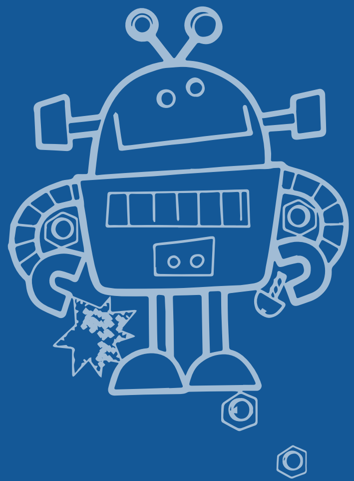

Robotica and Programming Lab

Designing an interactive experience at Museon

SHREYA PADMASOLA

Robotica Programming Lab

Designing an interactive experience Museon

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Design for Interaction

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Executive Summary

This project focuses on the conceptualisation of a new lab called the Robotic and Programming Lab, at Museon, a science cultural museum in Den Haag. The need for the lab comes from a larger societal goal - to encourage more Dutch nationals to take up technologically inclined jobs, as the Netherlands is currently lacking in technically skilled workforce. The purpose of this lab is to is to spark an interest in technology early in a person's life such that it cultivates a healthy outlook to technology as a career.

This project begins with a broad approach and dives into exploring the context that the lab is central to. These aspects include the current Dutch education system, STEM education,the role of museums around the world, robot toys and the impact of these toys on children and more. The analysis revealed insights across all aspects that helped form deeper understanding for the need of a Robotic lab. For instance, it was found that the Dutch government mandated science in school from 2020 but there are not enough skilled teachers to meet this need. This insight explained why schools would like to use the Museum's resources to teach science. It also emphasised on the importance of a space such as the robotic lab and revealed the potential of it as a forerunner of a programming experience. Such insights provided a understanding of the need and helped form the very first impression of what this lab could entail.

The insights from this phase helped in forming a concrete design brief and design decisions for the course of this project. For example, one of the design decisions was to use an existing robot toy, Sphero sprk+, to facilitate the learning experience in the lab.

This concrete brief lead to the second phase of design that includes interactions with the primary and secondary users - teachers, parents, educators and children. The insights from the user research combined with the context research paved way to the development of the lab's narrative. Three components were identified as the most integral to a holistic experience - a story, a theme and the activities. This ultimately resulted in the "Framework of the Lab's Experience".

This framework became the skeleton on which the robotic lab was designed and conceptualised. The project explores this aspect in dept' and outlines the process behind choosing the theme and the interactive activities.

Through an iterative process and with constant inputs from the stakeholders, a detailed conceptualisation of the interactive activities was outlined. This concept exemplifies the use of the framework and borrows lessons from pedagogies to build activities for children. These activities are designed with close consideration of the learning outcomes and the science concepts that children are already familiar with.

This thesis ends with suggestions and further recommendations for Museon to make the most of the framework and the conceptualised design.

Contents

Acknowledgements

Completing a masters thesis is no easy feat, even more so in the given circumstances, in the midst of a pandemic. This project would came together with the support of a lot of people and thank you is in order.
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To all the participants and the people who I spoke to about this project, thank you.

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Zoe, thank you for your encouragement and words of calm when I was losing it and for always being ready to help, no matter what .
I am glad to have found such great confidants in both of you and hope we continue this comradeship wherever we go. (Also, one down two to go!)

To Jesal (the weekly checks and the little rants helped to keep going,thanks) Preeti and Sonali for slowly but steadily becoming such integral part of my life here and for the numerous laughs, talks and bonding over the last two years. Thanks!
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Finally, to the life givers, life savers - Thanks ma and pa. I wouldn't have dreamt of being able to do this without you. You have been my biggest cheerleaders always, for that I am grateful!

Thank you.

Foreword

This report is a compilation of my master's thesis and brings together six months of hard work and fun. Before you get into it, might I nudge you to consider:

- The report uses literature, observations, and insights from interviews and interactions with real people. To secure the identity of people, pseudonyms were used and where possible, images of people are used in a manner that it retains their anonymity.
- Most part of this project took place during the 2020 COVID-19 outbreak, in isolation from the context and the users of the space. This directly effected the project and the process has been tailored to suit the new context of working. (There has been partial access to the museum only in the very beginning and the very end of this project.)

You can continue to read about my reflection of the situation and how it affected the project or skip to the next page.

Working through a pandemic - a reflection.
I am making this entry in my thesis because 2020 started with an epidemic that soon turned into a pandemic and everyone's life has been affected by this. This is an acknowledgment that this master thesis might be a moment of success but it by no means diminishes the fact it came about in the chaos of a global pandemic.

Three weeks into starting this project in early 2020, the Netherlands government declared a lock down that confined us all to our homes. The impact of it only dawned after a couple weeks when one begins to feel the absence of a physical context, working together, social gatherings and coffee machine/ beer chats that were integral to a regular student life. This new situation meant that my initial planning for this project was void. The project heavily depended on the space and users - children, but there was no way to gain access to them. I had to start with a blank slate and quickly adapt the project to suit this new situation. Looking back, this was one my crucial lessons - to be able to adapt and move ahead despite the circumstances.
A major change was in the interactions with users.

Interviewing people for the project was already a personal challenge (new to context and language barrier), the isolation made this aspect doubly challenging. The process of finding users to talk to was slow and time taking, more than usual. Once, I gathered some users, all interactions with people were done virtually. but the experience of it was not the best. The interactions seemed somewhat distant - for the lack of being in the same physical context, especially when meeting someone new. For a designer this also meant that there was no way to gather any extra observations or data from the surroundings (something I really missed) and to solely rely on what is being said on the screen. This realisation helped to see value in what is otherwise taken for granted.
There are many such smaller experiences that might make more sense down the line and enrich my learnings as a designer.

For now, working on this master thesis was the one thing that kept me going in the pandemic and I hope you enjoy reading this labour of love.

—Shreya Padmasola

01 Introduction

The design brief is to conceptualise and create an immersive space for children around the topic of Robotics and Programming. However, the thrive for the lab comes from a larger societal goal - to encourage more Dutch nationals to take up technologically inclined jobs, as the Netherlands is currently lacking in technically skilled workforce. ("Dutch Technology Pact", 2020)

In order to address this problem, the Netherlands formulated the Technology Pact in 2013 (revised in 2016). The goals of the Technology Pact brought about the need to promote science and technology through museums, which is how the idea for the robotic and programming lab came into being.

Chapter one describes the Technology Pact, and illustrates the connection of this pact with science museums in the Netherlands, specifically Museon in The Hague—establishing the context of this project , the initial brief and its challenges.

Overview

Currently, the Dutch economy has a surplus of technological jobs and dearth of people to take up these technical roles. This situation affects the economy in the long run especially considering the rapid technological development. The need to address this problem brought about the Technology Pact in 2013/16. One of the aims of the Pact is to help choose technology through the network of science museums and centers(National Technology Pact 2016 - 2020, 2016).Through their rich immersive experiences, museums can act as catalysts to ignite the interest in technology amongst children.

A sustained interest in technology would mean more technically skilled people in the workforce, and this attributes to more competent and healthy outlook to technology and rapid advancement in the future. (As illustrated in Figure 1)

Chapter 1.2 details out the Technology Pact, its goals and the role of Museon.

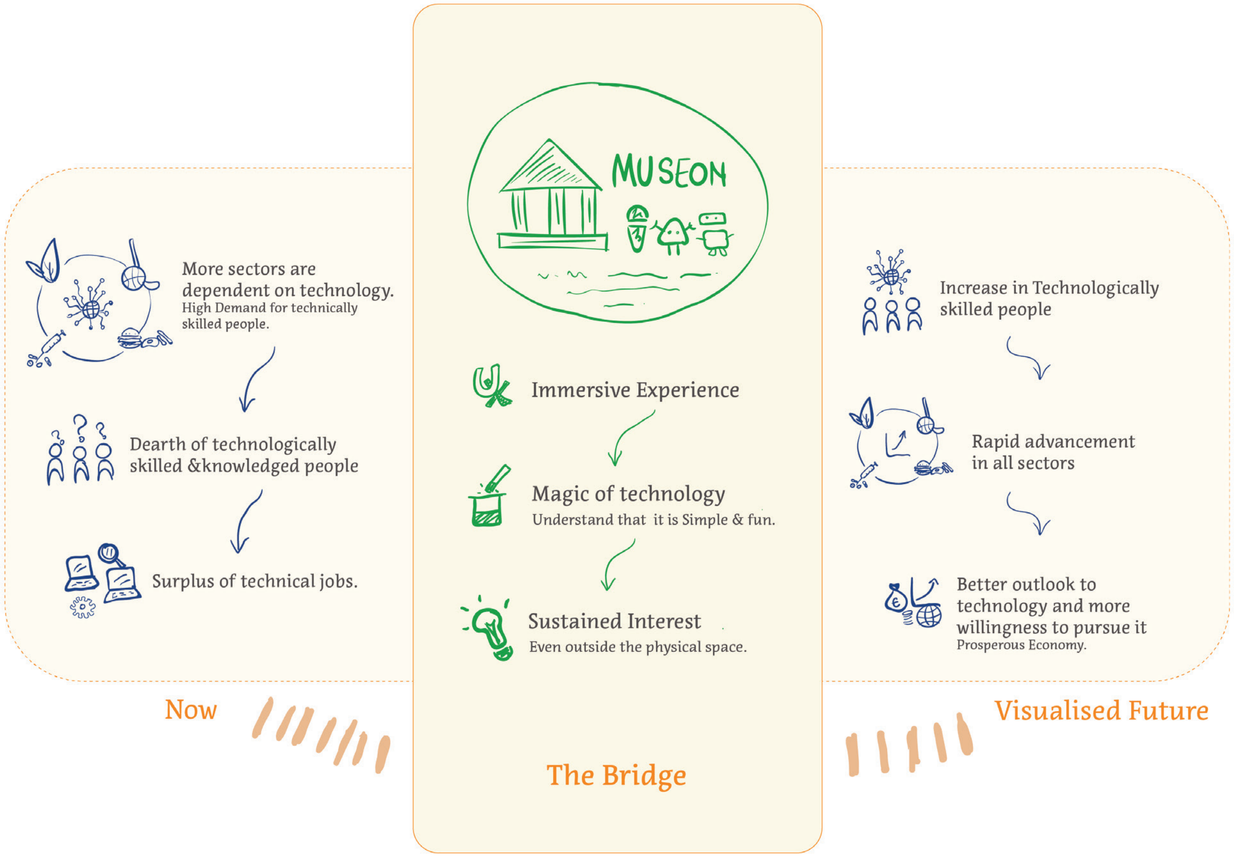


Figure 1 . An overview of the current scenario, the role of the museum and the visualised future.

1.1 The Museum

Museon is an interactive museum for culture and science, located in the international zone in Den Haag, Museon's mission is "to inspire visitors to discover the world". It encourages its visitors to take care of the planet and consider it their task to stimulate involvement.

