter how many languages you seem to throw their way...They can learn as many spoken languages as you can allow them to hear systematically and regularly at the same time. Children just have this capacity. Their brain is just ripe to do this... there doesn't seem to be any detriment to... develop(ing) several languages at the same time.

Young Children learn a language not in isolation but by consistently interacting with others and by being "involved" in conversations that fit into everyday activities. Being exposed to a rich vocabulary with lots of different words and real sentences contributes to faster language acquisition.

There are several psychological benefits of learning a second language. Studies by

Harvard University confirm that learning additional languages increases critical thinking skills, creativity and flexibility of the mind in young children. Research indicates that children who are exposed to a foreign language at a young age, achieve higher levels of cognitive development at an earlier age (Byalistok & Hakuta, 1994, Fuchsen, 1989).

Much of Montessori theory surrounding learning supports the idea that the mind develops best through the use of senses, particularly through the use of hands. Maria Montessori observed that anything that could or should be learned must be placed in our hands first. This also applies to language, words and grammar. For instance, the moveable alphabet is a tool within Montessori that guides a child towards writing as he visibly creates words from letters. Furthermore, she believed that language learning is driven by a child's social environment including interaction with peers and adults.

Past efforts in digital language learning have ignored the physical environment and in most cases failed to address all the sensory experiences. It is known that the act of moving is memory-friendly, and therefore there is a strong correlation between movement and long-term memory retention.



Spoken language must be learned in early childhood, or future ability will be restricted.

Play has been called the “work of children” because it is through play that children learn to interact with the environment, discover their interests, and acquire cognitive, motor, speech, language and social-emotional skills (American Academy of Pediatrics, 2007). Children learn through experiences they have with objects and people. It is through play that they make sense of their world.

When parents engage in playful activities with their children, they have an opportunity to facilitate and reinforce the growth of language skills that are important for later social and learning experiences.

There are many ways children learn language through play. In short, children learn by watching, listening, exploring and manipulating things around them, imitating others and by creating and formulating their own words, sentences and thoughts.

I intend to explore how to strengthen language learning through play, taking into consideration the physical environment and its learning potential. Additionally, I shall look at the human interactions appropriate for child learning.

1.2 Research Questions

With the above in mind, it is now possible to form research questions and hypothesis.

1. How might we create a rich multi-sensory experience that allows for maximum movement and physical play in language learning?



Traditional wooden toys

2. How might we create an engaging & playful alternative to touch-screen based solutions for training spoken language?

One hypothesis is that language acquisition happens subconsciously, while having fun through active play. The idea of “learning” no longer means rote memorisation, sitting still, forced repetition, or passive hearing but instead involving kids and their senses in different ways and let them explore and discover the language so they are able to build confidence and respond to the new language.

The second hypothesis is that learning in context through physical interaction with other people in a communal way, leads to better learning and retention.

In addition to the primary research questions I intend to look at the particular interactions of the tangible learning toy to make it naturally and seemlessly fit the learning environment created.

1.3 Research Aim

The research will focus on playful educational exercises and activities around language learning.

It will focus on young children interacting with a screenless tangible interface and with real world objects, people and spaces around them.

The project goal is to bring interaction design and digital technology to educational language learning toys that can be used to support children natural learning. I plan to design a toy which children can include in



The Thesis focus is not on written language, but on Spoken Language which relies on a trained auditory system



Traditional teaching activities have been honed over centuries

their daily exercises.

The research consists on interviews to different professionals in the areas of education, psychology, linguistics and instructional design as well as observational studies.

I intend to explore alternatives to the traditional classroom methods for language teaching, and the existing digital ones, where constructed games is at the center of the learning experience across the different spheres of the child's life: home, school and community

The goal is to explore whether a do it yourself approach, combined with the child's sense of touch, physical movement and social interaction leads to children remembering and learning better when active play or some type of physical activity is involved. Furthermore, as part of the research, I will explore key interaction modalities to be used with the physical device. I will look at interactive tangible technology to leverage conventional classroom toys/ games.

1.4 Research outcome

For the research outcome I intend to design two specific learning exercises or activities to be used with an physical educational toy for young children to be able to hear and recognise or respond to sounds, vocabulary/ phrasing in a foreign language.

The goal is to train the child's ears to the sounds/rhythm/intonation of spoken language. Hence the goal is not to become

fluent in a language, but rather to train the correct pronunciation of words and to acquire simple vocabulary through repetition and associating sounds of things E.G. animals.

The goal is not to complete mastery of language, but to build a foundation for future mastery.

The toy uses computer vision as the primary way to make sense of the world. It is used to recognise codes, colors, faces and toys. It intentionally doesn't listen to avoid a whole range of additional complexities. Receiving input via touch was considered, but not included in this project.

The toy only produces sound in the form of speaking reflecting human behavior. It has no visual User Interface and no buttons.

This approach was chosen to support traditional teaching principles and toys, and is an antidote to the past decades overuse of touch screen interfaces.

2 State of the Art

2.1 Topics and disciplinary areas.

This section provides a basic overview on how young children learn through play. I want to understand a bit deeper how children acquire language skills, through the interaction with the physical environment, using sensory skills such as audio, visual and tactile. I have researched the qualities of existing tangible educational toys for children aged 3 to 6 years old, including the materials they are made of.

Additionally, I have analysed their key interactions as well as their learning, entertainment and physical developmental potential. Furthermore, I have also researched how teachers from Montessori schools as well as Waldorf introduce language to their young students and the types of games and activities they use.

Benchmark research: I also searched and analysed already existing products, mainly tangible toys and digital apps that introduce language skills. In my research, I looked at:

- Physical toy design
- Learning Stage/Child Age
- Entertainment Value
- Educational Value
- Cultural Context (I.E. star wars theme)
- Longevity (very conservative change wise)
- Interactions for Child Motor Skills
- Illustrations (style influenced by child recognition, consistency with other products, fashion)

2.2 Tangible educational toys

Educational developmental toys create **endless** opportunities for learning through play and fun. From the day they are born, children are constantly learning. And the best way to learn is when they are not aware of it. They learn through using their senses, observing others and playing. In that sense, toys are tools that help children learn about themselves, their environment and the skills they need in life. Educational toys effectively stimulates learning. They can help develop a particular skill, or teach a child about a particular thing. They also provide fun.

Before analysing some of the existing products in the market, let's take a look at some of the qualities of educational developmental toys.

In a nutshell, a good toy is one that is fun for your child and suitable for his/her age, developmental needs, and personality. It is also one that provides time for unstructured play and inspire imagination.

Generally, it also has one or more of the following qualities:

- **Fun.** Any learning through play is enjoyable.
- Educational toys help in **sensory development**. They can help children develop fine motor skills.
- They retain a child's interest - the child will want to play with them over again
- Educational toys can help grow a child's IQ - through memory retention, motor



Play doh fun tube for 3 to 4

skills development, coordination, and even literacy and numeracy.

- Educational toys can strengthen **social and emotional development** – playing with others, sharing, bonding, taking turns, leadership and teamwork; all of these build confidence.
- **Challenges but doesn't frustrate.** A toy should be just on the margin of the child's growing capacities.
- **Can be used over and over again.** Toys that are designed to be played with in only one way inhibit imagination and creativity, and teaches a lack of influence on the world around them leading to passive consumption. A simple cardboard box can become just about anything your child wants it to be (house, car, store counter, boat, bed), and it can be pushed, pulled, crawled into, driven or painted.

Below is a list of some educational toys that currently exist in the market appropriate to 3 to 6 years old children and a brief analysis of their characteristics and educational value:

2.2.1 Play doh fun tube

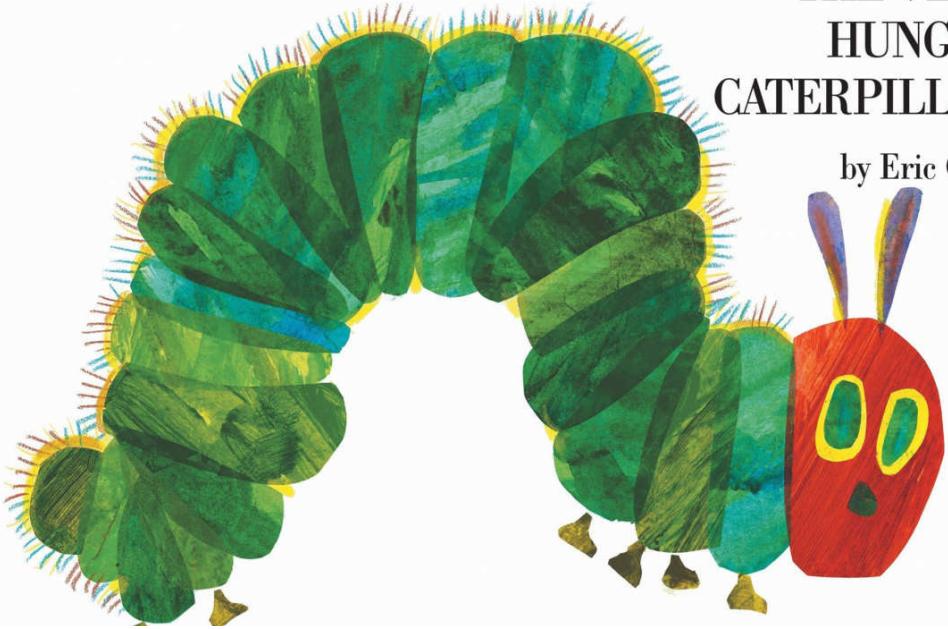
Dr. Roberta Golinkoff, author of *Becoming Brilliant: What Science Tells Us About Raising Successful Children*, notes “Kids learn from feel. At this stage, they’re really learning how things feel and what textures are all about. Their own agency is always present because they can turn that into a spider, a bear, whatever they think it’s supposed to be. As a parent, don’t say things like, ‘Oh that doesn’t look like a spider.’ Ask, ‘What is that?’ and let them tell you.”

Pros

- Encourages fine motor skills
- Tons of opportunity for creative play
- Variety of shapes and colors to play with
-

Cons

- Hard to clean



THE VERY HUNGRY CATERPILLAR

by Eric Carle

The very hungry caterpillar by Eric Carle

2.2.2 The very hungry caterpillar by Eric Carle

According to Sachs, a clinical child psychologist, as children develop their language skills, they can begin to understand basic rules of grammar. They may know that plural words end in 's,' for instance, but cannot yet grasp complex rules. "For example, a three-year-old may say 'gooses' instead of 'geese,'" he says. Reading books together with parents can further improve language abilities. Sachs recommends letting your child turn the pages of the book himself while you read.

Pros

- Nice colorful illustrations targeted at young children
- Good introduction to days of the week and food vocabulary

Cons

- It teaches reading and counting but not sounds
- Main interaction only by turning the page



Wooden Puzzles

2.2.3 Wooden Puzzles

Wooden puzzles are a wonderful toy for toddlers and helps them to develop important cognitive skills such as matching and spatial awareness. The specific type of puzzle will be dependent on the age and ability of the child.

Pros

- Encourages hand-eye coordination
- Cognitive development: Children learn to memorise something such as where a piece will go or fit. Teaches children to identify shapes, colors and associations.
- Vision: While working a puzzle, a child will have to look at the puzzle carefully. This sharpens their ability to identify certain things with their eyes such as

shapes, colors and sizes.

- Large wooden pieces makes it easy for young children grab and handle

Cons

- Pieces can be lost
- Not so challenging after a certain age



Melissa & Doug Band in a box

2.2.4 Melissa & Doug Band in a box

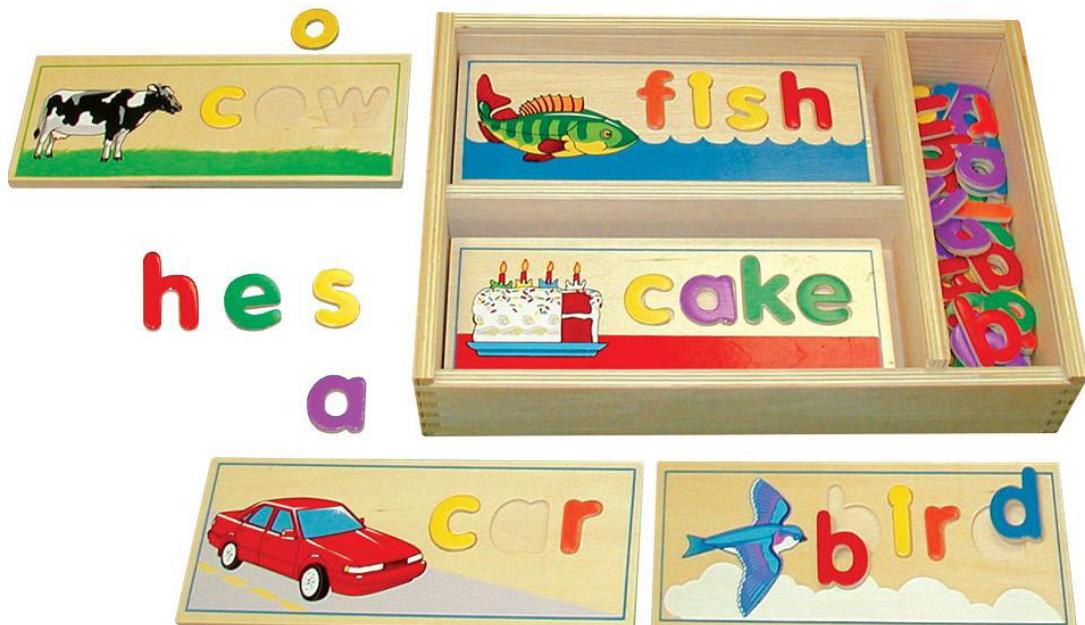
Music is a wonderful tool for encouraging language development with toddlers. In addition to learning important components of language such as rhythm and rhyme, music also has been proven to use many different parts of the brain. Finger plays, simple songs, and exposure to various musical instruments are all excellent ways to promote language development!

Pros

- Helps children develop a music ear
- Allows children to explore through play
- Light weight and durable
- Perfectly sized to fit into the hands of toddlers and grown up children

Cons

- Not so good sound quality



[Melissa & Doug see & spell](#)

2.2.5 Melissa & Doug see & spell wooden educational toy

This toy is for children to learn new words. It has over 50 highly colorful wooden letters that are arranged in ways that will help the kids to generate new words and in turn memorize them for an adequate learning process. While playing this game the sight is being developed coupled with vocabulary building and swift motor skill development.

Pros

- Comes in a compact storage case
- Increases spelling, sight-reading vocabulary and fine motor skills
- Three letter and four letters word made easy

Cons

- Choking hazard



[When I grow Up](#)

2.2.6 When I grow Up. Fabric Busy Book

This kinaesthetic book allows children to learn through interactive play, visual stimulation and tactile sensation. Some of the skills young children can master include buckles, zips, snaps, looping, velcro'ing and buttoning developing sensory, fine motor skills and pretend play

Pros

- Hands on activities in the book encourages motor skills development
- Interactive- each page contains an exercise that requires physical interaction
- Good for learning about shapes, colors and textures

2.3 Sound toys for Language Learning

After analysing different educational toys on the market, I've narrowed my research to educational sound toys that are screen free and aim at teaching language skills among others to inform my design goals.

These toys teach language and listening skills by providing interactive audio.

to reinforce learning. Each disc activates different content from the Timio's library to teach vocabulary, nursery rhymes, stories, music instrument sounds etc. Each disc has a different purpose/content. e.g to teach animals, colors, the alphabet etc

The discs magnetically attach to the player, so children can easily insert it by themselves.



2.3.1 Timio

Timio is a kickstarter project that was funded this year by a parent and it raised over 80,000 Euros. It is an educational audio toy and music player for children. It's screen free and consists of interactive content discs that support five languages.

Children tap a picture on the disc to play sounds. The audio player asks questions

Key benefits of Timio

- Screens have been associated with addiction, sleep disorders, vision and other issues. Timio has no screen
- No setup required and no buttons (not technically correct). Children can do it by themselves by placing a disc and tapping an image to listen to the audio content
- It helps develop motor, auditory, visual, cognitive and speech content in 5 different languages.

Disadvantages

- Fixed vocabulary which means that eventually it becomes repetitive

<https://www.kickstarter.com/projects/fattal/timio-educational-audio-toy-and-music-player-for-c/description>





2.3.2 Flora by Gund

Flora is an animated plush toy with two different play modes. Press the left foot to play an interactive game and the right foot to hear a song. It's a speaking doll although it only speaks in English.

Key Benefits

- Talks to a child in different phrases
- Sound and music helps children develop and learn while having fun

Disadvantages

- No way to control volume
- Doesn't speak multiple languages
- Unchanging content. After a while it gets repetitive

<https://vimeo.com/289117357>



2.3.3 Leapfrog lean & groove musical mat

Leapfrog musical mat is an interactive play mat for open-ended play to explore numbers, instrument names, sounds and animal characters. It encourages children to move and explore with songs and phrases. and three ways to play (explore, music and game mode).