Apart from the general public, schools and (therefore kids) are an important target group of Museon, The museum offers tailor-made lessons on various themes for both primary and secondary education. These lessons range from science (e.g. water, sound and space), to archaeology or the early men. The museum strives to stay up to date evolving technologies and constantly aims to involve schools and families alike to introduce them to global themes.

"The Museon is all about the future of our planet and its inhabitants. It's core concepts are innovation and sustainability, interactivity and dialogue, quality and excellence."

Figure 2 Floor plan of the first floor and current exhibits. Highlighted are the possible rooms where the new lab could be located.

History of Museon

The museum was started by a newspaper director Frits van Paasschen who was an avid supporter of resource-based learning/teaching. The current museum was open to public is 1986 and was rightly named Museon, a combination of Museum and Education (in Dutch :onderwijs).

Exhibitions of the Museum

Museon's exhibitions are housed in the ground floor and the first floor of this building. The ground floor is reserved for the temporary exhibits that change once or twice a year. Museon selects subjects from science and culture that appeal to a diverse public (Museon,2019). Currently, the ground floor has two exhibitions, one about the ice mummy, Otzi. It encourages children to use modern archaeological tools to unearth facts about Otzi's life and death. The other is a photo exhibition by National Geographic about Plastic- about production, use to litter. The first floor is dedicated to permanent exhibitions and houses the One Planet exhibition. One planet includes topics such as health, energy, sustainability and discrimination (Museon, 2019). Surrounding the One Planet are various smaller rooms/labs dedicated to different themes such as space, sound, law and peace, evolution and so on. The robotic lab is planned to be in this space.

Education at Museon

Museon offers science lessons to schools tailor made to fit the curriculum and the needs of schools. The program managers and educators develop these exhibitions and also actively conduct science, history and social lessons. Museon ensures these lessons are designed and updated constantly to keep up with the rapid developments in society and science. The resources of the museum and the ability to offer a context of space is why schools come to the museum (Museon,2019)

Figure 3 (left to right) The Sound lab and the Water lab.

Figure 4 (left to right) One planet exhibit, a school visiting Museon and Andre Kuiper's Hall

Figure 5 . (left to right) Museon's interior, Otzi exhibit and Temporary exhibit - National Geography's "colours of the world"

1.2 The Technology Pact

Background

Current lack of technically skilled people

Technology is everywhere, it has become an integral part of societies and economies we live in and will continue to play a large role in the future as well . Sectors including healthcare , food, energy, sport are becoming increasingly dependent on the technology. This will result in an increase in the demands for technologically inclined skills and knowledge in various sectors. However, in the Netherlands there is a dearth of people to take up the large number of available technical jobs in the market. ("Dutch Technology Pact", 2020)

The government saw this as a sire need to address, as a boost in technology means a boost in economic prosperity. This resulted in the Technology Pact in 2013. By 2016, the pact was revisited and 12 concrete goals were formed that shaped the coming future of technology . The goals aim to make technology an integral aspect of businesses and the economy by promoting lifelong development in technology.

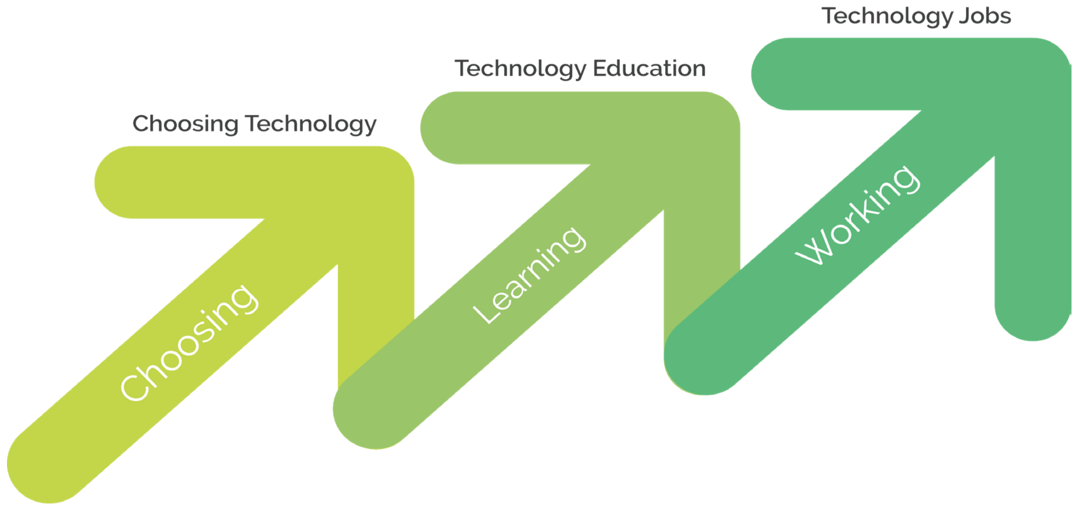


Figure 6 (left) The pact uses three action lines to recognise its ambition .
(right) The first 4 Goals of the Technology Pact are aimed at the education and teachers.

Connection to the Museum

The first goal is "choosing technology", focusing on science and technology in the classroom. One of the concrete solutions in doing this is to form a learning program with the network of science museum and science partners (VSC) in the Netherlands. Science Museums have long been the constant resource of 'learning outside of classroom', many museums tailor their exhibitions and their guides to fit the curriculum and the lessons taught in schools.

Museon is one of these museums and it is actively conceptualising a space for science called the Discovery Lab. Alongside the Discovery ab, the museum wants to develop the *Robotica and Programming Lab* which hopes to attract schools and regular visitors alike. By exposing children to concepts of robotics and programming, the lab hopes to ignite a spark of interest in these topics for children.

1.3 Project Brief and Outline

Design Brief

Science museums are interesting to children and hold their curiosity, the question is, does the interest sustain over a period of time? If not, how do you design in a way that it does. The short term aim is to design an interactive space that **plants a seed of interest in child's mind** as well as **simplifies** technology and programming for children.

> *"Design an immersive and interactive experience around Robotic and programming in a way that it provides an educational experience and sparks an interest for children (between 6 to 12 years) who enter and engage within this space. This experience would be conceptualised in a physical space termed the Robotic-Programming Lab in Museon."*

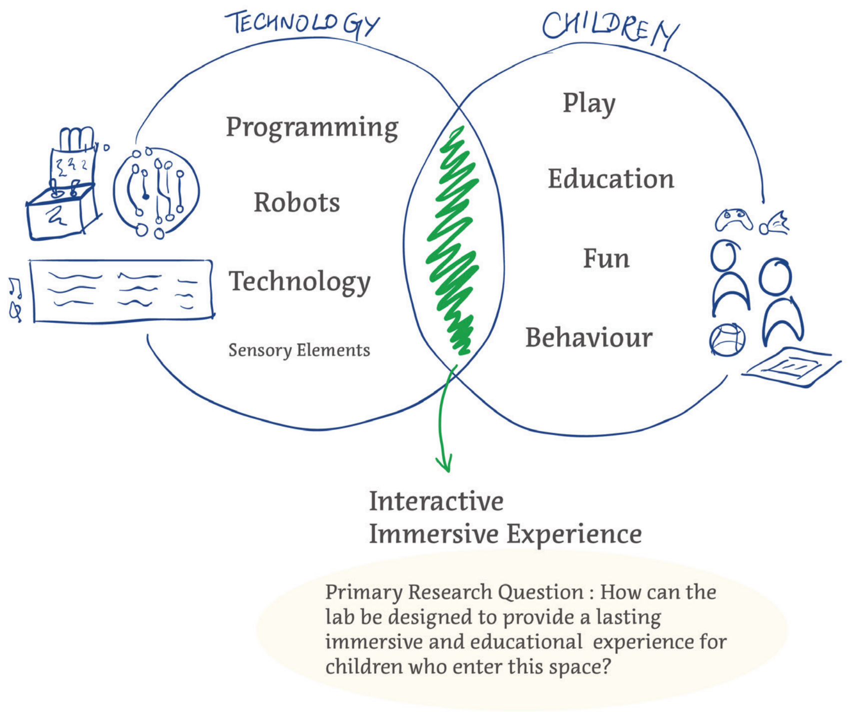


Figure 7 Visualisation of the experience. The soft spot lies in the intersection of elements of technology and children's play

Context and the challenges to consider

With the background of the Technology Pact and the museum's pivotal role, the project's purpose and meaning increased two fold. This means that, not only should the space be interactive, fun and educative, it should also leave an impression and ignite an interest in programming for children. With this in mind, the following challenges were identified and outlined :

- **Relevance to school education/ play**
  How can it be made relevant enough to hold sustained interest for the future?

- **The varied age group**
  Ages from 6 to 12 years. How does each group interact with their surroundings?

- **Target group - Families vs Schools**
  Individual exploration vs Group. How are they different and will this influence the design or the scope?

- **Adaptable physical design**
  Technology is fast changing, How can the elements be updated with minimal revamp?

02 Exploring the context

The robotic lab sits at the confluence of three main aspects - the education system, museum and children. It is therefore crucial to understand children's psyche, methods of learning in schools and museum, thought process behind computers and tools around robotics for children.

These areas were explored in depth and this chapter details the knowledge gathered and highlights insights that help in conceptualising the design of robotic and programming lab.

Overview

There are multiple facets that form the basis of research for this project, these are mainly museum(the visitors), education, children (learning styles) and computational thinking. To design a relevant experience it is necessary to dive into these aspects that would help forming a holistic understanding of the user and the context. This helps in creating a strong immersive experience—one that not only forms a fun learning experience but also an educative one.

- o How is the experience around robotics created in museums currently?
- o How is science taught at school and what is taught?
- o How do children learn? Learning in group vs individually, I s there a pattern to learning?
- o What tools and methods facilitate science education for children?
- o What are today's children like?