Key benefits

- Explore by moving
- Developmental benefits (numbers, counting, music and instruments)
- Build gross skills
- Listening and follow instructions

Disadvantages

- Low sound
- English only
- Instructions move too fast, doesn't allow too much time to locate and move to the number or picture



2.3.4 Furby

Furby is a stuffed and soft interactive animal toy that reacts to being touched, talked to and even tickled with a variety of movements. The more advanced Furby model allows you to keep track of their health, hunger level and even bathing routine. It speaks Furbish, English and babbles.

The idea of the Furby is that it behaves like a pet to care for and can speak, sing, fart and belch after eating.

Pros

- It's like a substitute for pet, a companion, that needs to be taken care of
- It's entertaining. It sings and does other tricks that are amusing
- It has a cheerful personality

Cons

- Furby has poor social etiquette, it will interrupt when it feels like it, without concern, if it feels like speaking it will speak, and won't shut up
- Some people reported it as being annoying because it needs constant attention. (User quote: "I wish it would wait until he's spoken to, he's like the friend that interrupts..." (<https://www.youtube.com/watch?v=oVAqOq82V2Y>)
- What is the educational value?

The latest Furby is an increment on the 20 year old original design, with faster electronics that can connect to a smartphone app, allowing for more options. The design doesn't seem to be functionally different.

The inside of the toy is solid plastic including gears, etc



[What's inside a furby connect?](#)



2.3.5 Huile Toys English and Spanish

Bilingual toy

This is an interactive, flashing and musical toy that teaches toddlers sounds and languages.

It is an example of toy I wouldn't want to design. It is made of plastic with loud colors and has multiple buttons. Grown ups tend to think that children are stimulated by loud primary colors. While this may be true it doesn't mean that it makes for good user interface. For instance in traditional GUI design, bold colors are used sparingly because they attract the attention. You typically pick an action color to represent anywhere where an action can be performed such as a submit button. After interviewing experienced educators, it was clear that the mix of many colors and extra buttons distract

the children from their own objectives and priorities and creates sensory overload. The toy steals your focus and thereby makes it hard to execute your own ideas.

The use of many buttons encourage children to press any and every button in a random manner just to get a response and not really learn anything. We want to think of better ways to design educational toys that doesn't distract us from learning objectives. Focus is a crucial skill in human development so it is important to encourage whenever possible and make it a habit.



2.4 Wooden Educational toys
 Educational toys need to serve a purpose beyond entertainment. Why are wooden toys still popular?

Wooden toys vs plastic

When buying a toy, parents usually want something that is long-lasting, safe, and allows their children to be creative so they can learn through play while it's easy to maintain and environmentally friendly. There are many different materials to choose from, like fabric or rubber, but wood and plastic have always been the most popular. Below are some of the advantages and disadvantages of wood vs plastic

When it comes to educational toys, wooden toys have been trendy for decades, if not centuries. They have been enjoyed by generations and are timeless and less distracting than for example electronic toys, that may feature sound effects, alarms, blinking lights, etc.

They are durable and resistant

Young children are rough on their toys. Wooden toys are solid and hard to damage or break. Besides, if they get dirty, they can be easily cleaned, so they are ready for the next learning activity. Wood also wears well, becoming smoother and nicer looking.



They are safe

Most wooden toys are designed to be safe. Most won't break easily and are designed so children won't be exposed to rough edges or small pieces that have broken off of the toy. They are also generally non-toxic, and made from natural materials, so children can chew or suck on them without hazard.

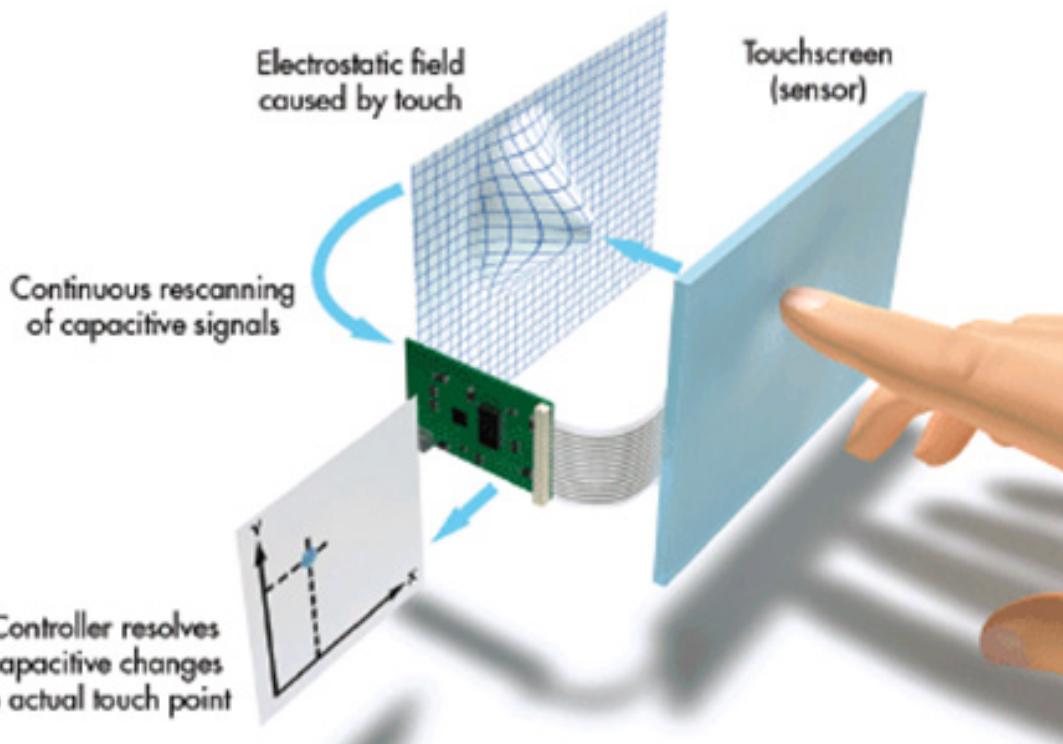
Open to child's interpretation

Wooden toys are more often simple and versatile than plastic toys. They inspire inventive and imaginative play instead of dictated play. They allow children to be more in control of the experience.

Disadvantages

Wooden toys are usually more expensive than plastic toys, harder and cannot be twisted or bent. The possible shapes are more limited.

Plastic toys on the other hand can be twisted and bent and can be easily washable. However, there is still the concern among parents of whether plastic toys are totally safe and toxic free for young children, who may chew on them.



2.5 Screen Based Products

Another alternative to tangible toys, are educational mobile apps for learning languages. While some are very effective in teaching language skills like sounds and vocabulary, many parents and child psychologists have expressed a concern regarding excess screen time. For instance, it has been shown that children spending extensive parts of their childhood watching computer monitors and TV do not adequately develop their spatial senses for the area behind them and as such do not

hear when someone calls from behind.

Traditional screen time (e.g TV and video gaming has also been linked to sleep problems and poorer developmental outcomes in children. Several companies have claimed that infants learn from using their devices or apps. Academic researchers, on the other hand, have been more skeptical, asking about what conditions are required to support infants' and young children's learning from screens (c.f., Richert et al., 2010; Hirsh-Pasek et al., 2015).



Studies have shown that young children are more successful in learning words and locations of hidden toys from screens if they are involved in specific contingent interactions, as compared to passively watching events unfold (Lauricella et al., 2010; Kirkorian et al., 2016)



2.5.1 Touch Screens

Touch Screens came to the forefront with the launch of the iPhone in 2007, showing a interactive device centred around interacting directly with visual objects in a 2D space by touching a glass surface with one or more fingers as the primary input. The hardware buttons present were there primarily for switching on and default interactions that one might want to do without watching the screen or while the device was in a pocket.

The qualities of the interfaces required much less explanation to the extent that a small child can discover the interaction rules by themselves unlike a traditional GUI/

keyboard/mouse paradigm. The devices is also small enough and light enough to be handled by such a “small human” without peril. This has given us an option to expose small children to digital devices for the first time, which immediately led to a rush of Toddler Applications being offered.

I've briefly explored the App Store for typical applications, which are listed here.



[App to learn about shapes: Very Hungry Caterpillar](#)

2.5.2 Very Hungry Caterpillar Shape

This app teaches children about shapes, colors, patterns, and scales with over 50 puzzles in six categories. Developed with the help of experts, it's easy to use. Available in English, German, Spanish, French, Italian, Japanese, Korean, Chinese, Portuguese, Russian and Turkish

Pros

The graphical interface is quite simple and easy to navigate by even very young kids on their own. However, the app's creators recommend parents to use it together with their children.

The words the book contains are grouped by the subject: animals, birds, fruits, and so on. When a kid selects an image, it turns into letters, and the speaker pronounces the word (parents can choose one or two languages). At the end of a learning session, there is an interactive quiz for the kid on what he or she has learned. That also consists of selecting

the right images.

The app has vividly colored graphics and is very interesting for kids. They will be thrilled to see their favorite animals and learn new ones. The only drawback is that words aren't used in a context.

Rosetta Stone Kids Lingo Letter Sounds

This app allows children to practice phonics based letter recognition, vocabulary and pronunciation.

Skills Developed:

- Identifying beginning letter sounds of familiar, everyday words
- Distinguishing different starting letter sounds in word families
- Recognizing upper and lower case letters
- Exploring active Spanish vocabulary
- Refining Spanish pronunciation
- Building confidence speaking Spanish aloud



App Rosetta Stone Kids Lingo Letter Sounds

2.5.3 Lingokids - English for kids

Lingokids is a mobile app that teaches children aged 2-8 English in a fun and playful way. It is a tool for young kids to begin learning English through a mixture of videos, songs, and activities. Kids interact with thousands of vocabulary words that form the foundation for learning a new language. In addition to lots of songs and animations, original content features live-action video of teachers introducing new categories such as animals, colors, and numbers.



2.6 Montessori & Waldorf Methods

Before our era of so called Modern Technology, teaching had a period where teaching methods were formalised based on an aim to develop well rounded human beings rather than compliant subjects.

The Montessori method is based on self-directed activity, hands on learning and collaborative play. Children work individually and in groups to discover and explore knowledge of the world. The teacher offers age-appropriate activities to guide the process. The activities targeted at children aged three to 6 years old contain a large variety of materials of sensory perception. For instance, for young children aged 3-5, a lot of emphasis is put on sound games using flash cards or small figures such as animals, vehicles etc. Sandpaper letters is another activity which lets the child see the letter, trace it with their fingers, while the teacher says the sound so they are having a multi sensory experience.

The Waldorf language acquisition method supports that children start learning a foreign language by pure imitation and with an emphasis on movement: with rhymes, songs, poems and plays. Comprehending

grammar and reading and writing starts later at the age of 9. According to Steiner, before reading and writing, children should hear the language with clear pictures so that they are exposed to the sounds and rhythms. For example, an activity with the letters of the alphabet can represent pictures, therefore a drawing of a mountain contains the letter M. “This helps a child to comprehend that the abstract forms we have developed as symbols for sounds, have a meaning in the pictures they represent.” [waldorfpublishations.org]

The Waldorf approach is based on “Listen! Imagine! Picture! Draw! See the signs in nature! Hear the sounds of the wind and of the word! What do you think the birds are singing to you?” [waldorfpublishations.org]

These methods are still widely respected by researchers, parents and teachers and should be considered when designing educational toys, games or activities.

2.7 Technologies Past/Future

Toy manufacturing has traditionally used very limited electronics to cut costs. It was perceived that the outside sold the product, and the inside was merely a cost overhead. I.E. Instead of proper loudspeakers cheap metal tweeters were used to make sounds, hence the annoying sound quality in most toys.

With the rise of Smartphones integrated circuits with 1000x the power compared to regular consumer electronics came down in price and availability in numbers.

This means that you can today produce PC(anno 2000) level functionality in very small formfactor in the price range of \$10.

Internet of Things is all the rage today, even if most dreams will not pan out, there is still an established market where you can make a WiFi enabled device with several sensors with off the shelf components. ESP32 for instance is a Chinese microcontroller where the prototyping/dev kit costs \$7 and the chip alone in volume costs \$1-\$2. It can drive motors, lights, microphone, tiny speaker, 8 touch areas, and connect to other devices while holding 4Mb storage and connecting via WiFi and Bluetooth.

2.8 Insights

As such Touch Screen devices seem to be better than Television, but it still limits the range and complexity of movement for the young child leading to a slower motor skill development when exposed for extensive periods. It would be desirable if the touch screen interactions could be converted to traditional real world object interaction, leading to much more complex hand/arm coordination and even extensive body movement. This type of environment is the traditional child playtime environment that we know culturally from hundreds of years of civilisation, and is generally considered to be promoting a good baseline.

Mobile Apps of all sorts especially games for children tend to follow simple patterns that are well established.

The game portion of the games tend to be naively simple from a psychology perspective, usually copying traditional physical/board games. The main feature tend to be the audiovisual content in order to make it look and sound nice, not on how to best challenge the user at his/her current level of ability. Having watched the App

Store over the past 5 years I have seen little change in this trend for Language Learning Apps in general. Hence the apps are likely to remain similar in the years to come.

Interactive devices.

In my analysis I've also touched on traditional board games(I.E. Sneaky snacky squirrel game or Hoot Owl Hoot) that promote language learning to young children. While I believe that they are very efficient at developing storytelling skills, reading and spelling as well as collaboration (where players work together to reach a common goal), and teaches additional skills like taking turns, they often lack the verbal "feeling" for the language, the sounds and the way words are pronounced.

3 Scenario Design and Concept Generation

3.1 Context/ Domain Analysis, User Research and Opportunity areas.

In order to define a clear concept for language learning through games and activities, I interviewed 2 parents, and 4 educators at kindergarten Montessori & International schools in Zurich and Zug and a Kindergarten private school in Lugano teaching young children aged between 1.5 and 12 years old with an average teaching experience of 20 years.

Both schools interviewed put a high emphasis on learning a second language from a very young age and follow a "learn by doing" through active exploration with their environment and through connecting learning with real things and life experiences.

At this stage, the aim of the research is to gather domain knowledge from the point of view of the users, who are primarily children but also parents. We want to learn more about what toys or things kindergarten children play with, how, where and who with.

The goal of the interviews is to understand:

- What is a 3/4 year old most excited about?
- An example of activity children really like?
- What topics do teachers start out with for children aged 3
- Do they mix the topics a lot or do they prefer to stay on topic?
- What types of materials/things do they use to support language learning?
- Do they see a difference between children aged 3, 4 or 5? How do they play

change?

- Are there any rewards for children who do well?
- How do teachers introduce language and what vocabulary/topics do they teach?

In this context it is also interesting to learn more about the environment in which children are motivated to learn as well as how the activities may change based on the student's interests, personality and learning styles.

In my former profession as an elementary school teacher I have taught children aged 5-10 years old and observed the way they interact with parents and peers. I got back then the opportunity to interview and engage in informal conversations with parents and have gained many insights from that which I will be using to inform my design. However, in order to refine the product design, as we produced prototypes, I interviewed parents and teachers centred around those prototypes, to gain more detailed insights in the nature of child's play and learning. The outcomes are personas, scenarios and anecdotal observations.





3.1.1 Research Insights

From the observational studies we could see that children like to engage in physical play, and they are happy playing by themselves and observing others. They can play with one thing for a long time, until they feel they want to try something else. They enjoy to move around and move things around.

To sum up, from this research we learned that children use language creatively in a variety of ways for example role plays, by acting out different characters and games with high verbal content like rhymes, chants, songs and clapping games. One school I interviewed used the Jolly Phonics method which is a multi-sensory method for teaching children to read, through actions for each of the 42 letter sounds.

The types of activities teachers use to teach a second language are:

- Roleplays
- Rhymes
- Chants

"Children start listening before they start speaking. Language is about communication and children will know when is the right time for them to use the words they have encountered or speak in full sentences. No pressure, it will come naturally"

"Children can learn complex topics at the age of 3 or 4. They can learn complex concepts such as trigonometry and meditation."

- Songs
- Clapping Games
- Matching object to picture
- Matching word to picture
- 3D figurines for storytelling and vocabulary learning

From the research we also learned that playing with things and real objects has always been and it still is an important aspect of play. Learning through play and through seeing, feeling and experiencing things is still a very popular method among educators. With the advancement of technology, however the nature of toys and materials used to create playthings have also changed. Smart educational toys have been popular in many contemporary homes for the past decades. For instance, many children now play with dolls and other artefacts that are "connected". These are toys that connect offline play with online activities such as Playbrush, which teaches children to brush their teeth properly by turning it into a game.

Montessori Kindergarten of Zug

3.1.2 Interview to Barbara Weiss - Head Teacher

Teaching experience 18 years
Montessori school Zug Switzerland
Age range: 1 to 7 years old

“Children learn best when knowledge is combined with physical interaction”

“We want children to help each other with discovery tasks. Children observe others and should have plenty of time to do it.”