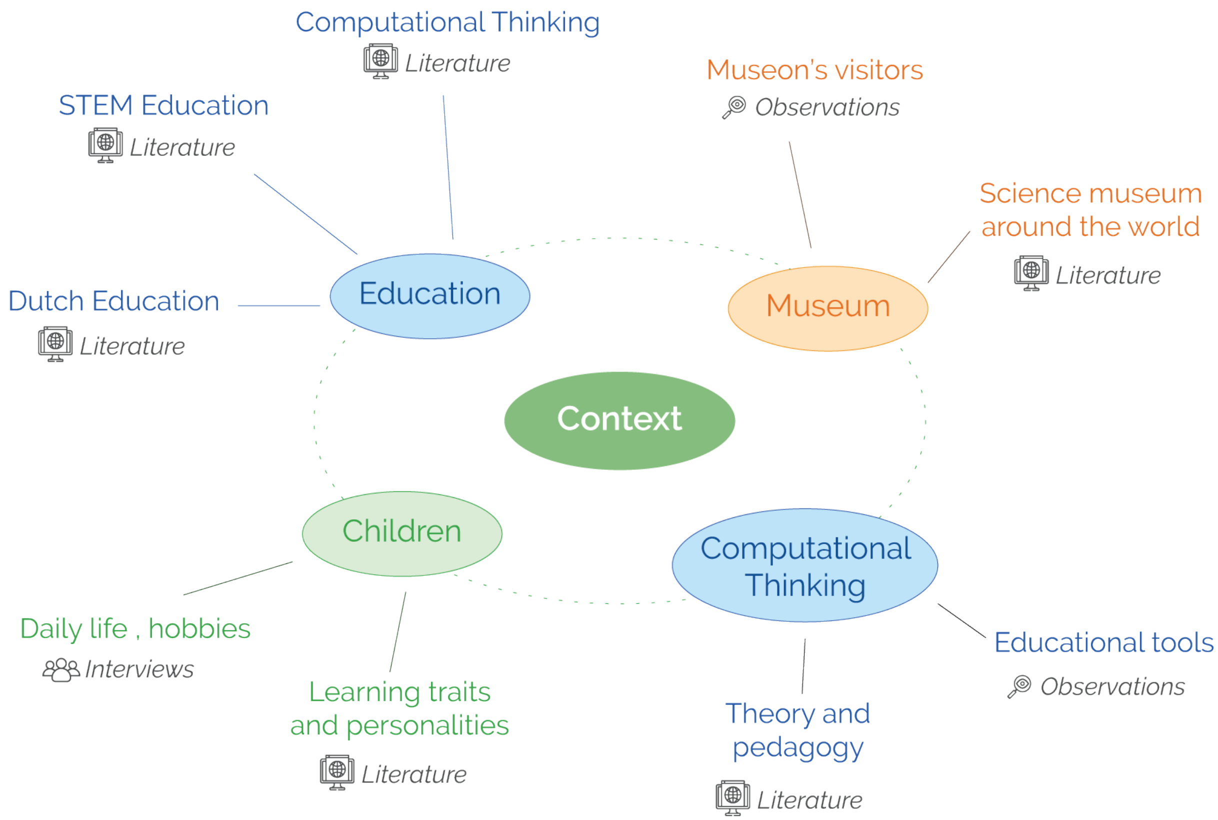


Figure 8 Overview of the context, the areas involved and the methods of research

2.1 Museum - The Visitor

Museon's visitors are mainly of two kinds: Children with families (mainly visiting the museum during the school break) and children with schools. Mostly, these visitors come to the museum to learn and have an educational day. However, this is still a generalisation and it important to understand if they have different purposes in coming to the museum.

Types of visitors

In his book titled *Identity and the Museum Experience(2009)* ,Falk talks about the different types of users that visit a Museum. He categorises them in the following manner :

- **Explorers** - Motivated by personal curiosity (ie. Children interested in science)
- **Facilitators** - Motivated by other people and their needs (Ex: parents bringing a child)
- **Experience Seekers** - Motivated by a desire to see and experience a place (Ex: tourists)
- **Professional /Hobbyists** - Motivated by specific knowledge related goals (Ex: researching a specific topic).
- **Rechargers** - Motivated by a desire for a contemplative or restorative experience.

The visitors for the robotic and programming lab are mainly *Explorers* ,*Facilitators* and *Experience Seekers*. The schools that bring the students for lessons to the museums could fall in the category of *professional/hobbyists*. The types of visitors and the stakeholders involved is illustrated in Figure 9.

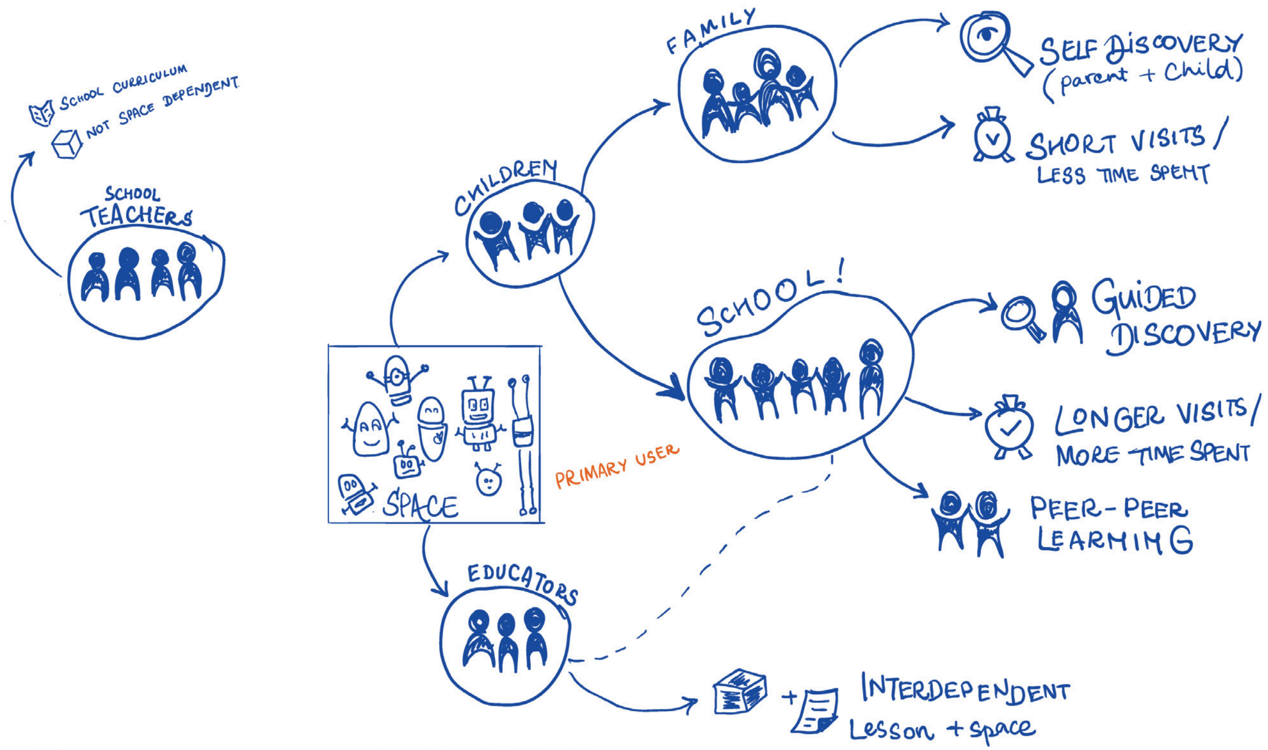


Figure 9 Overview of the stakeholders and the qualities the scenario.

Observations of visitors

The best way to understand the Museum's visitors is to see them, so I observed the people who came into the museum. Broadly, some patterns in visitors were observed, these are children with parents, children with nannies, children with grandparents, single children, children with younger siblings.

Some observations, collected over multiple days in various parts of Museon:

- Children are tactile learners- Most children get drawn to something either because it is visually attractive or because there are other children around it (peers).

- Children work better in a group- 2 to 3 kids keep each other focused and more motivated, discovery happens together.
- Children get bored easily- It is easy to lose focus especially if they don't have instant responses to their actions, It captures their interest if they relate to it and recognise it from a lesson in school.
- Parents facilitate the kids' discovery- Parents guide the children through the museum, sometimes hindering the natural tendency to discover and learn things.
- Children rarely read- Most children approach an installation and do whatever it affords them to do,overlooking any written text, They read only if there is some ambiguity in what the installation is.

These observations (see Appendix A for detailed observations) were made when the regular public visits the museum (children visit with their parents) , however children behave different when in school and around their peers. Museon conducts lessons for schools at the museum, this is a perfect way to observe and understand how the children perceive the same space sans parents or with minimal adult interference.

- Children aid each other's discovery - Young children thrive on each other's discovery of concepts. The interdependency leads to a healthy motivation of knowing and discovering more.
- There is no inhibition of what is right and what is wrong- The lack of a parent opens up doors for making mistake and not having the pressure of "eyes watching" you.
- Children are more patient in a class - Kids seem to pay more attention and learn more when they came to museon with the school, this could be because the visit is more focused to one part of the museum.

Figure 10 Drawings made from observations sessions, of both children visiting with school and children visiting with parents

Takeaway

Observing children in two settings- visitors (with families) vs school visit- helped to see that the requirements are very different for each and so is their purpose - educational (with schools) vs experience seeking (with parents). For this reason, even though it is ideal to design for both, it is not viable for the scope of this project. Moreover, keeping in mind the background of this project - to encourage science in schools, the primary user was narrowed down to ***schools visiting Museon.***

Image Source - https://www.deshgujarat.com/2018/04/13/rajkot-to-get-rs-78-crore-science-museum/

2.2 Museums around the world

How is the experience around Robotics created in museums in the world?

Robotics is a new field of study—so what are science museums doing to introduce robotics and programming to children? The Miraikan museum in Tokyo, the Science Museum in London and the Robot museum in Madrid boast of having the best robot collections in the world. However, these are non-interactive exhibits. While it is fascinating, it doesn't necessarily provide an holistic understanding of a robot. Most museums around the world have two kinds of museum interactions -

- **Visual Treats**- These are designed with basic/quick interactions, that are more visually appealing suited for regular visitors. These are generally designed for those who make quick visits and particularly caters to children of varying ages. Figure 11 shows some examples of these interactions.
- **Tactile Treats**- These are designed like workshops with deeper interactions and aimed at groups of children who ideally pre-book such events. These workshops, as shown in Figure 12, are conducted within the museum spread over a day and are tailor-made for a certain age group of kids. The detailed study of both kinds of museums can be found on Appendix B

Figure 11 Visual Treats . Exhibits at the museum that are mainly visually captivating and are semi interactive.

Figure 12 Tactile Treats. Workshops and lab spaces at the museum mainly for children to sit, tinker and create something concrete.

Takeaway

Museon's lessons for the primary schools are generally 60 minute long and are a combination of teaching and activities, this means that the workshop set up is more suited for this. However, the lab is not just for schools, it should be relevant to both, children who visit with parents (shor-lasting couple minutes) and children visiting with schools (long - lasting an hour).

The lab should be designed for long and short visits alike. This insight lead to visualising this space as an "interactive playground" where children get to learn, play, tinker and experience the essence of robotics. To conceptualise a space such as this, it is also crucial to understand the learning process of children. The next chapter explores this aspect in detail,.

2.3 Learning : Traits, styles and cognitive abilities

How do we learn? What are some common traits children exhibit while learning?

To understand how to teach children, it is first crucial to understand how children - humans learn things. Learning is innate to the Human mind and while it is still largely different from person to person, over the course of many decades, researchers have found patterns in learning to help decode the mind and make sense of our learning abilities. The Berkeley Center for Teaching and Learning states that *"Learning is an active process of engaging and manipulating objects, experiences and conversations to build mental models of the world".*

This leads to an important question, is there a pattern or ways in which we engage in these experiences and conversations?

Psychologist,Howard Gardner's theory of Multiple Intelligence, that focus on environmental aspects of learning will perhaps answer this question.