“Sometimes they spend 3 days with the same exercise.”

“Some children seek an older child that they can learn from, some look for a younger friend they can look after. This way pairs bond and help each other.”

“They start with explaining big topics like the universe and then zoom in on the smaller parts.”

“You can teach math trigonometry etc to 3y old”

“You don't teach alphabet, but sounds represented by starting letters, middle letter, end letter”

“You give children something to feel”

“Material used to support learning: Cards with printed illustrations and text. Physical figures, puzzles, world globe, maps, shapes to help them different ways to hold a pen with both hands.”

“Children love small things”

“One teacher will only speak one language their native tongue to create an association between the language and the teacher.”

“Let them take their time to finish the exercise and figure out for themselves if the exercise is correct.”

“We don't test for the right answer, so don't give feedback on correctness. The child can check the answer themselves.”

“We don't correct mistakes, we just record that the lesson needs to be repeated so the child learns the right answer.”

“From fidgeting or posture you can see that a child needs a certain activity. If you fidget, you need to do something with your hands.”

“If you slump, you need to jump around. children need more of: trust from parents, freedom to do what is right at their current stage, time to finish what they do.”

“No rewards”

“Although we do observe common rules for a safe and good environment for all present (running, shouting ...)”

The motivation must be intrinsic or you should be looking for psychological problems “

“All children have their own pace. Children are how they always were.”

“Some children deal with 5 languages, it isn't a problem, it just means that vocabulary comes a bit slower in the beginning.”



3.1.3 Interview at Casa dell'infanzia Fogazzaro - Lugano Interview transcript with Silvana Giunta (20 years teaching experience)

We start teaching English as a Foreign Language from the ages 1.5 years old. From 3 to 6 years old there is a more structured method, we use jolly phonics which is a specific method to teach English. It is based on sounds and pronunciation, where we show the letters and a specific sequence is used. Children learn phonetic sounds for example mmmmmmm to associate words with M.

Q: What is the most difficult thing when teaching an additional language to children? Children are used to speak Italian at home, therefore often their first choice is to speak Italian, so a challenge is to engage them into a new language and try to make this new language as familiar as possible. They are also learning Italian in parallel, so children have an additional difficulty to understand when is time to speak Italian or English.

Children start listening before they start speaking. We use tools like cards, color cards, figurine toys, sounds, songs, stories and CDs and we teach them everything a young child needs to learn, for example how to keep a pencil with their hands, how to express themselves with a draw.

Children always learn through play and it is important to cover all ways of learning/learning styles: Kinetic, visual and audio. For teachers it would be nice to have more tools to help children improve pronunciation.

3.1.4 Interview to Anna Flückiger, Head of Montessori School Lenzburg, teaching kindergarten children aged 3-6 years old (18 years teaching experience)

Q: In your experience, what is a three year old child most excited about?

A: Helping with daily activities

Q: What type of physical games does a 3 or 4 year old like to play?

A: Movement games, games involving rhythm and dance, guessing games

Q: Regarding vocabulary learning, what do you teach first? Or what topics do you teach first?

A: Enrichment of vocabulary-phonetic sounding of the letters, phonetic writing and then reading

Q: Can you give me an example of activities children really like?

A: Practical life activities (Hand-washing clothes, watering plants, setting up the table, cooking, etc)

Q: Are there any rewards for children who do well?

A: No. We teach them to be proud of their own achievements without receiving a reward.

Q: Can you give me an example of topics you start out with for children aged 3?

A: Everything in our surroundings is named and the teachers are native speakers. The child is given a 3 period lesson (period one: this is..., period two: show me, period three: what is this...?) when learning new vocabulary. We have many prepared language picture cards (used for three-period lessons) for enrichment of vocabulary.

Q: What is really easy for a young child?

A: Participating in everyday activities (practical life)

Q: What is really hard?

A: Sitting still for a longer period of time

Q: What learning support do children need more in their life?

A: Not to be put under pressure by their parents



3.1.5 Questions for teachers or assumptions

1. Name / age / country / what kind of school do you teach at?
2. What age range do you teach?
3. In your experience, what is a 3 year old most excited about?
4. What type of physical game does a 3 or 4 year old like to play?
5. Do you think it is important to teach collaborative skills to a 4 or 5 year old child?
6. What type of games do you use to teach collaboration?
7. What type of activities do you use to teach collaboration?
8. Do you repeat the same activity or invent new ones all the time?
9. What type of objects/materials do you use to facilitate language learning?
10. Can you give me an example of the topics you start out with for children aged 3 for example colors or fruits? What do they love to do the most?
11. Which one should you teach first?
12. Do they like to mix the topics a lot? Or do they prefer if you stay on topic?
13. Do you have a topic that you find the most difficult to teach or where you spend the most time on?
14. Do you see a difference between children 3 or 4 or 5? How do their play change?
15. Can you give me an example of activity that children really like?
16. What types of materials do you use to support learning?
17. Can you give me an example of a game children really like to play?
18. Are there any rewards for children who do well?
19. How do you engage children in fantasy/ fantasy stimulation?
20. How would describe the development of a child from 3 to 6?
21. How long have you been teaching for?
22. What is really easy for a young child?
23. What is really hard?
24. What learning support do children need more of in their life?

If you think I can ask the question in a better way, please suggest the better version and the answer you would give.

3.2 Personas, context scenarios and requirements

From the research it was possible to gain meaningful insights that will inform and justify our design choices later on in the process. Based on the interviews to parents, educators and observing children's play in and out of the classroom, I've tried to answer some of these questions:

- Where do they play?
- Who do they play with?
- What do they play with?
- What do they enjoy the most/ the least?

It is now possible to outline some personas, whom define the ideal users. They will help us to understand our users' goals in specific contexts. Furthermore, we are now able to develop stories or context scenarios as a means of imagining the ideal user interactions and to define requirements which will help to clarify the fundamental interaction framework for the product.



3.2.1 Curious Pre Schooler

Lynn Favre

Age: 3.5 years old

Nationality: Switzerland

Languages: German, Mandarine and English

ABOUT

- International pre-schooler Zurich
- Kinaesthetic learner
- Loves playing outside

FAVORITE ACTIVITIES

- Drawing
- Dancing to music
- Planting seeds
- Pet Caring
- Sand play

PERSONALITY

Lynn is a 3 year old preschooler who is always happy, energetic and bouncing about. She is curious, likes to tell stories and ask a lot of questions! Her parents keep her busy with extra activities such as playing piano and learning English. She looks up to her big brother and wants to be just like him.

GOALS

- Wants to play with toys alone without always needing an adult
- Making parents proud by learning new words
- Playing the piano

FRUSTRATIONS

When she is around grown ups they tell her what to do. She wants to make up her own mind

Dependant on parental oversight for the majority of activities

Wants to play Lego with older brother but it's too difficult

NEEDS

- Games/activities that are colourful and fun
- Easy to play and free play without too many rules
- Learn sounds and simple vocabulary and sentences
- Finding activities where she can use her imagination and explore



3.2.2 Autonomous Learner

Christian Jakobsen

Age: 5 years old

Nationality: Danish

Languages: Danish and English

ABOUT

- First grade student
- Visual/ solitary learner
- Likes books, building blocks, Lego, miniature animal toys and iPad

PERSONALITY

Christian is a slightly introverted and independent learner, although he also enjoys to spend time with his friends and family. He strives to understand a concept as much as possible on his own before asking for help. He is happy teaching himself new things and understanding how stuff works through trial and error. He is happy to spend time alone watching videos and playing with his favourite toys. He doesn't need an adult to initiate play or games as he spontaneously creates his own.

GOALS

- Have fun
- Feel a sense of achievement
- Find out more about the world

FRUSTRATIONS

- His mother doesn't want him to spend long periods on the iPad as she thinks that social participation is important
- He wants to be able to do more himself like building Lego systems all by himself

NEEDS

- Needs to learn English to communicate and play with his cousins that live in New Zealand



3.2.3 Informed Parent

Charlotte Persson

Age: 40 years old

Nationality: Swedish

Educational level: University

Profession: Head of brands at Coop

Children: 3

ABOUT

- Mother of 3 children - 8, 4 and 2 years old
- Career oriented
- Believes that education should be hands on, experimental/exploratory, encourage independence and foster social interaction

PERSONALITY

For Charlotte it is important that their children become well rounded people, aware of others and can explore different things and find their own interests. She encourages her children in participating in extra-curricular activities like dancing, ceramics and sailing. She has been spending a lot on educational toys and books for her children. She is picky with the type of toys she buys and tries to buy fewer of them but ones that encourage creative thinking, learning new skills and having fun while doing so. She believes that in order to develop social skills it's important that screen time is moderated, so it doesn't take over most of the childrens time.

GOALS

- Let their children explore and form their own opinions/ develop their own personality
- Be a supportive parent and be involved
- Have regular open conversations
- For her children to be happy doing whatever they choose to do

FRUSTRATIONS

- Screen time can interfere with quality family time

NEEDS

- To find the right toys that help her children develop with a good balance
- Find toys that encourages musicality and language development



3.2.4 Context Scenarios

After the development of the personas, I focused on high level actions from the user's perspective through constructing context scenarios. I split the context scenarios in three different moments of play: before, during and after play.

3.2.5 Lynn's Context Scenario

Lynn is playing at home for the first time with her mother present

Before

Lynn is at home with her mother and takes her new plush toy to the living room to play with. As she sits in front of the toy, she hears the sounds coming from the toy.

During

1. Talki doll says he is hungry and asks for an apple. Lynn doesn't understand the full sentence but has heard the word apple before, and knows what it is.
2. Lynn watches her mom playing with Talki for the first time. She grabs an apple from the wood toy set and puts it in front of Talki. She watches that Talki talks and makes different sounds every time something is placed in front of it.
3. Lynn finds that amusing and decides to explore by herself what happens if she gives Talki other things, for example a carrot or an ice cream. What will it say? Will he laugh? Is he happy? Is he still hungry?

4. She has a set with different things like animals, letters and colors. This time she shows Talki a letter to see what it says. Lynn hears the sounds each letter makes and decides to repeat it.

After

After playing for 40 minutes(as an example , no fixed given duration) with the doll, Talki says that he is tired and needs to rest in his home. (charging time), she takes it back to her room and places it in its home. After 3 hours she comes back to play with it again. The doll says hi as it sees the child and suggests the next game.



3.2.5 Christian's Context Scenario

Has been playing with Talki for over a year

Before

Christian is playing with Talki on the carpet on the floor. He wants to play Talki adventures, where he has to move through the carpet to find different elements and interact with them or has to pretend to do something like dive under water to help Talki achieve a goal. e.g to help him find a suitcase.

He is happy to try to understand what Talki is saying and figure out what things mean on his own.

During

1. Talki asks for something using two words that Cristian doesn't know. "Where are my red boots?"
2. Having an idea of what Talki might mean he brings a couple of things. He brings the red boots, a red ladybug, yellow flower, and a loaf of bread.
3. He shows them to Talki and Talki responds mentioning each of them. Talki says what it sees "I see a red ladybug", "I see bread", "Wohooo, thank you for the red boots! That's just what I needed!!!"
4. The tone of voice and excitement combined with specific interjections that

express emotions of joy and happiness like "wohooo", "yeyyyyy", "Yeahh! That's just what I was looking for!" or emotions of disliking like "ewwww", gives an indication of whether they are the right thing.

Finishing

The game ends when Christian finds the lost item and returns it to Talki.

After

The next morning Christian wants to play the carpet game again, this time with his friends.

The next big adventure is to help Talki cook a great meal, by finding lots of tasty ingredients Talki likes to eat like insect cakes with different shapes, triangular, square etc. Talki is a monster and eats very strange things!!!

3.2.6 Data Requirements

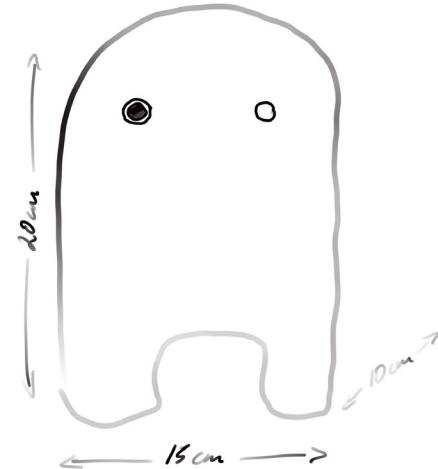
Certain things are necessary for Talki (plush toy) to work.

- Vocabulary (1000 words order of magnitude)
- Word relationships
- Machine vision model with labels = words
- Computer speaking model supporting short sentences
- Current goal (Talki tries to achieve one goal at the time)
- Current activity (it can switch between activities but it is only doing one at the time.)
- Wifi access

3.2.7 Functional Requirements

These can be thought of the actions of/with the product.

- Parents can change language setting using the app
- Recognising the child approaching and starting conversation, without the need to press buttons
- Recognising being given an item
- Initiate play by speaking in short sentences
- Give feedback on wrong choices made by the child



- Give feedback on right choices made by the child

3.2.8 Brand and Experience requirements

What attributes of the experience would we like users and customers to associate with Talki?

- Teaching principle led
- Play-based learning and imaginary play
- Natural materials
- Teaches native pronunciation
- Follows the principles of language acquisition through repetition and reinforcement
- Games follow an exploratory approach to learning used among certified teachers
- Control of error within the toy that enables the child to complete and correct the task without the help of parents. It propels the child toward completing an activity independently.



3.2.9 Technical Requirements

What components, weight, size and power constraints are used for Talki? Without knowing the exact technical design I will end up with, I have to consider a realistic set of technologies to use. For prototyping I have to use development boards rather than much smaller production pieces, so it will have to be a bit bulkier than an actual production ready design. I have made some paper experiments to get a feel for the size and component distribution, and found a doll that roughly similar to what Talki might become.

Physical dimensions of the doll



I expect Talki to be slightly larger than this existing doll:

The electronics inside the doll cannot take up the full space as most space must be padding to keep it soft

I've experimented with a possible insertion



Experiment adding from bottom



Experiment adding from bottom

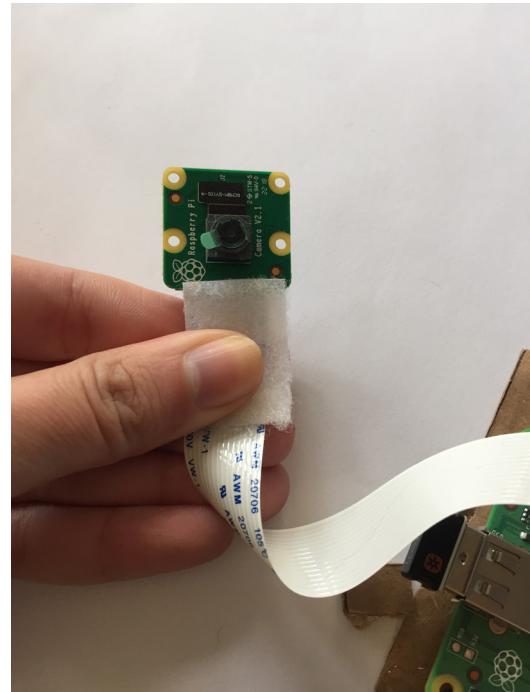
of electronics from the bottom of the toy of a squarish container that supports the shape of legs.