Theory of Multiple Intelligence

In his book titled *Frames of Mind : The Theory of Multiple Intelligence*, Gardner suggested that all people have different kinds of "intelligence."

He suggests eight different "intelligences", which could also simply represent personality traits and

Figure 13 Overview of Gardner's Theory of Multiple intelligence. Illustrated by JR Bee.

abilities. The theory is quite popular with most educators who use it.

- Visual-Spatial - Good at visualising things.
- Linguistic-verbal - Good at using words well when writing and speaking.
- Logical-Mathematical - People with a strong sense of this ability are good at reasoning and recognizing patterns, logically analyzing problems.
- Bodily-Kinesthetic - Good at movement, performing actions and physical control.
- Musical - Good at thinking in patterns, rhythms and sounds.
- Interpersonal - Good at understanding and interacting with other people.
- Intra personal - Good at being aware of own emotional states,feelings and motivations.
- Naturalistic - Individuals in tune with nature and often interested in nurturing, exploring the environment.

Learning Styles and learning process

The other aspect of a learning style includes perception and processing. David Kolb developed a model for experiential learning. It is based on the principle that learning happens in a cycle that includes four phases, as show in Figure 14.

Learners naturally enter this cycle at any point but go through the entire cycle through the course of learning something. Learning in these four phases is driven by the way the information is gathered and processed. This is primarily done- **by experimenting, by observing and reflecting, by conceptualising, by experiencing**.

Another dimension to the way we learn is abstract-concrete and active-passive nature of the learning . So to say:

- **Active learning** - Experimenting vs **Passive learnin**g- Observing and Reflecting
- **Abstract Learning**- understanding vs **Concrete learning** - Experiencing.

Put together it forms the learning styles - Diverger, Assimilator, Converger and Accommodator illustrated in Figure 14. According to Kolb, individuals learn better when subject matter is presented in a way that is consistent with their preferred learning style.(Healey and Jenkins, 2000)

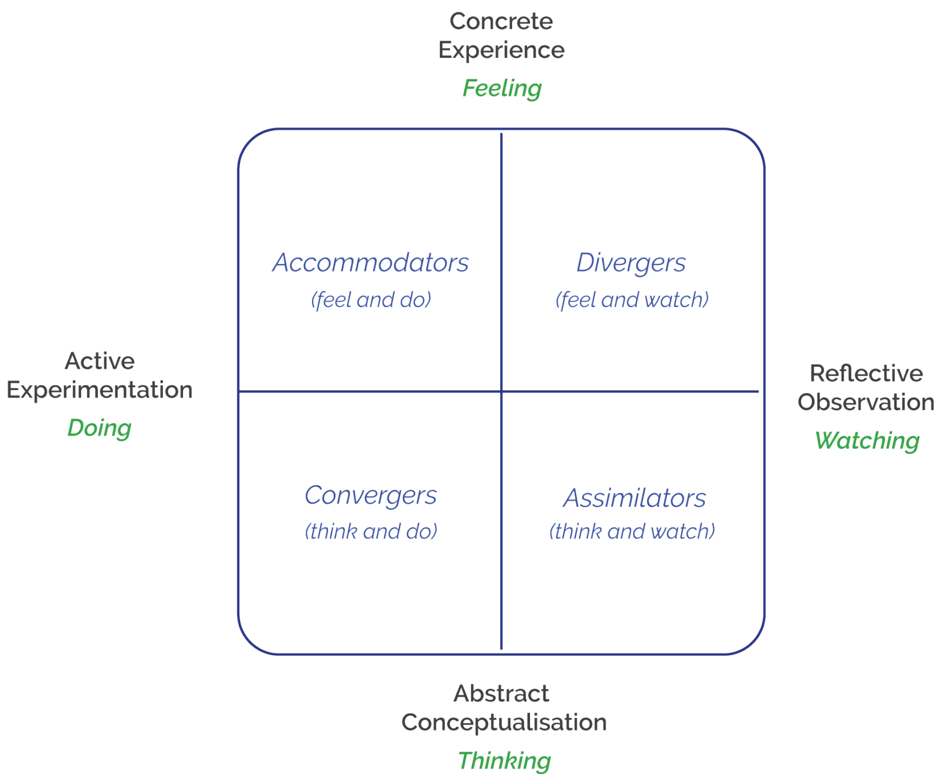


Figure 14 The Learning Quadrant by David Kolb.

Takeaway

Diving into the theory of learning styles and the process of learning is valuable as it identifies archetypes for a designer to base their conceptualisation on. Knowing that a child exhibits a certain learning style upon entering a space is helpful in creating a space that is relevant to each child, on an individual level.

2.4 Education : Dutch Education System

How is science taught at school and What is taught?

Dutch Education System

In general, school lessons are structured from simple to complex as the child progresses through the ladder of education. The topics taught at school commonly are science, social science,mathematics, reading and writing.
To someone who did not go to school in the Netherlands, it was crucial to get a context of the Dutch system of education and also understand the level of science taught at each level. As illustrated in Figure 15 all children first start their education at kindergarten and go on to Elementary school at age 4.

Elementary School - This is for eight years and split into eight groups, (equivalent of grades). Children primarily learn reading, writing ,mathematics, culture and nature sciences.

Secondary School - At the end of primary school, children are required to take a test. The results of this test helps determine what "stream" the child will be in. There are three main categories - VWO (for research) ,HAVO (professional education), WMBO (Vocational Training).

- **VWO-** This is for six years and VMO students can go on to research university. (WO).
- **HAVO -** This is for five years and students can pursue professional education after this.
- **VMBO -** This is for four years of vocational training.

Science in Schools

The Dutch Ministry of Education, Culture and Science offers an outline of the curriculum and the compulsory subjects for schools. One of the subjects is social and environmental sciences, this includes geography, history, biology, citizenship, road safety and political sciences. However, schools have freedom to organise teaching meaning they are free to determine what is taught and how it is taught (Scheerens J., Luyten H., van Ravens J. ,2011). In addition to this school teachers don't receive training in teaching technology and their affinity with technology is often low. (J.Rohaan, Taconis and M.G Jochems, 2010).

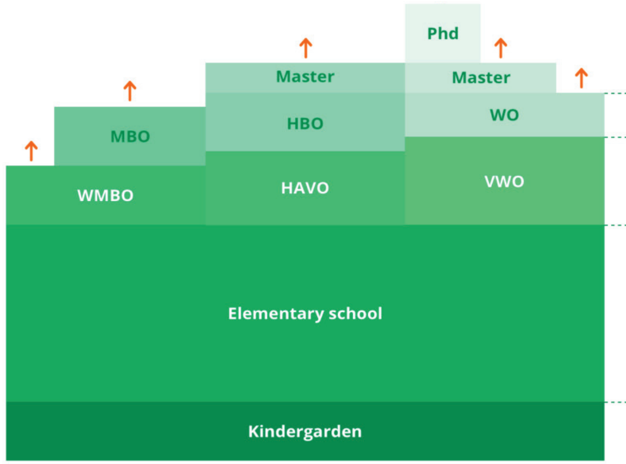


Figure 15 Overview of the Dutch Education System.

With this background of the Dutch Education system, it became clear that although there is a dire need to teach science in the primary school, there are not enough teachers to do so. This is also the reason why schools prefer to depend on science museums, their expertise and resources to expose school children to science and technology.

2.5 STEM Education

What level of science and technology is taught around the world?

What is STEM?

A background on STEM education

STEM is an acronym and stands for Science, Technology, Engineering and Mathematics and was an initiative created by the National Science Foundation (NSF), USA, in the year 2010. This was formulated with an aim to provide all students with criticial thinking skills that would make them creative problem solvers. (W White, 2014). It is a method that integrates all these subjects and addresses the concerns that these subjects are taught in isolation when in fact it is all intertwined forming a cohesive inter-disciplinary approach based on hands-on learning. STEM encourages kids to experiment, make mistakes and learn from own experiences to reach correct outcomes, than relying on what the book says. The traditional education lacks this approach, and is etched in memorising or rote learning.

STEM education in Netherlands

Currently, in the Netherlands, an advisory council called "curriculum.nu" (Figure 16)wants to focus on STEM education as it provides an interdisciplinary approach. The method is formulated such that it motivates and encourages children to conduct research and arrive at a solution to problems In doing so, children learn to handle the research and the design process, and learn to think independently. Through this process they gain knowledge about an event, areas, organisms, phenomena,etc. Although this approach touches upon science and technology as a subject, it doesn't mean that currently students pursue these subjects beyond the school's curriculum. (.nu, 2020)

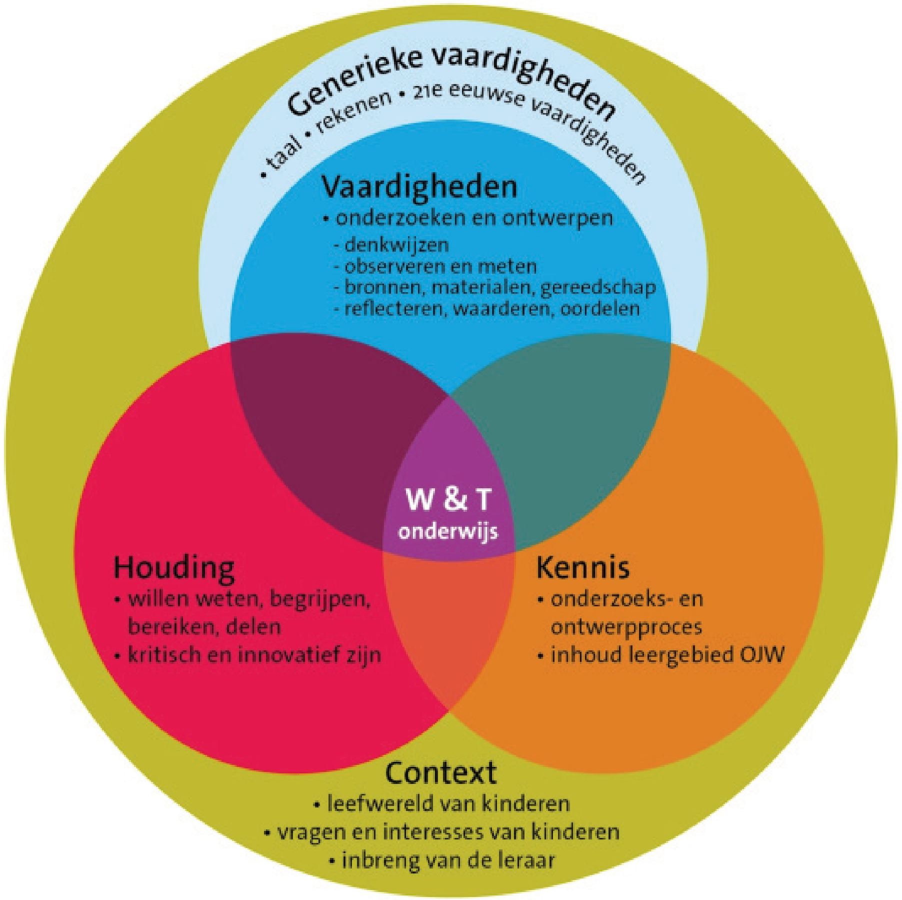


Figure 16 Overview of the interdisciplinary approach by curriculum.nu

2.6 Computational Thinking

What tools and methods facilitate programming and robotics for children?

What is Computational Thinking?

"Computational Thinking is the process of recognising aspects of computation in the world that surrounds us and applying tools and techniques from Computer Science to understand and reason about both natural and artificial systems and processes. It includes a range of mental tools that reflect the breadth of field of computer science."(Furber, 2012). Seymour Papert, a mathematician and researcher at MIT media lab, is first known to have referred to computational thinking as a tool for learning and education (Papert,1980). At the heart of it, computational thinking is composed of the following elements - Decomposition, Pattern Recognition, Pattern Abstraction and Algorithm Design (Figure 17)

Computational Thinking for kids

These elements find their obvious relation in programming, and a host of interfaces and tools designed specially for kids use these elements. Programs such as Scratch, Turtle Logo, Blockly, Kodu and Lego Mindstorms are increasingly popular amongst educators and children alike. These programs are designed with kid-friendly interfaces and even have a visual simulation alongside the programming that changes as per the code. The elements of code are also further simplified, as seen in Figure 19 to enable easy comprehension for children, while still adhering to basic programing logic. Apart from these digital simulations, there is also another aspect of educational tools for kids, that combine physical and the digital -namely robot toys. These are designed to make the entire experience of programming tactile, bringing the virtual world to the real world.

Computational Thinking sans technology

In an article titled "Planting the seed of computational thinking in early childhood", Ann Gadzikowski says that :

"Computational thinking is born in the preschool block corner. As children build towers, roads, forts and bridge using blocks of calibrated shapes and sizes, they gain experience recognizing and creating patterns using attributes such as shape and size."

Thus, computational thinking becomes a way of learning through tactile objects and outside of computer and technology. This is aptly illustrated through the Computational Thinking Bins , a set of activities teaching computing concepts designed for middle and high school students. (Morrison,Dorn,Friend, 2019). For instance, one of the bins called Computer Art consists of a grid with decimal and hexadecimal colours which the students must identify as RGB colours. These represent an image (pattern) and the students are then asked to fill the squares (pixels) with colours, to discover the image represented.

Takeaway

The elements of computational thinking are directly relevant to this project and the Thinking Bins could be used as an inspiration to conceptualise the activities in the museum space. Another essential learning is that robot toys play an active role in STEM education. They facilitate learning. *(To be revisited)*

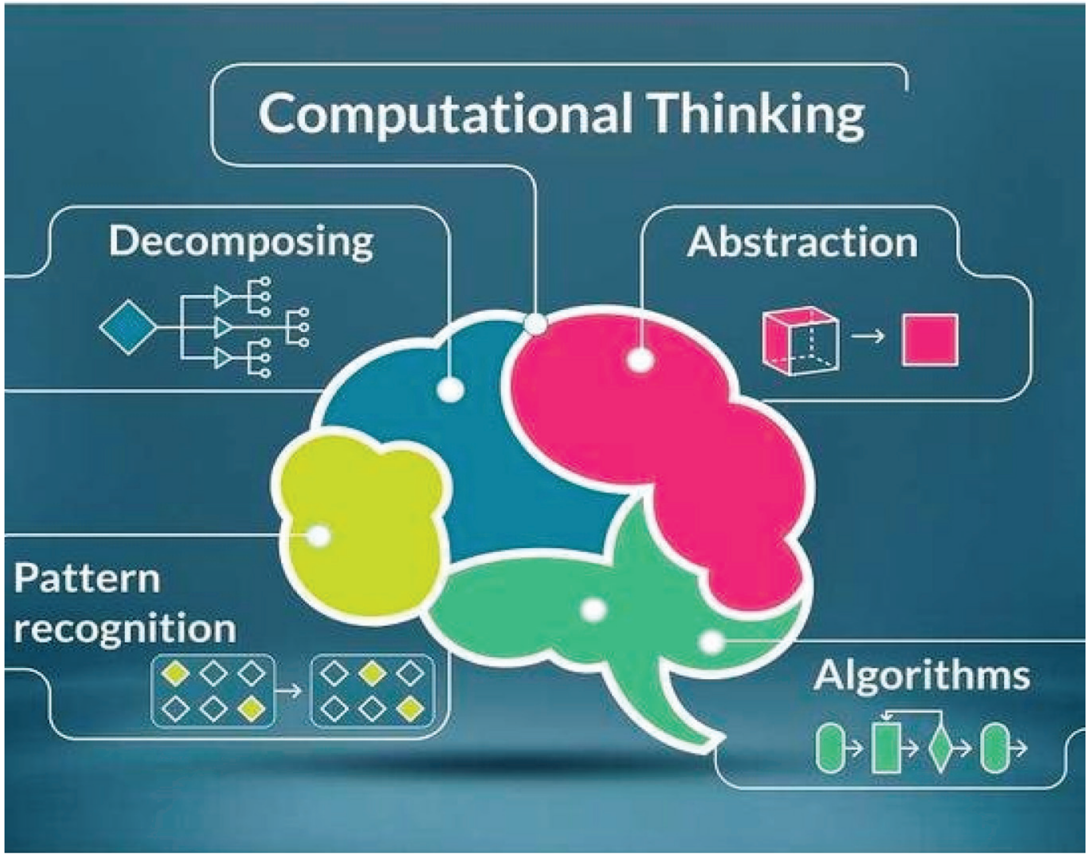


Figure 17 Elements of computational thinking

Figure 18 screenshot of a program written in Scratch. image source : https://www.miltonmarketing.com/coding/scratch/introduction-to-scratch-lifelong-kindergarten-group/

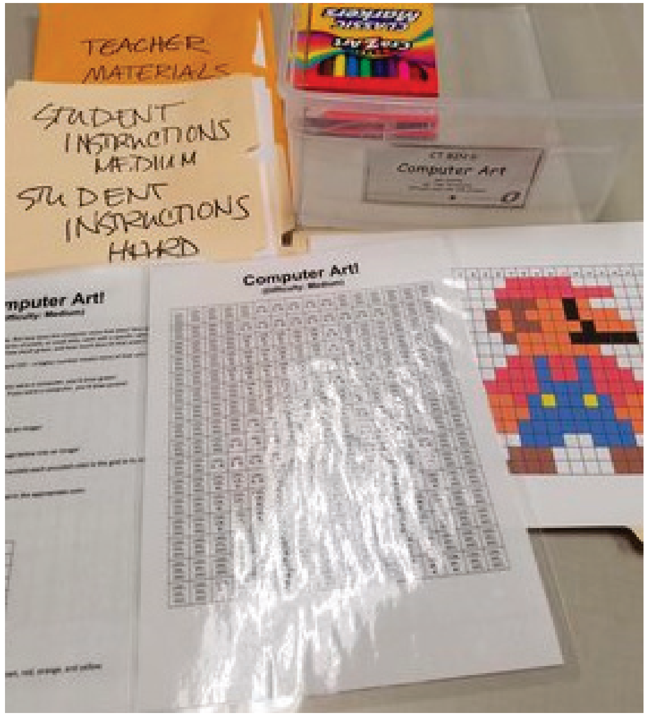


Figure 19 A screenshot of the thinking bins activity.

2.7 Computational Thinking and Educational Toys

What tools and methods facilitate programming and robotics for children?

Educational Toys

Toys facilitate learning amongst young kids and make learning fun through play. As mentioned in chapter 2.5, currently many educational tools are based on computational thinking. The role of these toys is two fold - to teach children programming and robotics but to also to make otherwise drab lessons such as math or science more fun.

These tools were looked atclosely at and evaluated based on experience of using it. Since some of these toys are expensive and not easy to procure, the reference (for some of the tools) in this evaluation is done through videos and talking to people who used them before.

Evaluation Results

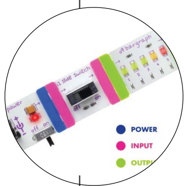
Each toy is evaluated based on ease of use, intuitiveness,familiarisation required, etc.
The evaluation is done keeping in mind the inexperienced user/ someone who is new to coding and computers.

While the Lego Mindstorms was the most fun and challenging to assemble and code, the easiest toy to operate is the Sphero SPRK+. It proved to be versatile in its functions and could be adapted to different settings because of it's non-intrusive shape. However, it does lack the ability to do and be multiple robots like the Mindstorms.

Takeaway

The evaluation helped to see the functions and the capabilities of these as tools to facilitate learning. This leads to question, how can toys such as Sphero be used as a bridge between programming and play for the visitors at the museum?

Educational Toys

		Experience	
Mindstorms  **Contents -** Intelligent Brick. Comes with a software to program, using basic Scratch.	**Play** The brick attaches to a variety of Logo bricks and comes with instructions on how to build.	- Not very intuitive. - Time Taking, to assemble and program - Unusuable without the right Lego pieces.	+ Customise what you want to make + Pre-existing familiarity with Lego + assembly and coding + high learning curve
WeDo  **Contents -** Intelligent Brick. Comes with a software to program, using basic Scratch.	**Play** The brick attaches to a variety of Logo bricks and comes with instructions on how to build.	- Doesn't feel serious - Limited customisation - Unusuable without the right Lego pieces.	+ Easy for beginners to coding + Pre-existing familiarity with Lego + assembly and coding + Simple steps to follow
Sphero SPRK+  **Contents -** A ball, the size of a baseball, angle measurement disc,measuring tape, app/software similar to Scatch	**Play** The ball rolls, speaks and emits light, using the app drive it around,play games or program it.	- No assembly, only coding - Not customisable physically	+ Easy for beginners to coding + Adapts to use/purpose of lesson + Can speak and emit light + Affords for game play and learning
Littlebits  **Contents -** Series of Modular electronics, instructions. Similar to arduino, but for children.	**Play** The different parts snap together using magnets, create a mechanism using a series of different things.	- Dependent on components. - Limited to available components - Mechanical, more about the circuits/ programming than robots.	+ See immediate results + Easy to tinker and learn + Tactile input and output
Cublets  **Contents -** a set of cube with magnets, input out put, light sensor, distance sensor	**Play** The different parts snap together using magnets, create circuits to see a light glow, for example.	- Dependent on components. - Mechanical, more about the circuits/ programming than robots. - Confusing and not entirely intuitive	

Chosen to use in the design

03 User Research

The primary users for the robotic and programming lab are children however, parents, museum educators and teachers are equally important stakeholders because of their everyday proximity to children and the role they play in the learning processes of children.

To design more holistically for the user , it is crucial to understand the user in their context. To do so, interviews were conducted with teachers, museum educators and parents. This chapter details out the learnings and the insights gained from interactions with users.

Overview

The project triggered several research questions that needed to be explored in order to gain a better understanding of young children and their play and learning behaviour.