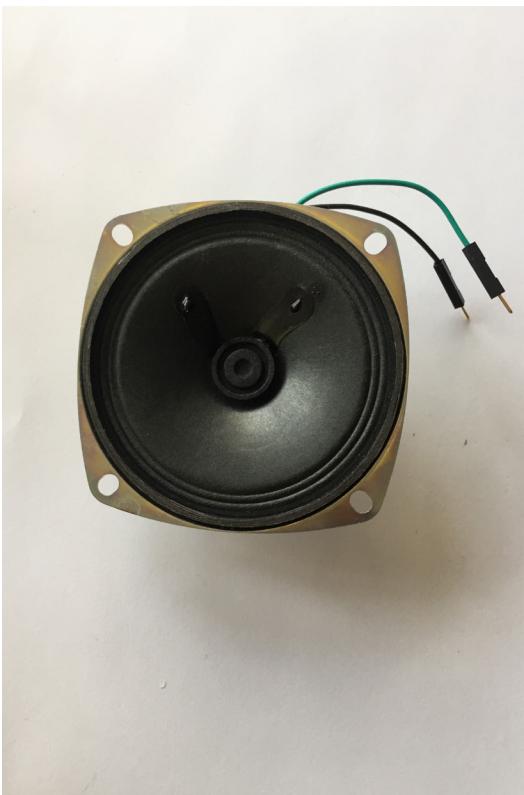
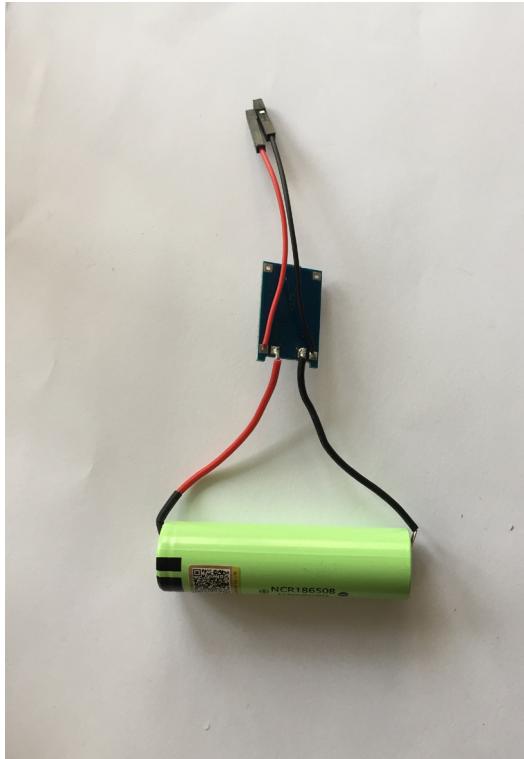
Internal Hardware Components

- Speaker
- 3W Amplifier
- Camera
- Raspberry Pi 3 A +
- Battery

The camera would be placed in one of the eyes

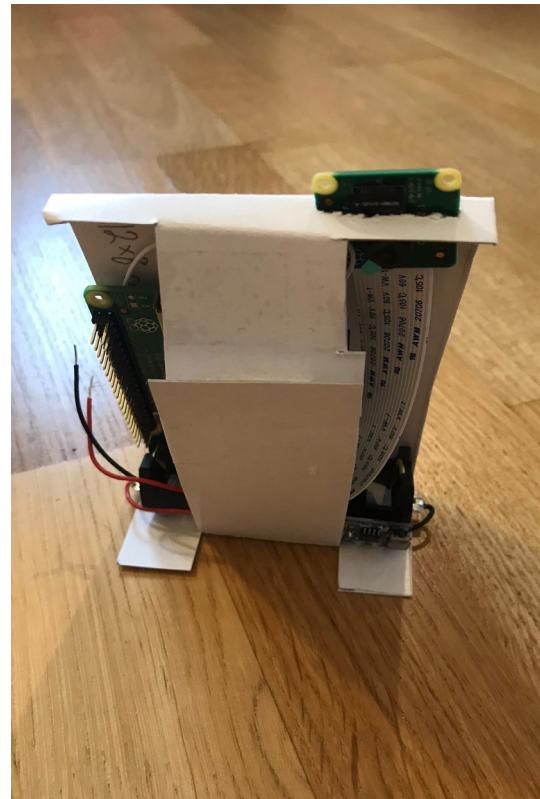
The speaker might be placed in the belly





Weight

The doll I am comparing Talki with weighs 110 grams. The components specified above weigh roughly the same (battery 46 g, Raspberry Pi 33 g, loudspeaker 50 g.) This means that Talki will probably weigh twice as much as a typical doll. It is important that Talki is not so heavy that the child cannot lift it, move it around, or play with it in a natural way. It also needs to be made in such a way that it cannot hurt the child during play, so no hard edges etc.





3.3 Framework Definition, Concept Generation

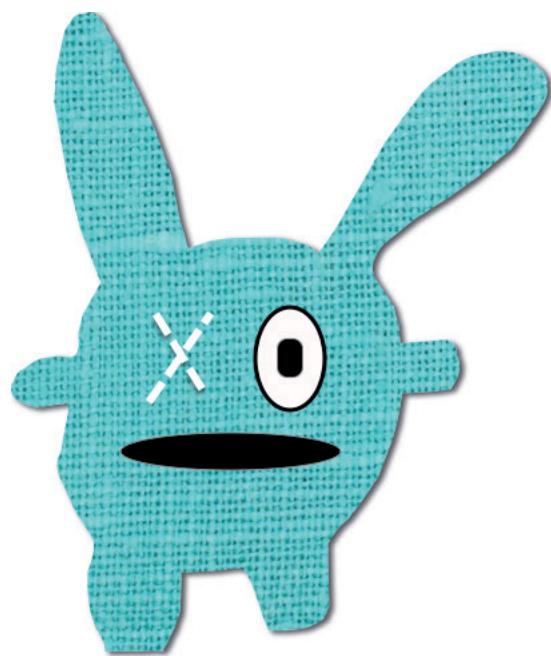
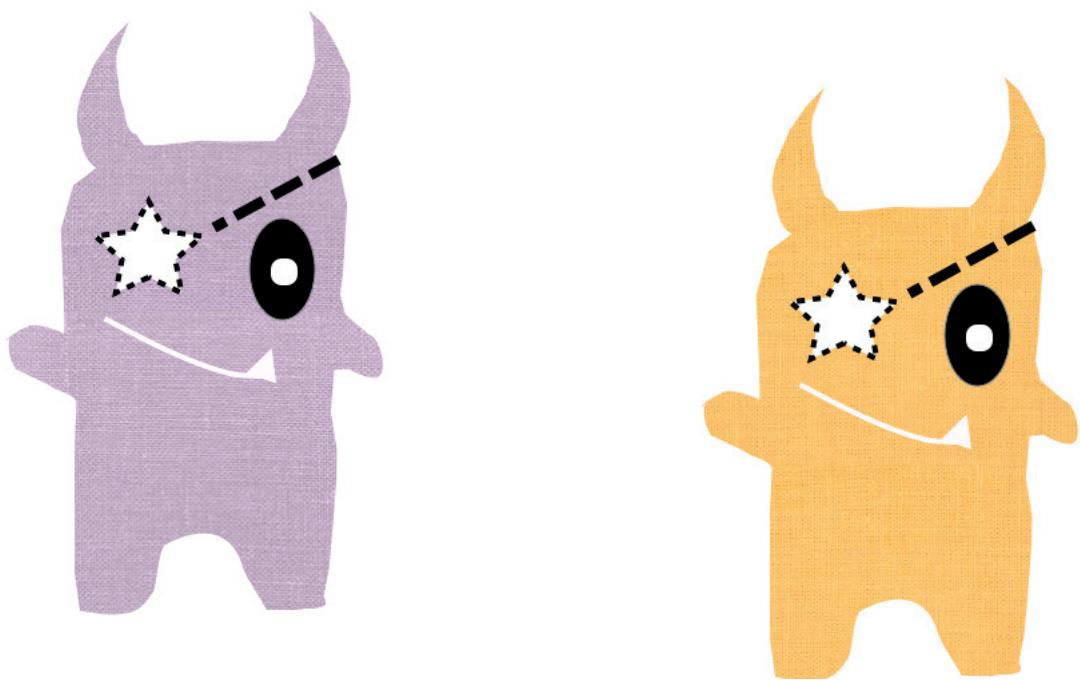
We are now able to define the overall structure of the toy and associated behaviours. At this stage, it is important to think about the physical form and interactive behaviour of the product.

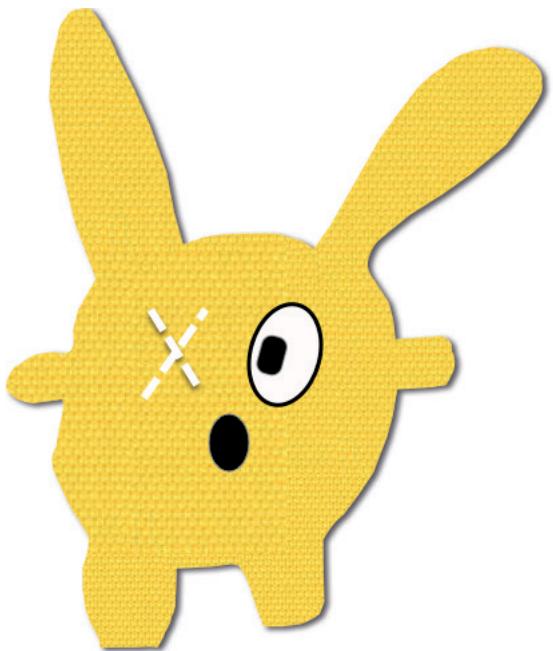
Shape and feel

Talkis default position is standing up straight. It will tend to move to that position through weight distribution and material springiness. It needs this position to point the camera in a predictable direction. The shape of the doll has to be simple and

straight forward, so that is appealing to young children. The shapes or outlines of the doll will be designed to resemble a monster. I have sketched different 2d shapes in different fabrics, so I can test it with children and see how they react to the different shapes, cloths, patterns and colors. It will be interesting to test different monster shapes and see if children think they are too scary, or what patterns or colors they will choose to play with.

I have also created rough prototypes made of foam and bamboo polyester (pillow material) for an initial test.



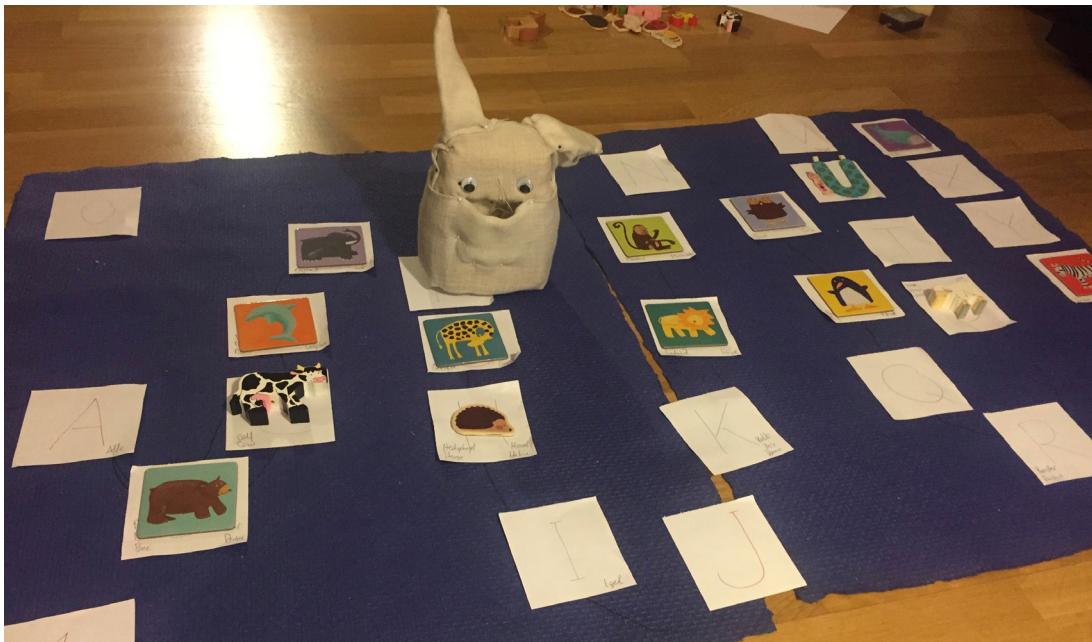




Materials

The toy materials should be child-friendly, lightweight, natural and washable. For the doll design I will use pure linen or organic cotton.





3.4 Detailed concept for prototyping

Who is Talki?

Talki is an educational plush toy that is very chatty and playful. It is a polyglot little monster that can say 500 words in different languages based on the objects it sees. Talki can't hear but can talk to the child and interact with him/her based on what it sees. The purpose of Talki is to introduce simple language, teaching young children letters, sounds and everyday vocabulary in a playful manner. It can also form full sentences and vary them, exposing the child to natural language. Talki is like a 3 year old child in what it knows. By this age a toddler's vocabulary is usually 200 words or more and many children can string together 3 or 4 word sentences. This is what Talki can do too, which makes it a doll that grows with the child.

It likes to make sounds, sing songs and play games with children, introducing them to things like the alphabet, numbers, colors, shapes and everyday vocabulary like food, and animals.

Talki reacts to what they do. It uses machine learning to recognise objects and responds using the word for the object, constructing full sentences. It is based on a friendly

monster mythology such as Tazmanian devils cartoon, Monsters Inc and Quark comic.

Talki's objective is not that the child speaks but to expose the child to the sound of the language in a way that makes it stick.

In order to become verbally fluent at a language you have to be exposed to it at a young age before 8 years old. No amount of training as an adult can retrain your auditory senses needed for native pronunciation.

Talki is made to imitate child communication and child sensibilities, with the type of sounds and emotional vocabulary and reactions it makes.

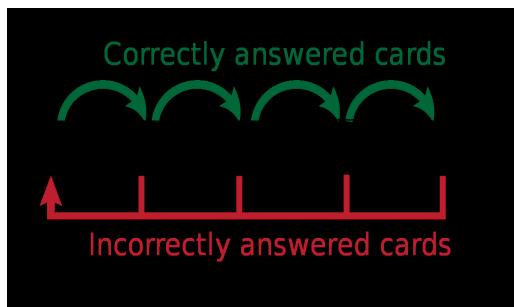
What principles does Talki use?

Talki contains a range of embedded electronics running constantly, but it doesn't feel technical. It doesn't use screens and other interfaces associated with digital devices. The child can play with Talki by interacting with the physical environment and experiencing real things with their hands and showing them to Talki. Research tells us that when a child learns in this way, she is more engaged and retains what she learned in a deeper way.

Talki initiates the conversation or game and encourages children to explore and figure things out by themselves. It gives the child feedback but it doesn't tell them if they are right or wrong. For instance, if Talki asks for a specific object e.g a bird and the child brings a tree, Talki says that it is a tree and he is looking for a bird. In this way, the child can learn by trial and error and at their own pace.

Spaced Repetition and Reinforcement

Talki uses spaced repetition principles to make sure children remember vocabulary.



The space repetition system is a learning strategy that gives you the information before you would forget it and makes sure it stays constantly fresh in your mind. <https://www.fluentin3months.com/spaced-repetition/>

For instance, Talki introduces the word apple for the first time. If the child responds by grabbing an apple Talki assumes the child knows this word and will repeat it the next day. If the child reacts by grabbing an orange instead, Talki assumes that this word is still unknown and will repeat it within shorter intervals e.g 10 minutes. In other words, the words/vocabulary you struggle with will be repeated more often than the words you have no problem with.

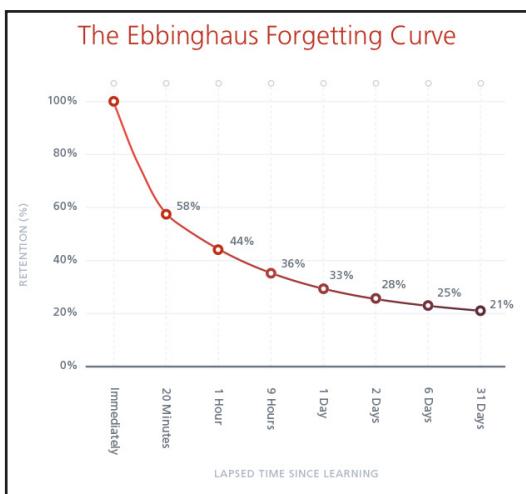
Encourages exploratory play

Our current educational culture is focused on job preparation, external motivation

and topics taught being a means to an end. When humans are born they are driven by curiosity in addition to hunger, tiredness, etc. After visiting some Montessori schools, it is clear that you can acquire advanced knowledge such as trigonometry at age 3 without any external pressure or rewards and purely by intrinsic motivation. Children are interested in everything and if given a way to explore a topic that is accessible to them, they will happily explore for days on their own. Talki encourages exploratory play by using all the senses, examining objects by looking, touching, listening and moving them to learn about the world a little better. A huge part of this type of play is trial and error which is an important way to learn. The ways in which the child can play together with Talki never ends. The games are designed to be versatile and can be used to teach many different topics and concepts, allowing for more exploration.

Speaking in full sentences- conversation

Talki speaks in simple full sentences, even if the child doesn't understand everything.



Being exposed to rich vocabulary and full sentences at a very early age is crucial for the child's brain development. In her book Thirty Million Words, Building a child's Brain, Dana Suskin notes that the numbers of words and how they are said are determining factors for development. Based on the things it sees Talki also varies the sentence construction e.g "I see a red apple" or "the apple is red".

Children are taught language by listening to their parents from when they are born. It happens automatically unlike the structured approach they later experience in school. Talki is based on this statistical learning language acquisition principle. The child will learn by listening to the toy speaking.

Parents interact in one-way verbal communication during the first year or two, and even when the child starts to speak they have a far wider command of the language so it can be seen as dominated by listening

in the early years. Since the child cannot ask, the parents respond to what they see and talk about it. The toy will likewise react to what it sees and talk about it.

In addition the toy is a property of the child so the child initiates the learning as play by grabbing the toy and showing it something. This interaction should ideally be registered in detail by the toy, allowing it to interpret this non-verbal communicated intent.

What vocabulary does Talki teach?

Talki teaches everyday vocabulary that is appropriate for children aged 3-6 years old, like animals in the farm, colors, food, the world and shapes. Talki also makes sounds e.g animals and speaks in full sentences.

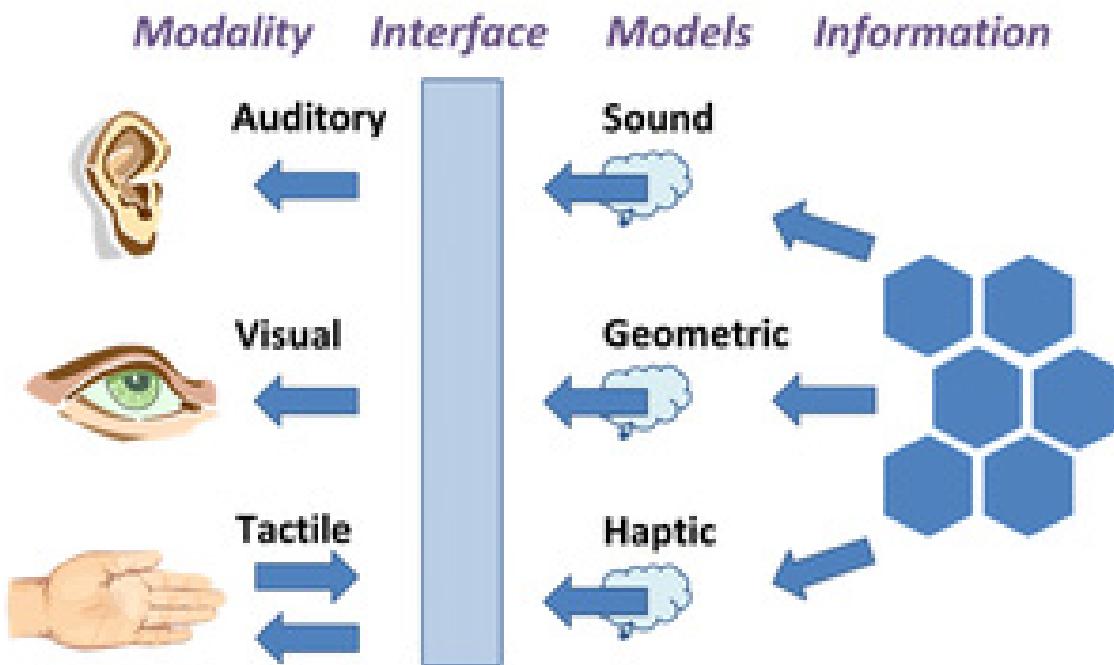




What activities can Talki play with the child?

The Talki activities are to be designed to target two or more senses simultaneously with the goal of teaching vocabulary and sounds. The materials will be carefully chosen to fit small hands and manipulate three dimensional objects and matching them to 2 dimensional pictures. Talki reacts to elements/items that are part of a game and activities that are specifically designed for it, using teaching led principles in which the child must interact with the physical environment, by touching things and doing things, before getting the verbal response for it.

The exercises and activities will be explained in a further section.4.2



3.5 Interaction Modalities

Talki uses multimodal communication.

Computer-Human modalities

Talki outputs communication to the child by speaking (in an embedded speaker), singing and making noises. This is intentional as technology has excelled in creating distracted environments, by only offering voice output Talki has the least chance of distracting the child from the physical play environment
and internal creative construction.

Human-computer modalities

Talki receives inputs via cameras in the form of movement sensing, facial recognition and object recognition. It also receives input when it is itself moved or lifted.

There are no alternative modalities, so Talki wouldn't make much sense to for instance a deaf child.

Normal Human Conversation

Since Talki is a talking and sound doll that emulates a friend rather than a machine, it is important to design the conversations it engages with and emotional reactions based on human conversation principles. Just like in human conversation, Talki can adapt to how it responds based on what the child does, making the conversation as organic as possible, instead of mechanic. It will react to events like when a child is nearby, lack of response and other things it sees.

For example, it will react spontaneously as soon as it sees the child nearby by initiating the conversation as a means to inviting the child for interaction/ play. It introduces conversation openers like "hello, I see you" or "peekaboo, where are you", in order to get the child's attention with the goal to play rather than requiring the child to start with a specific word or sentence e.g "Ok Google" or "Hey Siri". Talki starts the interaction with the child, when it recognises her/ him. Ideally it should not react to grown ups. It's fine if it reacts to other children.

It should not identify the child by name or identity, but by recognising it is a child. The early version is based on using proximity/motion sensor.

When this happens, talki will initiate an interaction opener by saying “hello”, “I see you”, or “Let’s play”. If it manages to keep the child’s attention, it will suggest starting the default activity by saying something like “can you help me”, “I’m looking for” or some other opener that describes the activity that Talki is suggesting. It might suggest a particular action for the child to do in order to proceed such as: “bring your color cards”, “let’s play animals in the farm”. If the child reacts as expected it will start the activity.

In addition to the default activity, Talki will recognise the intention to start an alternate activity by seeing what the child is bringing. Talki only knows a certain number of alternate activities such as purpose built board games, one of which comes in the Talki kit.

If the child is bringing a known object belonging to an alternate activity that Talki knows, Talki will suggest playing that activity instead. If the child interacts with the object in question Talki will then begin the activity such as bringing a picture carpet and putting it on the ground. If Talki recognises that is too far away, or too close, it will say for instance “I don’t see the carpet”, “where is the carpet?”

4 Project Development

Talki is the only seeing and speaking smart educational toy
That uses totally invisible technology
to enable language learning
through open-ended physical play alone or with other children

4.1 Initial Physical Design

Sculpturing Talki the Toy

Before settling on a final shape, I have created several low fidelity prototypes made of foam and paper. The first prototypes were more squarish, and the latter more rounded. Since Talki mimics a living being I wanted to explore a more rounded shape that emulates a face. The reason why it has to be a face is that the mouth has to be big enough to put a wooden figurine inside, which means that adding a body would make the toy very big. Talki's mouth is always open, as it is always ready to eat things. The mouth is a wide open oval (an actual hole taking up 70% of the width). The other features of Talki include two ears that hang on the side, and one eye open and one closed.



I have used a childrens bedroom lamp as my main inspiration for the shape

Talki should have the following features.

1. It looks like a normal plush toy resembling a monster, without any technology giveaways.
2. An open mouth for eating toys, that smiles so it seems welcoming and fun. It can eat toys up to 8cm wide.
3. Ears that stand out to the sides like human ears. Rounded to seem familiar and friendly, ideally slightly goofy. Strong enough so they can be pulled or used to carry.
4. Camera placed behind one of the eyes to see with.
5. Speaker placed below the mouth pointing towards someone facing Talki to speak with.
6. It can recognise child faces with the camera in normal lighting conditions and ideally distinguish between different children to treat them as individuals, making the experience personal.
7. It can recognise the toy it is given out of a well known set of toys in order to teach the vocabulary of the set, using the camera scanning for a bar code.
8. It can be charged by plugging in a USB cable (prototype not end product)
9. It can be accessed for demo and testing purposes over WiFi by designers and developers.
10. It can be charged by placing it in its home.
11. Learning Progress and Details can be accessed via Bluetooth using a dedicated Smartphone App.



Foam Model. Dimensions: 18cm high , 14cm deep, 16cm wide



After settling on the right dimensions of Talki, I created paper models of the different parts of the toy, to allow me to cut the fabric in the right dimensions to sew.



Patterns have been scanned in order to later make digital models for manufacturing. It is likely that the dedicated manufacturing software will be used for modelling. I have experimented with different fabrics to test the look and feel of the toy on children later.









I am experimenting with different fabrics, facial expressions and different ear sizes of the toy to give it a bit of character. My aim is to find a good balance between cute and scary. From my experiments,

the exact position of the zipper in the mouth is important as it gives the toy a more of a cheerful face rather than grumpy/moody. It also acts as a way to easily assemble the toy by stuffing it with the different pieces and easily removing them for washing the doll. Some fabrics are more resistant and durable than others.

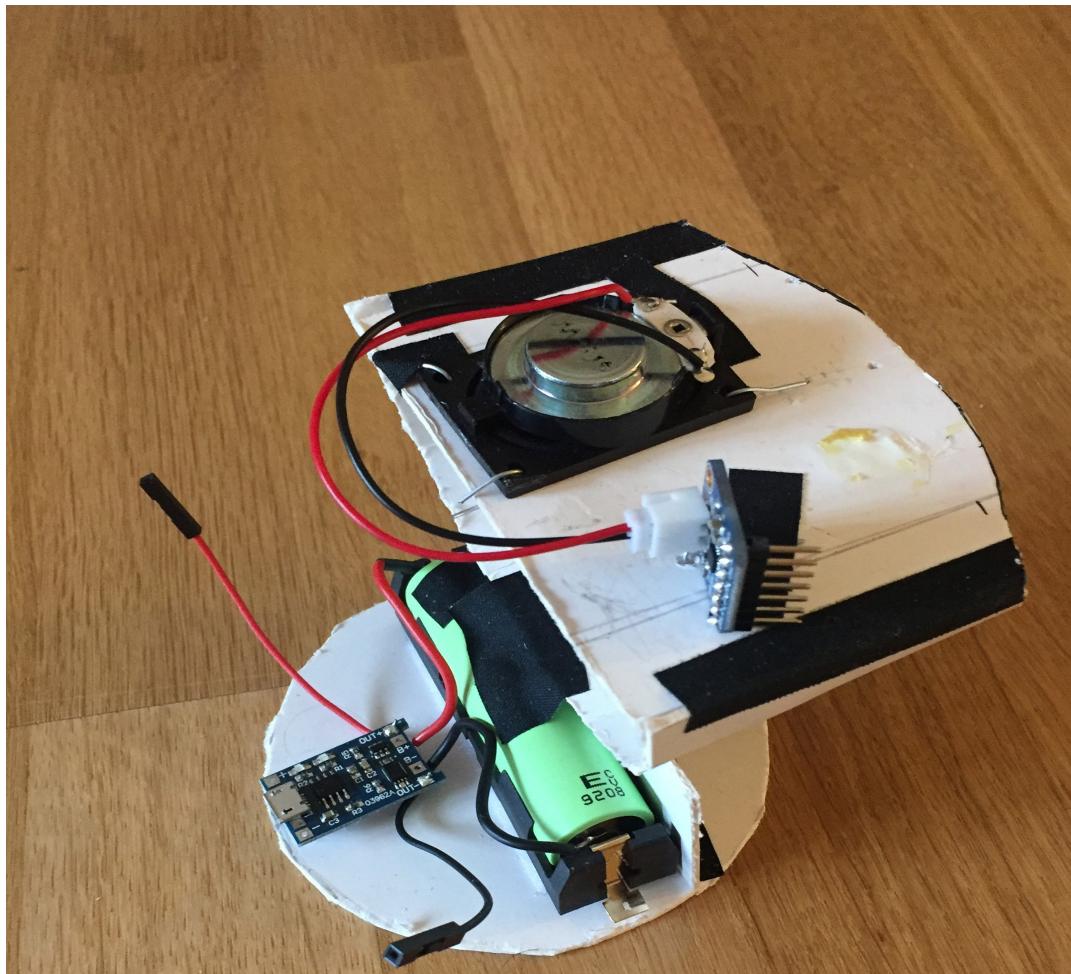
I'll be looking for those that are a bit stiffer, stronger and can last for a long time.



My first three prototypes of Talki Monster

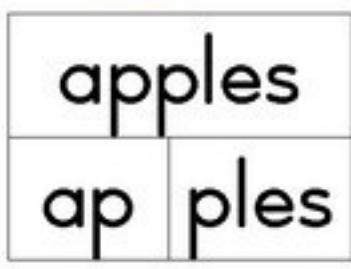
4.1.1 Design considerations

The inside of the toy contains a structure of electronics. For the final product it is important to seal the electronics in an inner layer, so even if the child destroys the fabric, the electronics won't get affected.



4.2 Instructional Design

The purpose of Talki is not that children speak a language fluently but to **train their ears** to the sounds, rhythm and flow of a language. It also exposes them to native pronunciation of words. It trains **phonological awareness** which is the ability to hear the sounds within words. It is a listening and pre-reading skill (before children can read and write) that allows children to recognise and work with the sounds of spoken language. A child who is phonologically aware can hear how many words there are in a sentence and hear how many syllables there are in a word.



As a secondary goal the child learns everyday vocabulary through repetition of words centered around topical toy sets and storytelling. Each set has a theme and a story. E.G. Talki goes to the Zoo.

Food Vocabulary	Animals	things in nature/gardening	Colors
ice cream	cow	tree	red
cake	calf	flower	yellow
carrot	pig	sun	green
chocolate	horse	moon	grey
cheese	bird	star	black
apple	duck	cloud	white
cookie	dragon	water	orange
mushroom	dinosaur	grass	brown
orange	dog	rainbow	
pumpkin	sheep	water can	
fish	bee	boots	
banana	ladybird	bird	
tomato	bat	vegetable	
lollipop	cat	fruit	
lemon	rabbit	gardening fork	
pear	snail		
candy bar	zebra		
bread	elephant		
	flamingo		
	seal		

Table of vocabulary taught

4.2.1 Learning Goals

The learning goals for Talki are

To teach Vocabulary:

- 34 animals & things in nature
- 17 food items

To teach Phonological Awareness:

- Rhyming
- Identifying syllables
- Intonation
- Recognition & Pronunciation of 28 Phonemes

	i:	I	ʊ	U:	ɛɪ	eɪ	Phonemic Chart	
Vowels	sheep eagle	ship busy	good should	moon grew	ear through	train say	short	
e	ɛ	ɜː	ɔː	ʊː	əɛ	ɪç	əʊ	long
dead said	about police	the the	hurt bird	work work	saw walk	saw tourist	boy point	diphthongs
æ	ʌ	aː	ɒ	əɛ	eə	aɪ	aʊ	voiced
cat apple	mat apple	up up	cut cut	bath car	what because	hair careful	by there	unvoiced
Consonants	p pen hopping jump	b ball hobby	t table herb	d dog added	tʃ chips itch	dʒ jam danger fudge	k key car	g green hug
f fire laugh phone	v video move	θ thick healthy	ð mother teeth	s see city	z zebra cogzy	ʃ shop nation special	ʒ television visual	ʒ leisure
m man tummy lamb	n no funny	ŋ sing uncle	j yes onion	l light smelly	r right berry	w win where	h house hungry	h who

The 44 phonemes of Standard British English with examples of common spellings.

adapted by AlbaEnglish.co.uk

Sound Chart				
th 	sh 	ch 	wh 	ph
ai 	ay 	ee 	ea 	igh
ie 	oa 	oe 	ow 	ow
ou 	or 	aw 	au 	oo
oo 	ue 	ui 	ew 	ar
oy 	oi 	er 	ir 	ur
ake 	eve 	ike 	ope 	ule

4.2.2 How Talki Teaches

Talki teaches vocabulary by requesting toys. It tracks the response to the requests. How often was it correct/incorrect. Thereby it's possible to deduct what has been learned.

Talki teaches Phonological Awareness by speaking slowly & clearly, breaking words down and emphasising central phonemes. There is no good way of tracking the progress of learning in this area. A microphone couldn't do it, and even if it could, it would not added to the design for security concerns at this point.

4.2.3 Learning and Teaching Principles

Talki follows 5 principles

- Rhyming (learn that some words end with similar sounds) e.g When Talki sees the child it says “knock knock, it’s play o’clock” or “Cuckoo is that you?” or “Hey there!!Let’s play!” or “Peek-a-boo I see you! I found you!” Rhyming is an important skill because it is a good indicator of how well children will read.
- Repeating the beginning sounds of a word e.g shhhhhhhh for sheep or shark or chhhhh for chocolate or cheese or frrr frrr for frog or spppp sppppp for spider. It is also possible to repeat the end sound of a word e.g shhhh shhhh for fish or ckkk ckkk for duck or phhh phhh for dolphin
- Introducing musicality and rhythm by clapping the syllables in words e.g three claps for **e-le-phant**, 3 claps for **Kan-ga-roo**, one clap for wolf. Teaching the concept that words can be broken apart
- Associating sounds with words or things/ objects and actions (nouns and verbs) e.g Mooooo Moooo is associated to a cow, ni-no ni-no to an ambulance, woo woo to a train, vroom vroom to a car, shhhhhh for quiet, mwaaaah to blowing a kiss, splash to water, bzzz bzzz to a bee, etc
- Using voice pitch and exaggeration to describe concepts e.g it’s a biiiiiiiiiiig elephant





4.2.4 How does Talki give feedback to children?

Talki doesn't reward, for instance it doesn't praise and doesn't say the child is wrong when they bring a wrong object. Instead, it gives them feedback by using **interjections** which are expressions to show emotion, surprise, or excite. For example, when a child brings the wrong thing it says "uh-oh" or "oops", in a way that doesn't express **disappointment** or **sadness** but is emotional enough to be clear. It also uses the principle of repetition and re-structuring/arranging the sentence to reinforce learning.