- How do children perceive a robot?
- What role does technology play in a child's life?
- What do they currently learn at age 6 and age 12? How do children at different ages perceive or learn?
- What role do teachers and parents play in their learning?
- What kind of science do children learn in school?
- Are teachers inclined to teach science in depth?
- How do the museum's lessons tie in to the lessons at school? Is there an orientation or brief in school before or after the museum visit?

It became clear that the research, while focused on children, would mainly be approached through interactions with parents, teachers and museum educators.

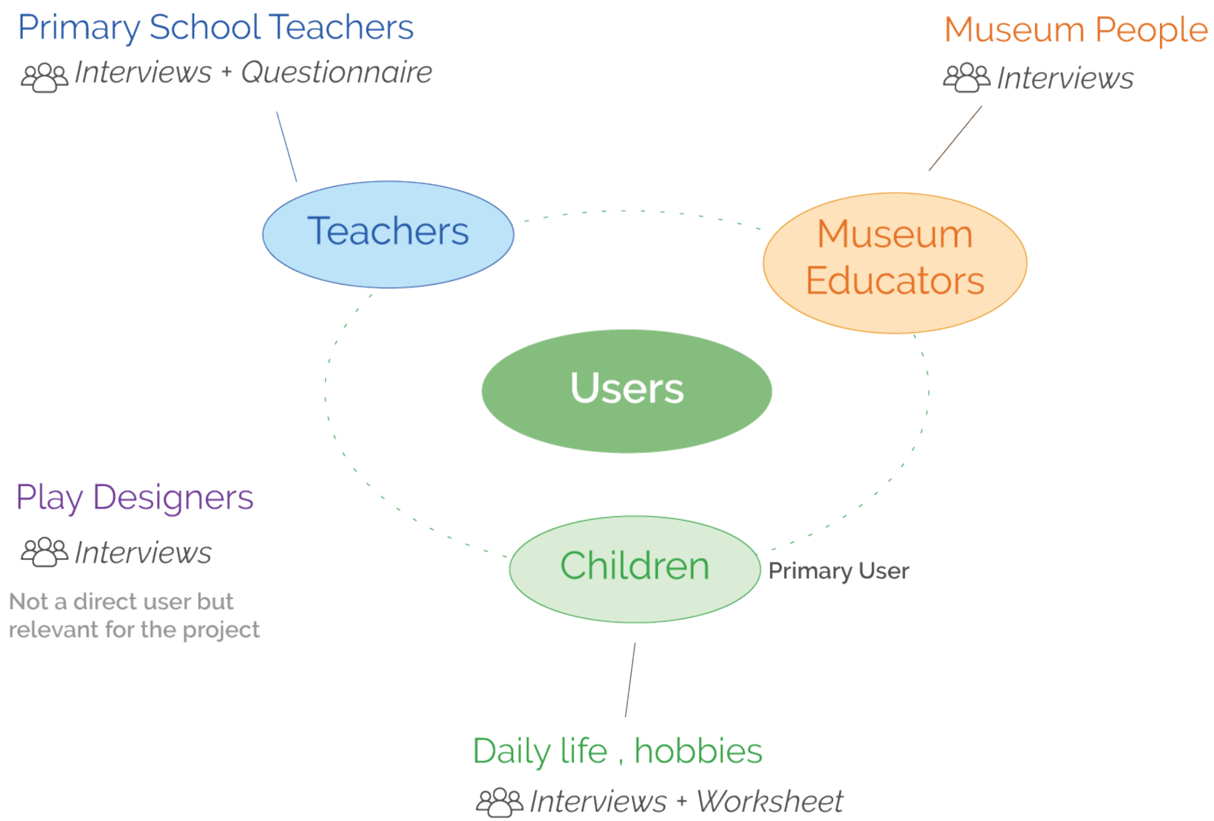


Figure 20 Overview of the users. Primary and Secondary users along with methods of research.

3.1 In conversation: Teachers

What are children like?

How do they engage in a space?

To design for children, it is necessary to understand what the children are like in school, at home and what they currently do in these spaces. Technology plays a huge part in the life of children today and lessons at school are incorporating technology in various forms so children are sufficiently familiarised about use of technology. How does learning and everyday technology overlap? The best way to understand children is to see them in their natural environments (at school or home), however the presence of a stranger may alter their behaviour and wouldn't really result in desired insights. So the alternative approach is to talk to people who spend time with children everyday, this includes teachers, parents and also children-play designers.

In conversation with a school teacher

My research lead me to a primary school teacher in Rotterdam, currently working as a substitute teacher for group 4 and group 5 children. The substitute teacher, Renee shed some light on the Dutch school culture. The following are the questions asked and a summary of insights were compiled:

- What do children learn in primary school?
- Would children relate to robotics?
- In case of a trip to the museum, does the lesson continue outside of the museum, in school as well?
- What role does technology play in school education?
- Is science taught in school, how is it currently taught?
- Do children learn better in groups or individually?

Renee, School teacher

Substitute teacher with a background in design

"Children are like sponges, absorb everything around them in the moment. They remember through their sense and learn by making, breaking things."

"Children relate to things if it is recognisable from their daily life. Stories are particularly enticing to children."

"Children take to social media actively from the age 8-10. TikTok is a big bit and it forms a basis of peer socialising outside of school"

"Most learning happens from peer to peer , however in groups also each child learns in their own way."

The conversation helped to understand patterns and behaviour of children in a school space, especially since it was coming from a teacher,'s point of view.

Having been only exposed to the culture and people in Delft, it seemed to me that the Netherlands has a strong science program for children. However, it was surprising to discover that science is barely taught in schools. This insight from Renee confirmed the research covered in chapter 2.2 (Dutch Education System).

"Math, Dutch, Social science, Behaviour are taught with more focus than science. However, once a week some schools programming is only taught for a special class, with selected students, once a week. They learn things like Lego Mindstorms."

It became evident that schools therefore depend on science museums to teach certain lessons. However, these lessons are only taught in the museum space, and there is no follow- up or preparatory lesson to it in the classroom space.

These two problems highlighted a crucial need for a systemic solution, and lies outside the scope of this project. However, the robotic-programming lab can be seen as a bridge or a starting point between the school and the museum experience. It can develop into a space for children and teachers to learn alike, and still be able to relate and learn about it outside of the museum space.

3.2 In conversation : Children's play designers

Designing for play

Designing for children, although fun, is quite challenging, especially as we are hard wired to think like adults (duh). The way that children think, perceive and respond to things differs greatly from an adult. Especially today's children grow up facing rapid changes in the society and are unintentionally exposed to various global challenges. It is therefore imperative that the children are empowered to take on active roles in such a situation. They need a deep conceptual understanding that allows them to connects concepts and skills, apply their knowledge to different situations and spark new ideas. (Winthrop & McGivney, 2016; Frey, Fisher, & Hattie, 2016). This can be achieved through playful experiences, to create optimal experiences for deeper learning. That leads to question - what does it take to build such an experience for children? what are the elements to consider when designing for children? To help gain some insight in this context, I reached out to the designers Maria Lupetti and Mathieu Gielen, who specialise in children's play design.

In conversation with Designers

Mathieu Gielen, specialises in designing for children's play, and is at the forefront of this relatively small and specialised area within industrial design education.
The conversation with Mathieu touched upon kinds of play. It became clear that the physical context and the duration of the visit are central in determining the information provided which in turn determines the extent to which children immerse in the experience. For instance, a museum space is new and fascinating for kids, and it is most likely that they visit a museum just once, not recurring . Hence, the interaction and the information consumed should be designed for short visits and presented in small quantities.

How to create an engaging experience?

Mathieu : "Motivation is key. It is driven by feeling of Autonomy and determines child's motivation in doing the activity."
Motivation is determined by an intrinsic interest in wanting to learn. This in turn is fueled by the needs of feeling autonomy, relatedness and competence. (Wang, Liu, Kee & Chian, 2019)
So to say, when a child feels in control and perceive that they have choices, they feel more engaged and creative in performing the task. (Connell and Wellborn, 1991). Finally, the ability to do something efficiently and relatedness, feeling connected fuels the autonomous

Mathieu Gielen
Children's play designer.

"For a museum, the play should be more of a free play where children lead the experience, it helps to engage and immerse in it."

"Parents are a container of rules, a child's natural play becomes restricted when an adult intervenes."

"Visits to the museum is a one time thing. So the experience should be small and snack sized. They should be able to achieve competence sooner."

motivation. Figure 20 illustrates this in a Venn diagram, the center of which lies the sweet spot for an experience that keeps kids engaged.

What are the elements of a holistic experience?

Maria : "the story telling / narrative of the space is crucial, it helps build the experience from start to finish."
Story telling gives children a reason to listen and something to remember (Mary Medicott, 2003). It plays a unique role in both the tangible and intangible aspects of an experience and helps to fully immerse in an experience allowing children to play an active part in shaping their own learning. (Johnsson, 2006)

The conversations helped to see that the following are the elements needed to keep in mind while conceptualising the experience for the robotic - programming lab :

- To present information in easy to understand format.
- To design in a way that the experience affords for self - discovery.
- To design in a way that it affords for freedom of choice/autonomy.
- To formulate the activities such that it is challenging and affords for seeing and doing.
- Create a story or a setting in such a way that the children connect with their prior knowledge.

Maria Lupetti
Researcher with a background in human - robot interaction and play for kids

"Children enjoy it where are things to see and do. They like to see a tangible effect of their actions - doing and seeing. Trial and Error comes naturally"

"Children usually get too excited around robots or things that are new, so it is nice to give a specific task, keeps their focus."

"Storytelling is crucial, it helps build the experience from start to finish."

"Activities with the robot can be around the things they learn in school .Eg. working solar system, create a landscape, etc."

"Children are conscious that it is a robot when they see one. They get super excited and like to be challenged."

"Generally girls are more engaging and boys are more mechanical. Subject such as robotics is interesting to both"

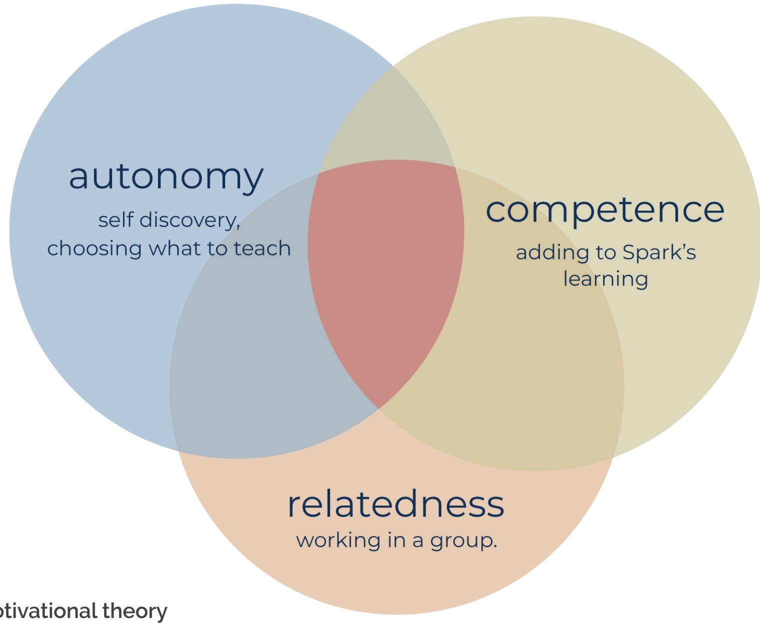


Figure 21 Overview of the Motivational theory

3.3 Museon educators and lessons at Museon

How are the lessons at Museon taught? Are they close to school curriculum?