To express happiness "yeyyyyy", "wheeee", "woooow" but in a way that is more playful rather than hysterical.

To express satisfaction or joy, for example when it's eating "yum yum" or "yummiiii".

4.2.5 Conversation and Exercises

All Talki exercises are designed to train Phonological Awareness (skills associated to listening and recognising the sounds of a spoken language, usually taught at kindergarten and pre-school through first grade, before children can read). All exercises follow the same principles based on human conversation and human interaction.

Talki has no off switch. It is has a battery that keeps it functioning at all times. If it runs low on battery it will become tired and want to go to its home to sleep. After sleeping it will have a fully charged battery and be ready to play. Regardless of the exercise or activity Talki starts out in an 'awaiting' state waiting to recognise the child. When it sees the child it will greet, and proceed to suggest an activity if the child doesn't initiate one first.



4.2.6 Exercise ONE

Feed me!! I am a monster, I will eat anything like bugs, food or colours.

Designed for kindergarteners and preschoolers ages 3-6 years old

Learning Goal: Reinforce phonological awareness- pre reading skills through listening, emphasis on sounds at the beginning or end of a word and vocabulary retention through repetition

Children are able to identify the first sounds within a word, and to hear and identify different parts of words. Repetition of the word is used to reinforce vocabulary learning and information retention.

Vocabulary taught: food

Talki is a little monster that loves food and things to eat. He loves when children feed him. So, it will always be asking for different things to eat. Talki initiates the activity by asking for something specific to eat. The child has to recognise what it wants and bring it what it's asking for.

To do this exercise, children need to have a set of food toys like the one in the picture

below:

Note: If the child is completely new at a particular language, the set should not contain more than five pieces. It is better to minimise the frustration by limiting the choices. Too many choices can be distracting, although the ideal and optimal amount of pieces would have to be tested with children.



As the child progresses and learns the vocabulary, new pieces and figurines can be added to the set to teach a specific topic, for example food. Also it is advisable to add to the set objects that interest the child. So if for example the child is interested in dinosaurs, it will appeal to their interest and they will want to learn more.

Teaching single words:

- Ice cream
- Cake
- Carrot
- Chocolate
- Cheese
- Apple
- Cookie
- Mushroom
- Orange
- Pumpkin
- Fish
- Banana
- Tomato
- Lollipop

- Lemon
- Pear
- Candy bar

Full Sentences

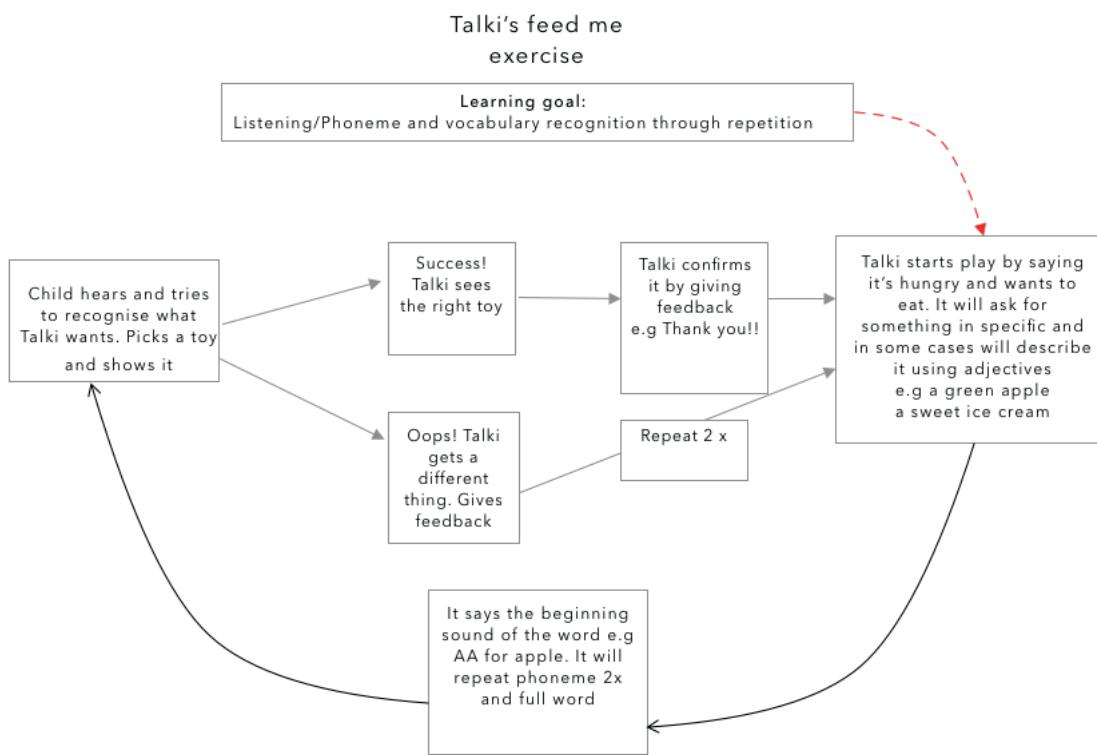
Talki has 4 different response possibilities based on the child's action. So, based on what the child does and shows it, it can respond in different ways

E.g Ice cream

React: (When a child spontaneously shows him an object he knows) "Yummmy I love ice cream! Ice cream tastes good! Yum Yum ice cream is de-li-cious!"

Asking: (When Talki knows someone is there and starts an exercise by asking for something) "I like Aiiiis Aiiissss ice cream! Can you give me an ice cream?"

Confirming: (When a child brings the right object) "Thank you!/ Yayyy/ woohoo/ wheeee/Hooray, Ice cream is yummyy!! That's what I was looking for!"



Exercise Goal: Listen to phonemes and words, identify right toy

Denying: (When a child brings the wrong object “Oh oh!!, That is an ice cream!! but I’m thinking of something else...Can you bring the... (repeat asking for the other thing)

Repeat: “I’m looking for”

Banana

Asking: “I’m hungry! Can you give me a bbbbb banana?Yummiiiiii I like banana!!!!”

Cookie

Asking: “I want a “kkkkk” cookie! Where is the cookie? Yum Yum I like cookies.”

Chocolate

Asking “Chhh Chhh choc choc... chocolate...I want chocolate!! Can you give me a chocolate?”

Apple

Asking “AAAAA” Apple... I want an apple! Can you give me an apple?

2. Talki says “I’m hungry! I want a skeese, cheese!” or “I’m hungry! I want a banana, fanana!” or “I’m hungry! I want a pumpkin, bumpkin” or “I’m hungry! I want a cake, pake” or “I’m hungry! I want a carrot, blarott or “I’m hungry! I want a waffle, faffle!”
3. Allow children to correct Talki by engaging them in role-play, by letting them teach Talki e.g (No, it’s cheese!) and encourage them to bring and show the right object
4. It’s ok that Talki gets a bit silly and make up words or nonsense words in this activity, since the purpose is to teach rhyming. The parent is there to help the child validate what is real and unreal and encourage the child to correct and teach Talki what the right word is.
5. When the child brings the right object, Talki says the correct word e.g “Yumiiiiii I love cheese! Cheese tastes yummiiii!”

4.2.7 A different variation of the same game using rhyming - Ideally played with parents

Objective of the game: Reinforce phonological awareness- pre reading skills through listening and rhyming. Research shows that children that spend time singing and rhyming as babies, toddlers and preschoolers are more likely to be ready to read as they enter school. Rhyming and singing help children learn how language works. Rhymes and rhythm help children hear the smaller parts in words, the sounds and the syllables.

In this game, children are encouraged to correct Talki’s silly and nonsense words and bring the right food!

Example of how Talki behaves when seeing the child during Exercise one.

1. Talki sees the child and says “Hello, I can see you, I found you!”



4.2.8 Exercise TWO

I Spy! Designed for kindergarteners and pre-schoolers ages 3-6 years old

Learning Goal: Reinforce phonological awareness- pre reading skills through listening and Guesswork/Guessing. The child has to listen to the sounds Talki makes and associate them to a thing/object or action e.g splash is associated to water, woof woof to a dog, and tick-tock to a clock. Reinforce exploratory play by letting the child guess what Talki wants and allow them to go hunting or look for something.

Goal:

Goal: Learn everyday vocabulary/ Recognising sounds in words

Guessing games such as “I spy” or “Let’s go find it” can be used as an engaging phonological awareness activity that is a great way to help children identify the beginning sound in a spoken word.

Vocabulary taught: Animals, gardening and things in nature

To do this exercise, children need to have a set of toys consisting of different figurines, like the one below:



Teaching single words

Cow
Calf
Pig
Horse
Bird
Duck
Dragon
Dinassaur
Dog
Sheep
Bee
Ladybird
Butterfly
Bat
Cat
Rabbit
Snail
Tree
Flower
Peas
Watering can
Gardening fork
Grass
Boots
Sun
Cloud
Moon
Gardening fork
Fish
Rooster
Snake

Full Sentences

Asking: “Hello, let’s go gardening! Woof-woof I spy something brown in the garden that says “woof woof”

What is it?"

Confirming: "yeeyyy it's a DDDDD dog. We found the doggie!! The dog is brown and says woof woof!"

Denying: "Oops!!! This is a ... duck! Let's find the dddd dog! Where are you dog? Woof woof"

Asking: "I spy my little eye on something

that says Moooooohh Mooohhhh. Can you help me find an animal that says moooooohh mooohhh?"

Confirming: "Wheeeeh!!!! It's a kkkkkkkkk cow!! Hello cow!! The cow makes Mooohhh Moohhhh.

Denying: “Uh-Oh!! This is a dog! Help me find the ccccccccc cow”

Confirming: "Bravoooo!!! We found the
ssssssssss snake!!! The snake is in the
grassssssss! Hello there, sssssss-nake"!!!

Denying: "Oh oh!! This is a dog!! Help me find the ssssss snake!"

Asking: "I spy something swimming in the pond. It's a fffff fish. Where are you

goldfish?"
Confirming: Yeyyyy!!! It's a fish! Make a wish

goldfish!!!
Denying: "Uh-oh!! This is a snail! Let's find

the fffff fish!

Example of how Tardí behaves when seeing the child during exercise two:

1. Talki sees the child and greets, "Hey there, let's play!"
 2. It starts out by asking for something in particular: "I spy with my little eye something singing on the tree that says Tweet tweet. What is it?"
 3. The child has to guess what sings and makes this noise and bring the right toy.
 4. If the child brings the wrong toy, Talki says what it is and goes back to repeating mode, by formulating the question in a different way. e.g "uh-oh this is a rabbit! Tweet tweet! Help me find something yellow that sings on the tree! It says Tweet Tweet. Can you see it?"

4.2.9 A different variation of the exercise above

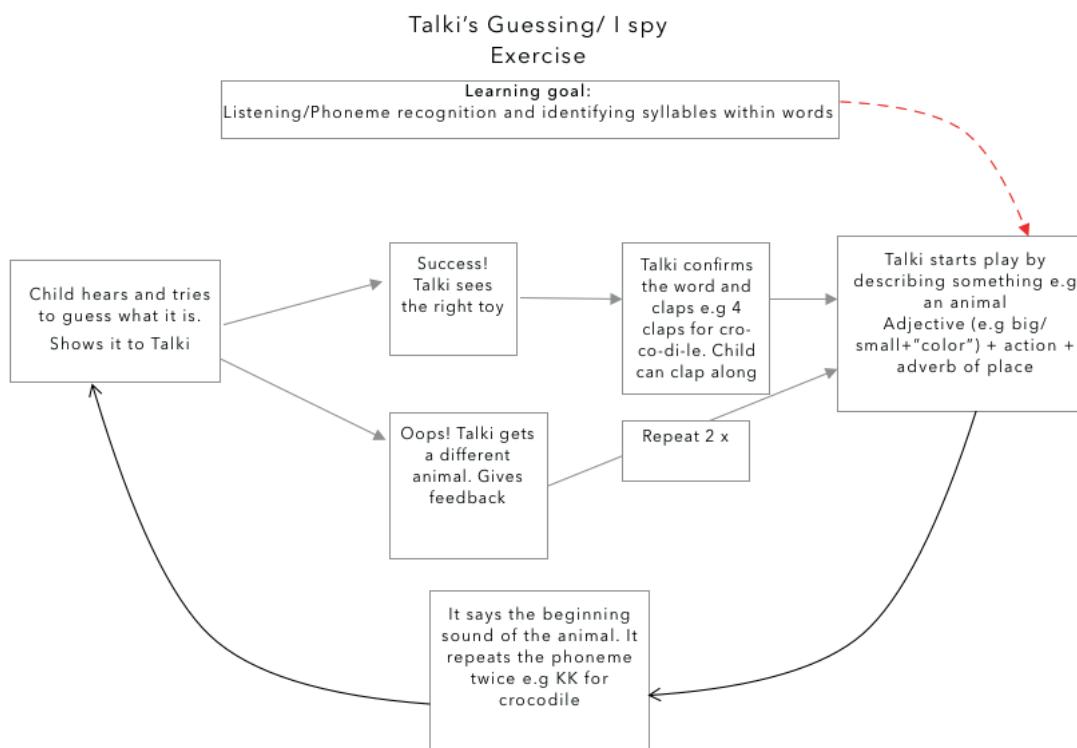
Teaching concept: Recognising syllables in words

Designed for kindergarteners and preschoolers ages 3-6 years old

Objective of the exercise: Reinforce phonological awareness- pre reading skills through listening and follow the beat/ clapping to the beats the child hears in words. Clap out each syllable together. It teaches children that the words are made up of different parts, and some are longer and others are shorter. Children learn to break words into parts and trains their ear to the different sounds in words which prepares and makes reading easier later on. Learn everyday vocabulary

Example of how Talki behaves when seeing the child during Exercise two.

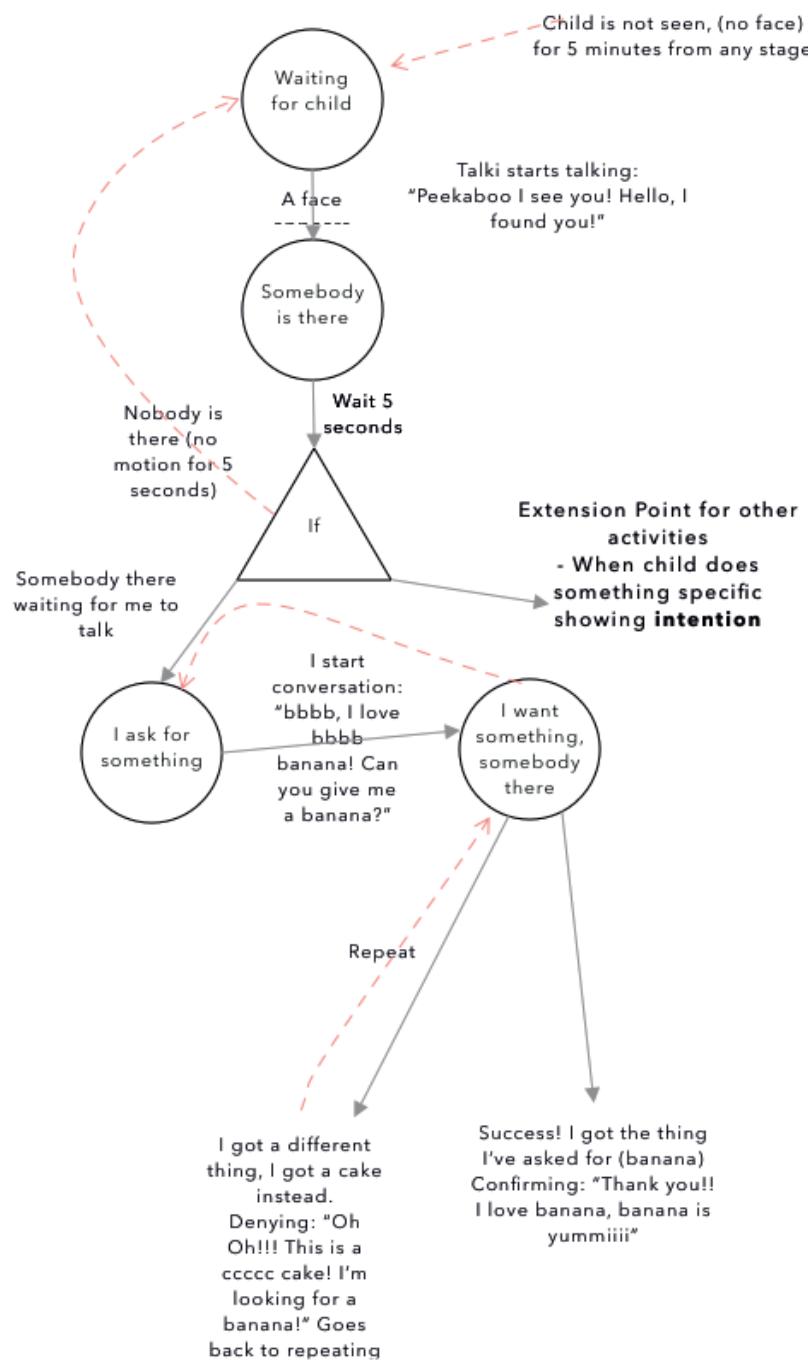
1. Talki sees the child and says “Hello, I see you!!!” And asks for something e.g Help me find the biiiiiiig elephant!
2. Talki claps to the word e-le-phant, 3 claps.
3. The child is encouraged to clap together to the word with Talki
4. The child is encouraged to show Talki the right figurine.