Museon conducts regular lessons with primary schools in The Hague, the age group of children varies between 6 to 12 years. These lessons are conducted by employees of the museum called educators who also design these lessons but also actively design the content of the museum spaces. Most educators come from teaching backgrounds, having taught in Dutch schools before moving to the museum education space. This helps them bring the needed relevance to the museum's lessons. The lessons are tailored to connect to the age group, the topics of the museum and the school curriculum.

Museum lessons and observations

The museum conducts lessons starting from 9 am to 12 pm, throughout the week during school days. Different lessons for different schools take place simultaneously. Lessons are conducted in three different time slots, each lesson lasting for about sixty minutes. An overview of the process of conducting a lesson at the museum is illustrated in the Figure 22. During the course of a week, some lessons were observed. Below is a compilation of observations and few insights from the lessons.

What lessons were observed?

- Electricity for Beginners (Group 4, 8-9 year olds)
- Climate and Seasons (Group 5, 9-10 year olds)
- Mini Media (robotics) (Group 8, 12 year olds)

What are the observations about the lessons ?

- The space is set up in a classroom format, usually in the middle of the room surrounded by the exhibits, where children are listening to the educator.
- The sandwich format of delivering lessons is used (interactive lesson- activity - interactive lesson), this helps keep the lesson interesting and informative at the same time.
- Having physical context relevant to the lesson is useful in immersing the learner in the subject being taught. Educators can point to things and give information about it.

What are the observations of the children ?

- Peer learning - Children learn as a team, helping each other, discussing and solving together.

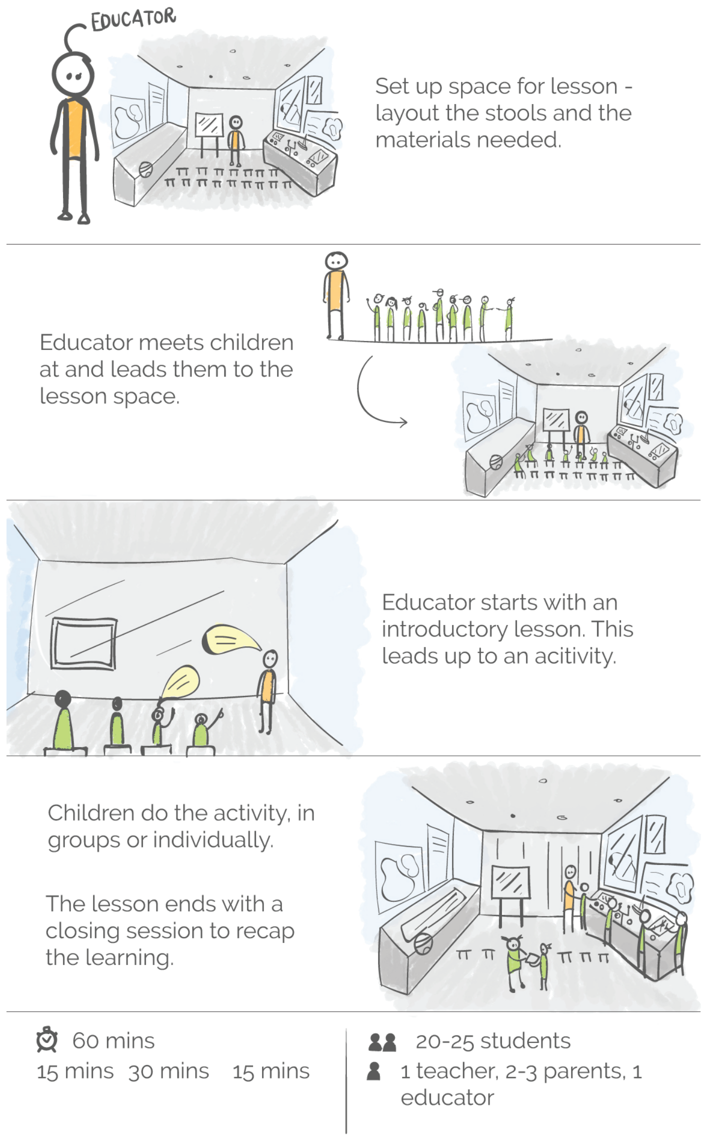


Figure 22 A gist of a regular Museon lesson

o More Focused - Children are more focused when visiting with a school, than when they visit with parent. This is because they focus on only one part of the museum when they visit a school.

Interviews with educators

The fact that the educators teach, design and develop the content for the museum, interact with children on regular basis makes them valuable source of information for the development of this project. The following few questions were asked to the educators, to mainly understand their perception of what the robotics, programming and science. In addition some information was also gathered over chats and discussions about the project, education and the interaction with children.

- o What do you think about the current way that science is thought in schools?
- o Why is it valuable for schools to bring their students to the museum?
  How do you imagine the robotic lab to be ?
- o What role do you think it would play in the goal of the government—to encourage science?
- o Do you think children would enjoy learning robotics? Do you think it is important?

Some of these answers and related information about Museon was compiled, as seen in figure

Gert-Jan, Science Educator
Since Jan 2019
high school science teacher
science nerd
went to a Montessori school
teaches electricity, programming and water.

"The lessons are designed depending on the schools' needs from the museum."

"Teachers depend on the museum for the resources, and knowledge expertise, especially in science "

"I think the terms "technical" and "technology" are often confused for one and the other. It is essential to understand these are different "

Marieke, Educator
Since June 2017
worked in insurance for 20 years
didn't know anything about science
enjoys teaching really young kids
teaches biology, nature and beginners electricity

"In a lesson about solar rays for 10 year olds, most of the class didn't know how to use a sccrew driver. They don't use their hands anymore. It's shocking."

"Children depend on parents a lot. In a classroom ,it is better as the teacher is more strict, so they listen."

"Robotics gives me a futuristic image but for children, I imagine a warm, welcoming space for them to move and play."

02. These quotes are combined with background information to form the persona of educators. This helps to give context to the statements and to the role of educators in the development of this project.

Figure 23 Drawings made during my observations of Museon lessons with schools

3.4 A short study : Children's perspective

How do children perceive robots? What is the daily life of children like? What would they like a robot to do?

Children perceive world with a different lens and it is hugely insightful to talk to teachers and parents to understand child behaviour and habits. This chapter zooms into the perspective of individual children. This helps gain some insight into children and how they think.

A worksheet was created and shared it with children (digitally). The worksheet was designed in two parts, the first part was about their daily life and the second part encouraged the participant to draw a robot they would like to befriend. The detailed worksheet and the answers can be viewed in Appendix D. The worksheet was filled in their time and it was later followed by a semi-structured virtual interview to chat about museums, and robotics. In particular, this interaction was aimed to understand their perspective on :

- Robotics and programming
- Museums as a space to learn

Interview and Analysis

One of the interviews was with a 11 year old girl named Tess, who is adept at programming and has been coding things in Scratch since she was 6years old (this participant didn't fill in the worksheet). Upon asking if she did Scratch in school, Tess promptly said that anything related to Scratch is forgotten as soon as she goes to school. It became clear that programming is viewed as an extra curricular or an hobby to do outside of school.

The initial worksheets helped to see what children have on their mind and helped to set a tone for things to talk about in the virtual chat. This kept the momentum of the interview and facilitated an otherwise awkward way of interviewing children, over a digital call, without the context of a given space.

As part of the interview, the Sphero Sprk+ was shown to them and asked if they thought it was a robot. Almost all children first replied with a no and once they saw what it can do(move and emit light) ,

Tess, 11 years old
learnt to program since age 6 or 7.

Would like to be an actor when she grows up and wants to own a pizza bus with her sister.

"I like to create and play games on Scratch."

"Maybe I can act with robots or use robots in my pizza truck, that would be cool"

"I once created a funny story about a boy who gets cake on his face on scratch and it was a lot of fun I would love to use a robot to make such stories."

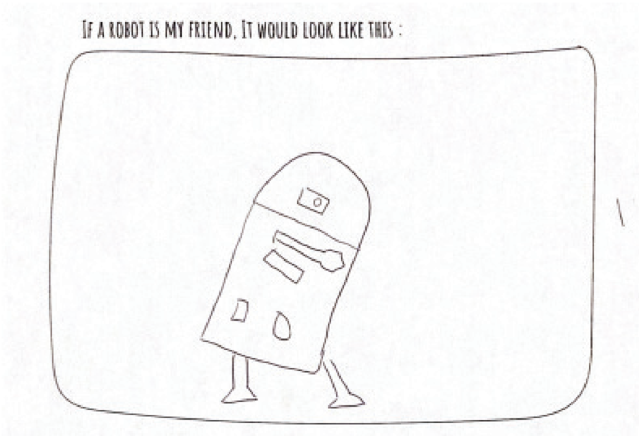


Figure 24 . A drawing of 'ideal robot' by a user.

they would change their answer to yes.
Only one child said it was a robot before seeing what it can do. This busted a prior assumption that children imagine robots to be human like or big and looking very mechanical. On the contrary, children perceive something as a robot for what it can do, if it responds to a set of instructions and moves "smartly" then an object can be called a robot.

The main takeaways from the interviews are-

- Children learn to code outside of school curriculum or at an extra class : From the children's responses and the parent's inputs, it became evident that a kid learns programming outside of school, through a parent or in the day care. It is also considered more of a hobby.
- Children envision robot as an aid: When asked what they would want their "dream" robot to do, the common answer was "help me with my homework" or "play games with me". The robot is perceived like a companion who can aid them in the things they do.
- Children exposed to programming vs who don't: There doesn't seem to be a stark difference in the perception of what they would like to do with a robot. However, children's answers are influence by the things they have in their house. For instance, Max says that he would like to code a robot such that it is better than Alexa, the smart hub.

Children remember the experience around the robots/activities more than what they exactly did with them:
Children remember the stories around the robots, where they saw them, what they did with them and the result of their actions. "I played table tennis with a robot arm, it was creepy" or "I remember going to the museum and enjoying the pulleys (specific activity) but I don't know exactly what it was for".

Max, 10 years old
Learnt a little programming at coding camp

"I played table tennis with a robot arm once, it looked creepy so I wouldn't want to play it with it again."
"I would love to program a robot to make it understand a lot of things, like Alexa sometimes doesn't know somethings or understand me."