Exercise Goal: Listen and guess the right animal, clap along

4.3 Logical Design

Talki changes behavior based on the state it is in. The available activities determine what is possible, and how it will react. The designed behavior can be described in a single State Machine Diagram. All exercises are variations or fit in this logic.



4.4 Test and Iterative fine-tuning of the Prototype

For testing interactions we will be making a remote control version where an operator registers inputs by pressing buttons such as when a child approaches, the child shows Talki a red tomato, the child feeds Talki a red tomato etc. Talki will then react to the inputs by speaking. In the beginning this will have a very limited vocabulary and set of reactions but over time we will expand.

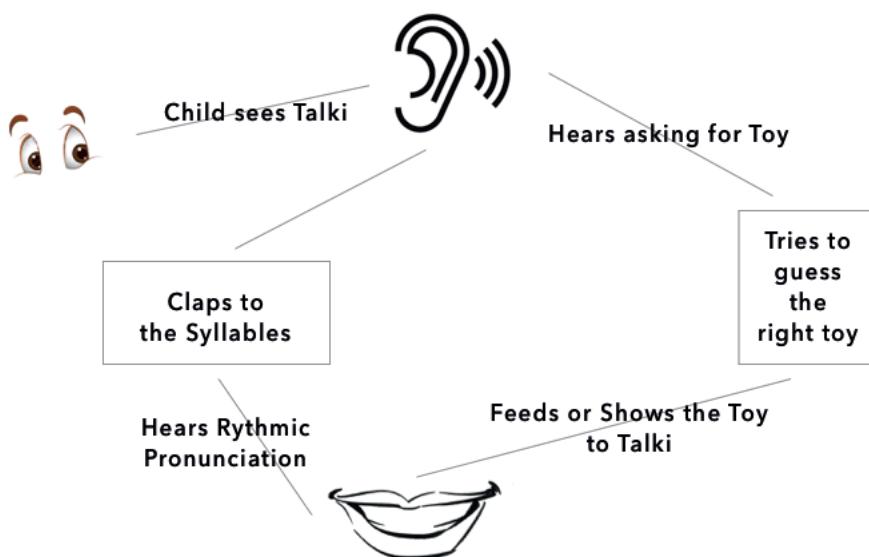
4.5 Detailed design of: User experience, system behaviour, Interaction modalities and User interface

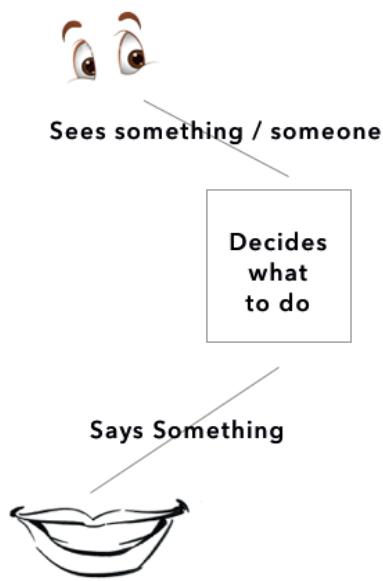
4.5.1 User Experience

Talki is straightforward and pleasant. It has a child-like voice so children can relate more to it, and treat it more like a “buddy” figure, just like a pet. Talki uses principles of real

human interaction e.g. when it is running low on battery it will say it is tired and asks the child to take it to its home. It teaches children concepts that go beyond language learning, such as concepts of empathy, care-taking and nurturing. It is a plush toy that speaks, and reacts to what the child does, making it a toy that is “alive”. Talki is a monster and has a mouth, so children can feed it and engage in imaginative/pretend play, which according to some Child Development Experts is crucial to their mental and social development.

Talki is also always happy to play. It reacts when it sees its owner by greeting them with a cheerful sentence. When playing, it will give feedback to the child, in an emotionally clear way, but never by overly praising or showing disappointment. Rather than speaking nonstop, Talki takes pauses, giving the child the chance to respond and focus. It uses repetition so that the child can master new skills and recognise sounds and words after a while.





Children play with the toy by listening to what it asks and showing it different toys that are part of a toy set to teach a specific topic.

It is a fluffy toy that can be easily grabbed and transported around the house. It is educational but to the child it is like a playmate. Talki's voice is childish and cheerful.

4.5.2 System Behaviour

Talki reacts primarily to visual inputs such as a child appears, a known object is seen, being fed a known object. The reactions are primarily by speaking in full sentences.

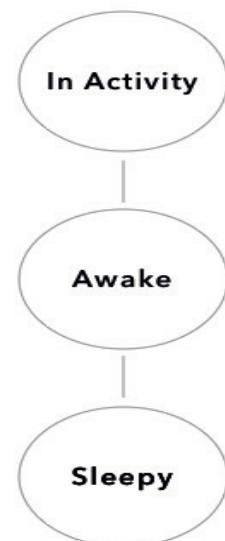
4.5.3 Modalities

Talki is a physical artefact. It has no off switch. It has a battery that keeps it functioning at all times. When it runs out of battery, it will say it is tired and needs to go to its home to sleep.

Talki will always be waiting to see the user. When it sees the user it will attempt to start a "conversation". In other words, it will greet and will want to do an exercise where the child fetches for specific toys that are part of a set. The user doesn't have to press any buttons to start an exercise.

There are a few modes that Talki can be in,

1. Awake
2. Doing a specific exercise
3. No activity
4. Sleepy/ tired



4.6 Detailed System Specifications

The Talki Toy is covered by fabric sewn together in a normal fashion. Components are placed on their own structures and attached inside. Around the structures stuffing is filled in causing the shape of the toy.

The camera and speaker are placed in natural positions for vision and voice, behind eyes and below the mouth

To ensure loudness the amplifier and speaker must support 3W mono output.

To ensure vision detail the camera must support VGA resolution (640x480).

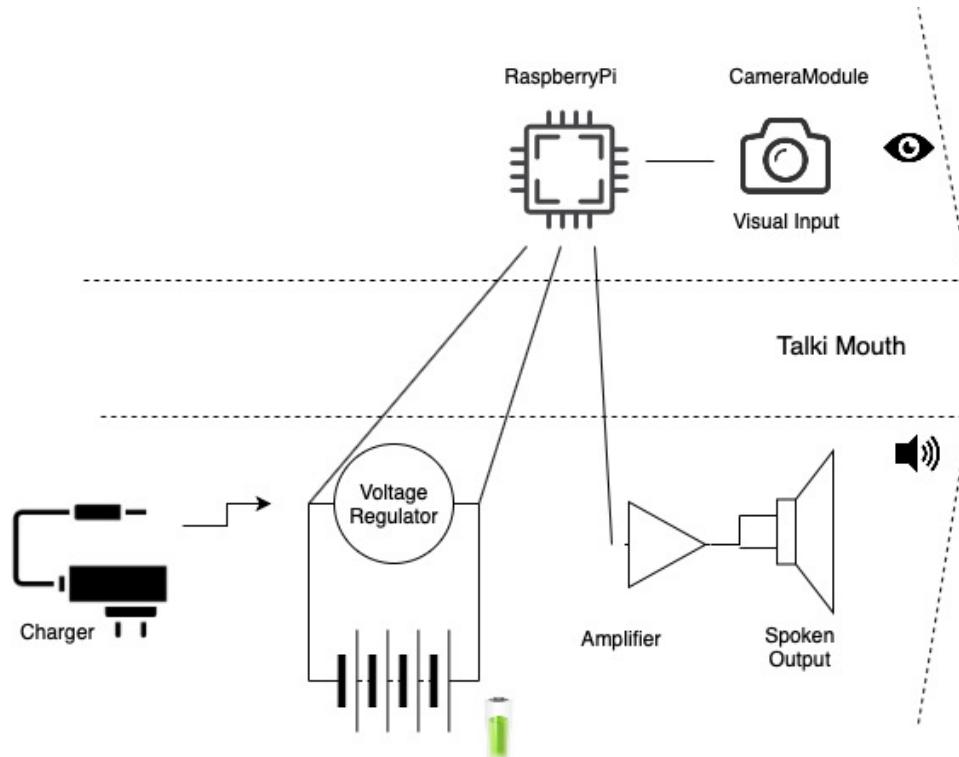
Hardware used in the prototype

- Raspberry Pi 3A+
- Camera Module v2.1
- Adafruit I₂S 3W Class D Amplifier Breakout - MAX98357A
- 3W full range loudspeaker
- Panasonic 18650 LiPo battery

- LiPo charging shield

Software Installed on Prototype

- Raspbian Stretch OS
- OpenCV 4
- Python 3.8
- Various python modules
- Talki Python Source Code



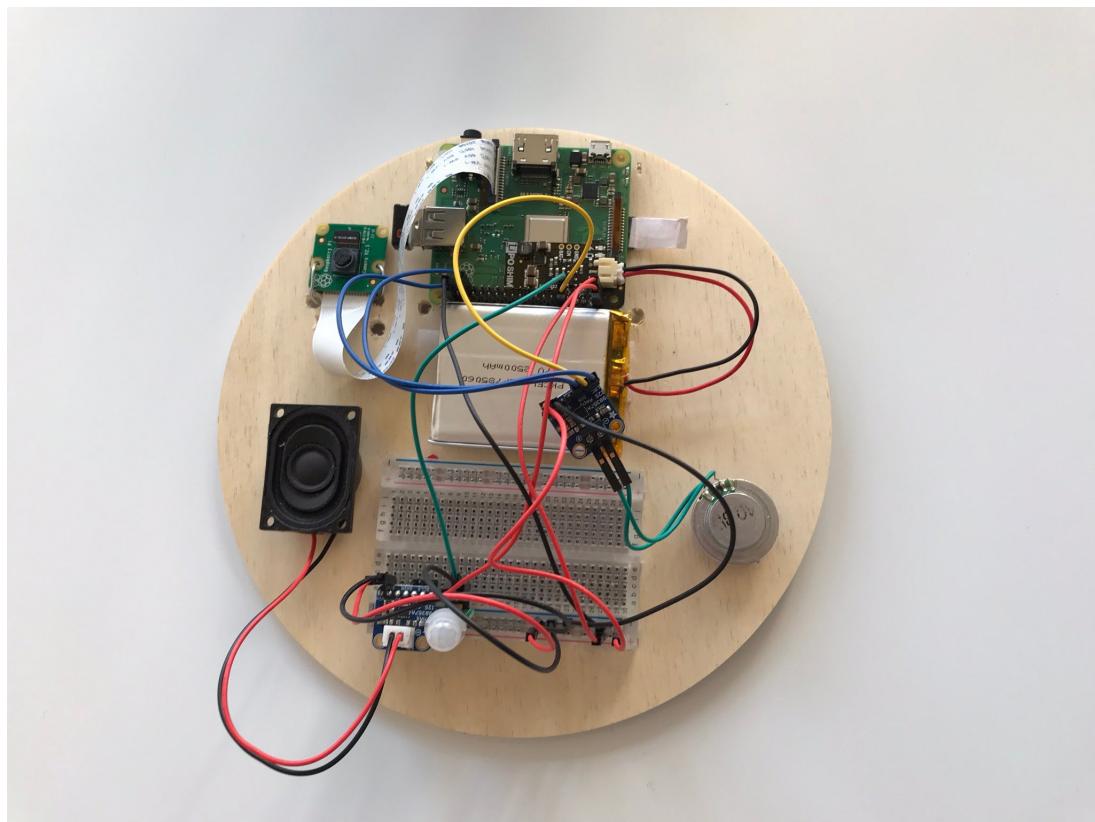
4.7 Hardware and Software Development

For the prototype we used off the shelf development boards which means that it takes up much more space than needed.

The Raspberry Pi is poorly suited to make a real Computer Vision System, but it is good enough to test the concept.

The first electronic prototype is laid out on a wooden platform for easy access and demonstration. It allows testing variations such as different loudspeakers.

The second prototype takes the exact same setup and places the components inside a Talki Prototype.



The software is being continuously improved to manage a seamless behavior for Talki. The following represents the high level source code for the Default Activity State Machine.

```
import os, time
import state, sight, voice, memory
import pi_camera
import cv2

class IdleState(state.TalkiState):
    """
    In this state Talki is waiting for a child to appear.
    """
    name = "Idle"

    def face_seen(self):
        # print("I see a face.", sight.person_present)
        greeting = voice.compose_greeting()
        voice.say(greeting)
        state.transition_to(SomebodyPresentState())

    def item_seen(self):
        print("Ignoring item seen.")


class SomebodyPresentState(state.TalkiState):
    """
    In this state Talki will wait 5 seconds to come up with something to ask
    for.
    """
    name = "Somebody Present"

    def child_lost_interest(self):
        transition_to(IdleState())

    @SecAfterApply(5)
    def default_request(self):
        global current_state
        if not sight.face_presently_seen():
            current_state = IdleState()
        if not sight.last_seen_item:
            self.ask_for_something()
            state.transition_to(WantingSomethingState(self.last_asked_for))

class WantingSomethingState(state.TalkiState):
    name = "Wanting Something"

    def __init__(self, last_asked_for):
        super(WantingSomethingState, self).__init__()
        self.last_asked_for = last_asked_for

    def child_lost_interest(self):
```

```

        transition_to(IdleState())

    # how to do scaling repeat of asking
    @SecAfterApply(10)
    def giving_up(self):
        if last_action_seen < current_milli_time() - 10 * 1000:
            self.ask_again()

if __name__ == "__main__":
    state.transition_to(state.IdleState())
    while True:
        sight.update_view(pi_camera)
        state.do_late_calls()
        key = cv2.waitKey(1)
        if key == 27:
            break

```

module: pi_camera

```

import os
import atexit
from picamera.array import PiRGBArray
from picamera import PiCamera
from RPi import GPIO
from threading import Thread
from imutils.video import FPS
import face_recognition
import imutils
from PIL import Image
from pyzbar import pyzbar
import pickle
import numpy
import datetime
import time
import cv2

PIR_SENSOR = 11
GPIO.setmode(GPIO.BOARD)
GPIO.setup(PIR_SENSOR, GPIO.IN)
pir_state = 0

data = pickle.loads(
    open(os.path.join(os.path.dirname(__file__), "sight", "face-encodings"),
         "rb").read())
detector = cv2.CascadeClassifier("/usr/local/share/opencv4/haarcascades/
haarcascade_frontalface_alt.xml")

class PiVideoStream:
    def __init__(self, resolution=(320, 240), framerate=32):

```

```

# initialize the camera and stream
self.camera = PiCamera()
self.camera.resolution = resolution
self.camera framerate = framerate
self.rawCapture = PiRGBArray(self.camera, size=resolution)
self.stream = self.camera.capture_continuous(self.rawCapture,
                                             format="bgr", use_video_port=True)

# initialize the frame and the variable used to indicate
# if the thread should be stopped
self.frame = None
self.stopped = False

def start(self):
    # start the thread to read frames from the video stream
    t = Thread(target=self.update, args=())
    t.daemon = True
    t.start()
    return self

def update(self):
    # keep looping infinitely until the thread is stopped
    for f in self.stream:
        # grab the frame from the stream and clear the stream in
        # preparation for the next frame
        self.frame = f.array
        self.rawCapture.truncate(0)

        # if the thread indicator variable is set, stop the thread
        # and resource camera resources
        if self.stopped:
            self.stream.close()
            self.rawCapture.close()
            self.camera.close()
            return

    def read(self):
        # return the frame most recently read
        return self.frame

    def stop(self):
        # indicate that the thread should be stopped
        self.stopped = True

vs = PiVideoStream(resolution=(640, 480), framerate=4).start()
time.sleep(2.0)
writer = None

fps = FPS().start()

def read_frame():

```

```

    "Read a frame(image) from the camera"
    return vs.frame

def show_frame(frame, faces, barcodes):
    "Show frame as a preview with information"

    # loop over the recognized faces
    for ((top, right, bottom, left), name) in faces:
        # draw the predicted face name on the image
        cv2.rectangle(frame, (left, top), (right, bottom),
                      (0, 255, 0), 2)
        y = top - 15 if top - 15 > 15 else top + 15
        cv2.putText(frame, name, (left, y), cv2.FONT_HERSHEY_SIMPLEX,
                    0.75, (0, 255, 0), 2)

    for decoded in barcodes:
        points = decoded.polygon

        pts = numpy.array(points, numpy.int32)
        pts = pts.reshape((-1, 1, 2))
        cv2.polylines(frame, [pts], True, (0, 255, 0), 3)

        for bc in barcodes:
            cv2.putText(frame, bc[1].decode("utf-8") + " - " + bc[2], (30, 30),
cv2.FONT_HERSHEY_SIMPLEX, 1, bgr, 2)

    # cv2.imshow("Barcode Scanner", numpy.array(image, dtype = numpy.uint8))
    cv2.imshow("preview", frame)
    fps.update()

bgr = (8, 70, 208)

def decoded_to_toy_name(decoded):
    if decoded and decoded.type is "QRcode":
        if decoded.data.startswith(b"https://thepia.com/talki/toy/"):
            return decoded.data.replace(b"https://thepia.com/talki/toy/", b"").decode('ascii')
    return None

def check_for_barcode(image):
    return [(barcode.polygon, barcode.data, barcode.type, decoded_to_toy_name(barcode)) for barcode in barcodeReader(image)]

def barcodeReader(image):
    gray_img = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
    barcodes = pyzbar.decode(gray_img)

    return barcodes

def check_for_faces(frame):
    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)

```

```

rgb = cv2.cvtColor(frame, cv2.COLOR_BGR2RGB)
# r = frame.shape[1] / float(rgb.shape[1])

# detect faces in the grayscale frame
rects = detector.detectMultiScale(gray, scaleFactor=1.1,
    minNeighbors=5, minSize=(30, 30))

# OpenCV returns bounding box coordinates in (x, y, w, h) order
# but we need them in (top, right, bottom, left) order, so we
# need to do a bit of reordering
boxes = [(y, x + w, y + h, x) for (x, y, w, h) in rects]

# compute the facial embeddings for each face bounding box
encodings = face_recognition.face_encodings(rgb, boxes)
names = []

# loop over the facial embeddings
for encoding in encodings:
    # attempt to match each face in the input image to our known
    # encodings
    matches = face_recognition.compare_faces(data["encodings"], encoding)
    name = "Unknown"

    # check to see if we have found a match
    if True in matches:
        # find the indexes of all matched faces then initialize a
        # dictionary to count the total number of times each face
        # was matched
        matchedIdxs = [i for (i, b) in enumerate(matches) if b]
        counts = {}

        # loop over the matched indexes and maintain a count for
        # each recognized face face
        for i in matchedIdxs:
            name = data["names"][i]
            counts[name] = counts.get(name, 0) + 1

        # determine the recognized face with the largest number
        # of votes (note: in the event of an unlikely tie Python
        # will select first entry in the dictionary)
        name = max(counts, key=counts.get)

        # update the list of names
        names.append(name)

return (boxes, names)

def check_for_motion():
    global pir_state

```

```
pir_state = GPIO.input(PIR_SENSOR)
return pir_state

def cleanup_camera():
    # do a bit of cleanup
    writer = None
    vs.stop()
    cv2.destroyAllWindows()
    GPIO.cleanup()

atexit.register(cleanup_camera)
```

4.8 Usability Test and Evaluation Report

I have tested Talki with children at kindergarten schools. The testing was done as a continuous activity to test different parts of the design. The initial test was just to see how children reacted to the toy's appearance and how engaged they were in storytelling. At this point I showed them Talki, and introduced it as a monster that can see and eat. I have narrated the stories and conversations. For instance, I have created short stories about Talki going to the zoo and seeing all sorts of animals. The other story was Talki went gardening, and needed help with certain things, for example it wanted to plant a flower, but needed water



Participants:

Kindergardeners and pre-schoolers aged 3-6. They are all learning a second language or come from bilingual families

Research techniques used

Field Studies
Expert Reviews

Hypothesis

Will be physical with Talki (hugging, pulling the ears, carrying it by the ears).

Will initially be curious after hearing Talki speak for the first time

Will not know how to show Talki an object, unless shown how to by an adult

Will repeat attempts to pick the right object 10+ times (patience/persistence)

Will clap along to words

There will be a big variation for the playing time ranging from 10 minutes to hours

Findings

Children were very curious by the toy, and wanted to hold it

Children were physical with Talki. The first reaction was to pull it by the ears

The mouth is intuitive and children tried to put in different things, not just toys, even their full hand

Picked different toys randomly and showed it to see a reaction. Got amused by reactions

Tried to repeat the individual sounds, and clapped along

for it, so it asked children for it.

Children were generally very curious, “hooked” and very participative. They were more open to share their feelings, help out and engage in conversations with Talki “speaking”, compared to me telling them the same story by reading it aloud.

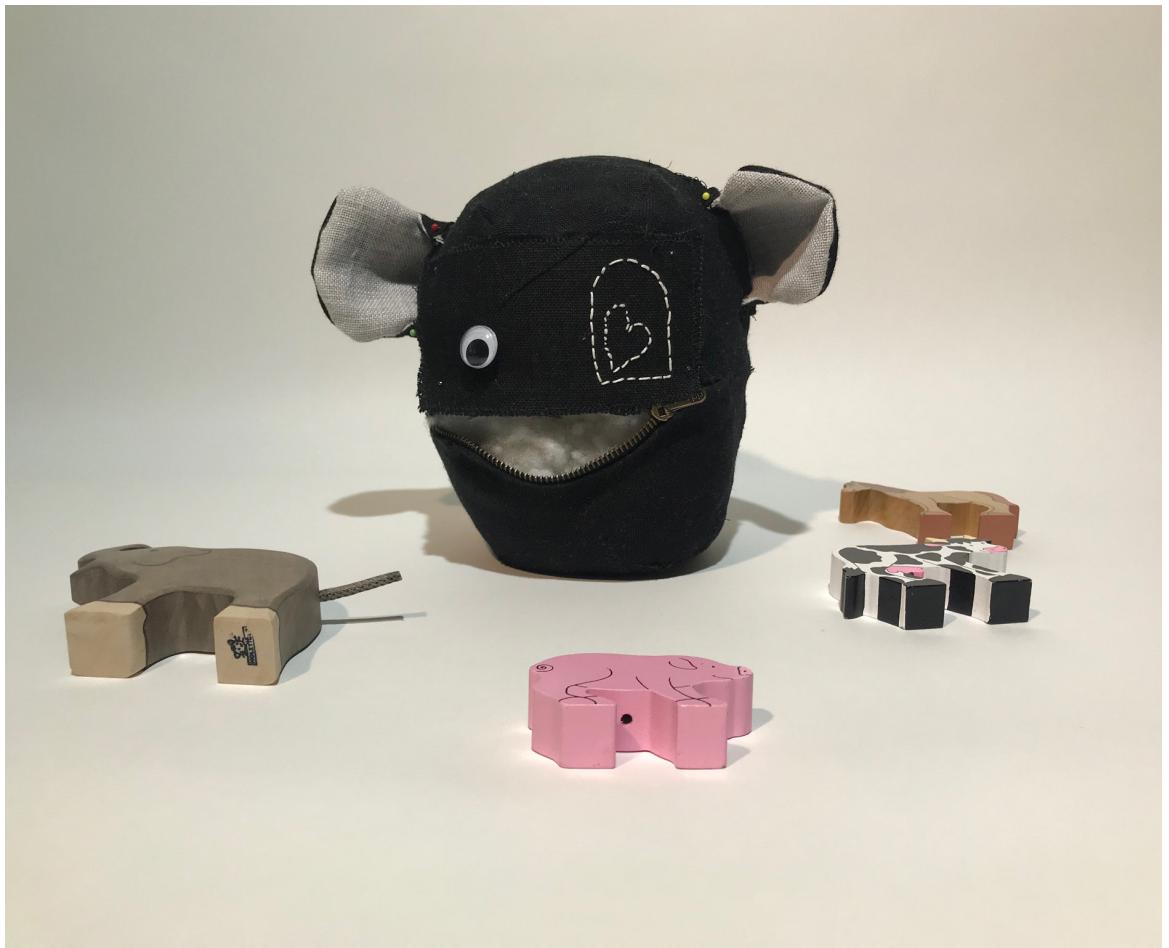
Findings	Further hypothesis/testing & next iterations	Further hypothesis/testing & next iterations
<p>When told the toy can see or spy things children's reaction was to associate it to the eyes</p> <p>Children were engaged for the duration of the test (30 mins).</p> <p>Did not understand full sentence but recognise isolated words (e.g recognised white but picked the wrong animal)</p>	<p>Testing with a Talki speaking prototype.</p> <p>Children will talk to Talki explaining whatever they think of irrespective of being asked.</p> <p>After a while, the child will finish Talki's intro rhymes knock knock...</p> <p>Will try to speak back to Talki to see if it reacts (maybe can hear?)and will talk back</p> <p>There will be a big variation for the playing time ranging from 10 minutes to hours</p>	<p>Different ages will have different attention spans. Younger children will be picking toys more randomly and older children will be faster at recognising the right toy.</p>

4.7 Final Product told in Pictures









4.9 Next Steps

The Talki prototypes test the core idea, but it needs to be evolved further to be production ready.

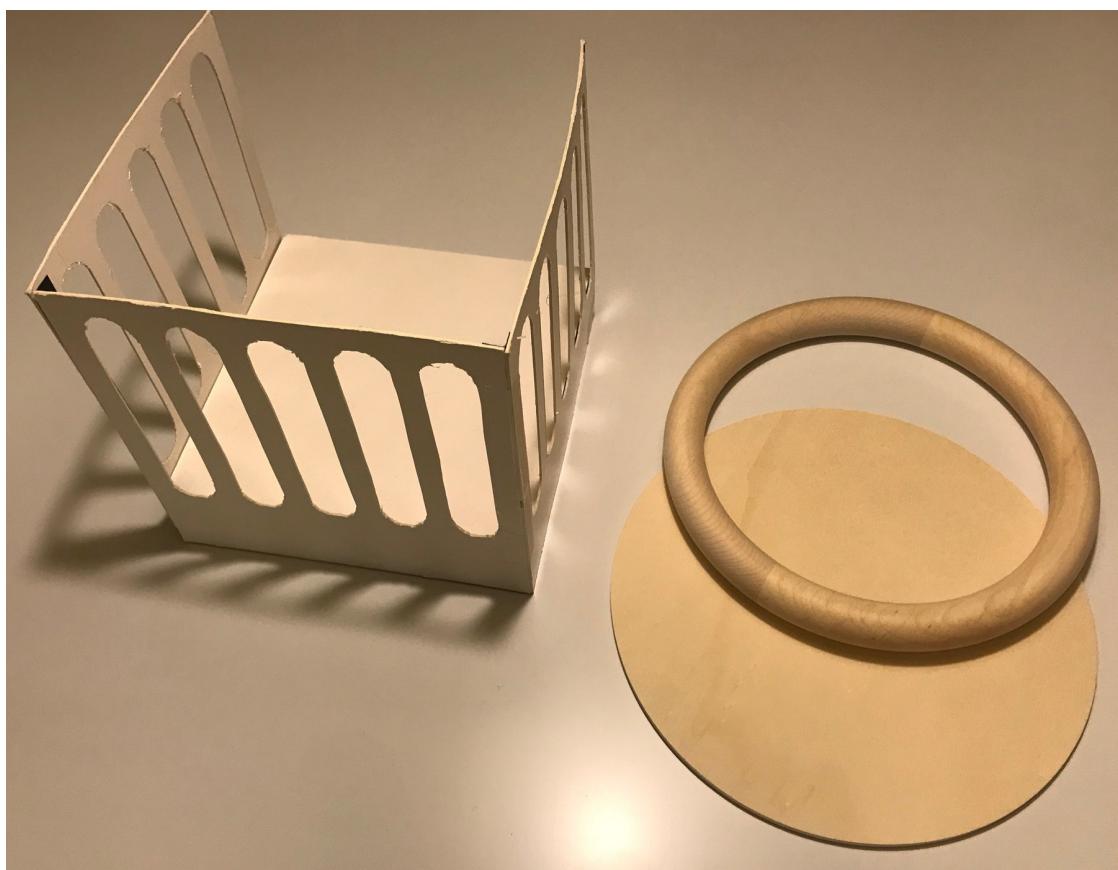
- Making the mouth hard internally, but maintain flexibility and softness of the toy.
- Making it stand up to dirt, ideally by making it washable.
- The current electronic circuits are for PoC only.

Talki has a home to go to when it is tired and need to be recharged. I have prototyped that in cardboard and carton, but not made a wooden prototype. It would be one of the next steps.

Talki would come with a starter set of toys to play with. The exact pieces must be decided

upon and potentially custom designed. Further toys would come as topical sets each with their thematical storyline activity and dedicated pieces.

Talki rests in itself by default, but can be optionally adjusted via a Smartphone app in terms of: Managing playtimes, vocabulary updates and progress tracking.



4.10 Standard Project Description

Title:

Talki
Learning Languages Through Play in Early Childhood

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Supervisors

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Made in collaboration with: Digital Sculptor GmbH Zurich

Year/ Edition
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Abstract

Talki is an interactive educational toy that teaches children aged 3-6 years old an additional language. Young children learn and develop in a stimulating environment with room for curiosity, exploratory and imaginary play. They learn by watching, listening and especially by doing. By combining technology and traditional educational exercises, Talki provides a multi sensory learning experience to reinforce learning by:

- Hearing
- seeing
- Doing
- Touching

Talki's methodology encourages open ended exploratory play, by giving the child as many chances as they need to find the right answer, without ticking clock, loud noises or rewards.

Talki reinforces phonological awareness, an auditory and pre-reading skill (before children can read and write). It allows the

child to listen and recognise the sounds within words and break the words apart based on syllable counting.

It trains the child's ears to the sounds, rhythm, flow and pronunciation within words of a spoken Language. Talki uses educational exercises and principles such as rhymes, repetition of sounds in words e.g chhh for chocolate or shhhh for sheep, associating sounds to things and actions e.g woo woo for train 🚂, ding-dong for door 🛡, shhhhh for quiet 🍀 or tick-tock for clock 🕒, moooo moooo for cow etc and clapping the syllables exercise e.g 3 claps for e-lephant to reinforce learning. Children can learn together with Talki everyday vocabulary such as food, animals, gardening and things in nature.

Interface and Interaction Modality

Talki is an interactive educational plush toy that helps children learn an additional language by training their ears to the sounds within words of spoken language.

Talki is a physical artefact. It has no off switch. It has a battery that keeps it functioning at all times. When it runs out of battery, it will say it is tired and needs to go to its home to sleep.

Talki will always be waiting to see the user. When it sees the user it will attempt to start a "conversation". In other words, it will greet and will want to do an exercise where the child fetches for specific toys that are part of a set. The user doesn't have to press any buttons to start an exercise. The main complexity involved is the intentional construction of the language and behaviour. All exercises follow the same principles based on human conversation and human interaction, where Talki asks for something in specific and awaits for the child's response, and gives them feedback based on what they chose. The exercises played are traditional exercises for language learning taught at kindergarten and pre-school level.

Technology

Talki interfaces with a camera and a speaker

and is controlled by a modern micro-controller. The PoC is implemented with a raspberry Pi but the real implementation would use a more specialised micro-controller build for machine learning. The PoC uses facial and barcode recognition due to the limited capabilities of the Raspberry Pi.

User Experience

Talki is straightforward and pleasant. It has a child-like voice so children can relate more to it, and treat it more like a “buddy” figure, just like a pet. Talki uses principles of real human interaction e.g when it is running low on battery it will say it is tired and asks the child to take it to its home. It teaches children concepts that go beyond language learning, such as concepts of empathy, care-taking and nurturing. It is a plush toy that speaks, and reacts to what the child does, making it a toy that is “alive”. Talki is a monster and has a mouth, so children can feed it and engage in imaginative/pretend play, which according to some Child Development Experts is crucial to their mental and social development.

Talki is also always happy to play. It reacts when it sees its owner by greeting them with a cheerful sentence. When playing, it will give feedback to the child, in an emotionally clear way, but never by praising or showing disappointment. Rather than speaking nonstop, Talki takes pauses, giving the child the chance to respond and focus. It uses repetition so that the child can master new skills and recognise sounds and words after a while.

Finally, the games played with Talki use multi sensory instruction, by engaging the child in auditory, visual and kinaesthetic play

- Hear It!
- See it!
- Do It!
- Touch It!

Research and Development context

Talki allows children learning a second language to get familiar, recognise and expose their ears to the sounds and flow of spoken words. It can also work as a tool to teach the right pronunciation of words in a foreign language, something parents often struggle with and often choose native speakers of a language to teach their children.

Phonological awareness skills are the building blocks for reading success. Furthermore, Talki trains listening and attention skills through play and encourages children to focus.

Children learn to talk by listening and this is a skill that develops over time. It requires a lot of practice for a child to learn how to tune into a sound, recognise and make sense of it and keep it in mind to work with it, all of which happens subconsciously by proficient speakers.

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