Eva, 8 years old
no exposure to programming

"I don't really like robots, I never played with any ."
"But if I had a robot, I would like to introduce to my friend and play games with it and teach it to paint"

Sam, 8 years old
played with robots but never programmed one

"I think it would be cool to have a pet robot and teach it small tricks"
"He has a robot, it does a limited set of things. He hasn't played with it in long time, maybe cause there are no newer things to do with it " - parent

3.5 Conclusions from Research

Conclusions + Insights

The research and interview presented knowledge to help create requirements in creating an engaging museum experience for children. It also helped to make decisions on the different aspects such as the content of the lab , the feel of the space and the tools to use. These decisions were mainly made with keeping in mind the Technology Pact and Museon's approach to education for children. These decisions or requirements thus become the skeleton based on which the content and the experience of the lab is conceptualised. Some of these decision are as following :

- **What is the feel of the space?**

As mentioned in chapter 2.2, museums are either primarily designed for short experiences or long workshop-style experiences. For Museon, considering the 60 minute lessons for schools and the purpose of the lab - to spark and interest, it is crucial that the lab's content should encourage for 'doing' and 'learning', this means that it should feel like a combination of a tinkering Lab and an interactive playground. Where children can spend both short or long time in this space.

- **Who are the users?**

The general age group of kids visiting Museon are 6-12 years. However, the way that 6year olds

- How is interaction going to take place?

The evaluation of different robotic toys in chapter 2.6 highlighted the potential of these toys in facilitating learning. It would be beneficial to use these toys as they hold potential in promoting individual learning in a large space such as the museum. The Sphero SPRK+ was found to be the most adaptable and was picked as an element to be central in conceptualising the experience.

- **What is the content of this space?**

The content for the lab would be largely based on the elements of computational thinking. However, to make this content relatable for children, it is crucial to juxtapose elements of play and storytelling to create an experience. In addition, it is also important to align activities of the Robotic lab with the Museon's themes of sustainability and hence this would be another criteria of consideration in the conceptualisation.

With these decisions, the project moved into the ideation phase and eventually leading to the conceptualisation of the robotic and programming lab. At this point the design goal is as follows.

04 Design Development

The insights from the research lead to some design decisions for the experience of the robotic and programming lab. This became the starting point for the conceptualisation of the content and experience of the lab.
This chapter begins with a relook at the design brief and outlining the design requirements, leading to the ideation that helped to form the framework of the lab.

The activities done during this stage are, ideation (brainstorming and brainwriting) , story development (story boarding) and evaluating the storyboard.

4.0 Overview

While the research diverged to get a holistic view of the context and the users, this phase converged to form concrete requirements and outcomes. Once this was set in place, the process diverged again to explore, ideate and find relevant ideas and themes for the lab. The process of converging and diverging is recurring thereafter, this helped to get a holistic view of the details and the larger picture, at the same time.

This phase dives into the aspect of storytelling as a tool to bridge a connection between the robot toy and the children. The experience is built and developed around the story and the following chapter details out this process.

Since no physical space called the robotic lab exisits, the entire conceptualisation, prototyping and the designing was done with references of the other labs in Museon and these are mainly represented through storyboards and sketches.

4.1 Revisiting the Design Brief

What is the design brief?

With the insights and the knowledge from the research so far, the project reached a point where it was crucial to re-look at the initial design brief and to make it more relevant to the context.

The insights from the research helped to make some design decisions, as detailed in chapter 2.12. To summarise these decisions, they are as follows :

Content : The activities of the lab would be based on elements of Computational Thinking. These will be borrowed from the large data base of activities available online and modified to fit the context of the lab.

Feel of the space : The lab should feel like a combination of a tinkering lab and an interactive playground. Children can spend either a short time or a long time in this space, and yet they would still be able to have some takeaway.

Tools to use : The Sphero SPRk + was identified as a fitting tool to be central to the interactive activities in the lab.

But what is the overall quality of the experience and how is the user going to experience it? And who are the users for this space, what age group are they? These questions lead to the creation of the following design brief :

Create an experience that evokes a sense of engagement with robotics through curiosity and wonder.

The activity is relatable and affords for self discovery, making it easy to understand and to take away as a simple but treasured learning experience.

This experience will be designed for children visiting Museon with their school and are aged 8-10 years.

A metaphor for the desired interaction

While the design brief details out the elements of the experience it still falls short of painting a picture for the desired interaction. To facilitate this visualisation, the following visual metaphor was created.

The desired interaction should feel like a treasure hunt where you complete a set of brain teasers and challenges with a shared goal of finding the "treasure".

While the reward is the motivation, the real experience lies in the various challenges. In other words : **it should feel immersive, exciting, anticipative.**

Image Source - https://www.deshgujarat.com/2018/04/13/rajkot-to-get-rs-78-crore-science-museum/

4.2 Story development and the birth of Wizee

Context

Chapter 2.7 outlined and evaluated the toys that are currently available for children to play and learn about robotics. This helped to see that they hold a great potential in facilitating a child's learning. For this reason, it was decided that a robotic tool should be used in the robotic-programming lab.
As stated in the evaluation in chapter 2.7, the Sphero Sprk+ was found to be the most suited, for a space such as the robotic lab at Museon.
However, just placing the robot in the museum space is not enough to spark curiosity, it is likely that it catches the eye of one kid and doesn't pique curiosity at all for another kid. It brings to light some questions: what is a child going to do with it in the robotic lab? This toy can easily be used in a classroom and doesn't necessarily have to be in a museum, so what value does the space bring to the toy? how can it bring this value?

Storytelling

The learnings from conversation with children's play designers (chapter 3.2) echoed at this point : "Create a story or a setting such a way that the children connect with their prior knowledge."
On delving into this and reading a little more about stories, I found inspiration in a PhD thesis(Lupetti, 2017). The author creates a story for her prototype - a lost robot that is found and needs help, this helped to connect with the child's imagination and pique curiosity.

The development of Wizee

Having a story was found to be relevant, especially to a setting such as the robotic-programming lab. To begin with, the Sphero Sprk+ was renamed to Wizee and after multiple iterations and retelling the story to multiple people, the following story was outlined.

> *"Wizee lives on Titan with its friends, and they all love science and would like to learn everything about science. Together they have one dream - to fly to Earth, because they hear it is the only planet with many resources. They would like to come to Earth and learn all about it and become 'Earth scientists'.*
> *One day they hop on to their spaceship and land Earth. But they are in a for a shock because they see a lot of people, a lot of buildings and are overwhelmed by it all. So they find the one place that could explain life on Earth, a museum. They come to Museon and find that they can learn more about Earth. but they are still new to Earth and they need help. Would you like to help Wizee and it's friends learn more about Earth?"*

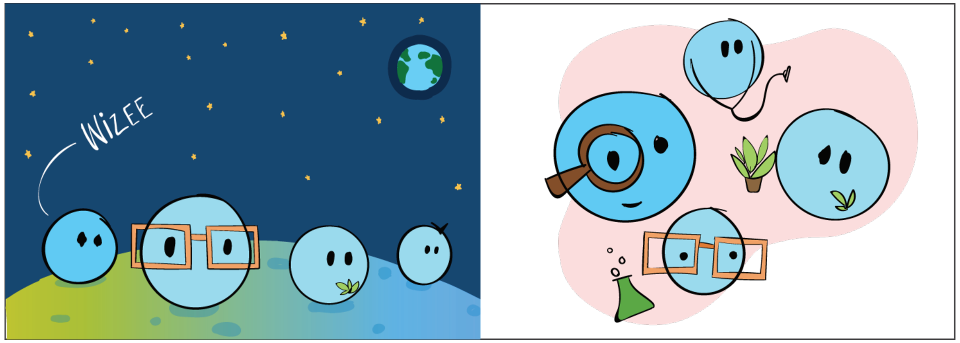
A storyboard was created for children to have a visual reference. This storyline became the foundation or starting point for the rest of the experience to follow.
For instance, upon creating this storyboard, the following questions immediately came to mind:
Experience Oriented :

- What kind of things can be taught to Wizee such that it is also educational to children?
- Does the storyline fit well with science lessons/activities,for example?

User Oriented :

- Do children like the story and is it a meaningful introduction to the lab?
- What would the children like to teach Wizee?

These questions were explored and the explorations are detailed out in the following chapters.

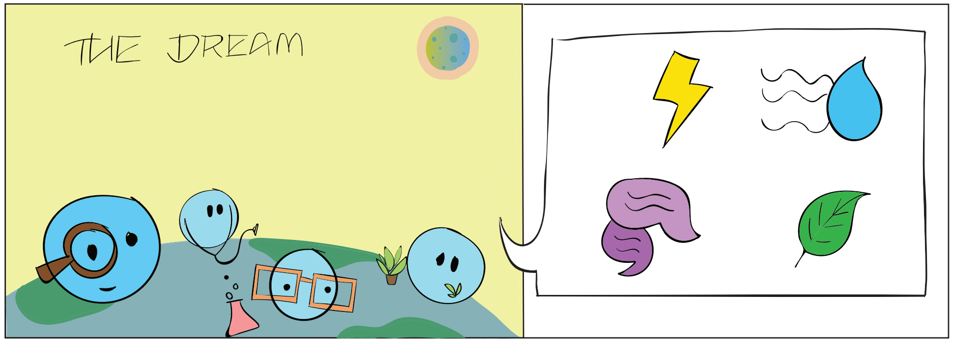


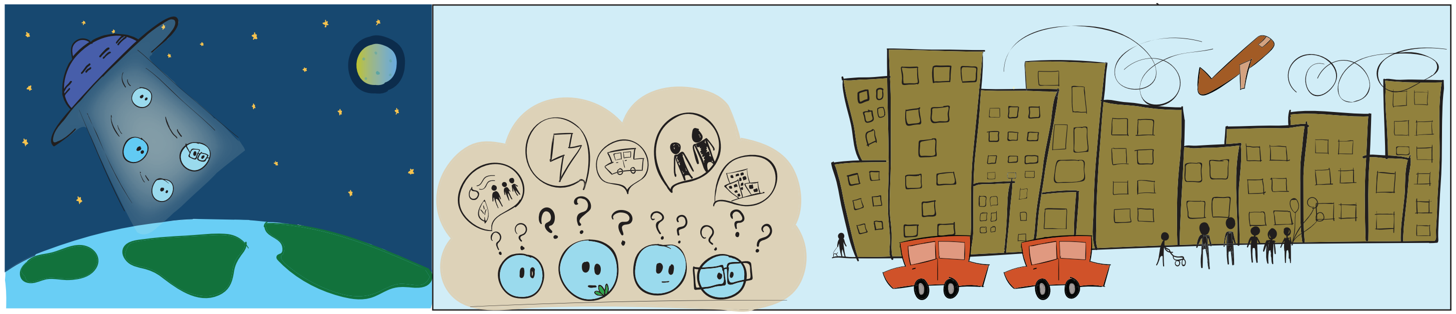
This is Wizee and his friends. They live on Titan.

They like to explore and learn everything about science.

Together they have one dream

To travel to Earth, learn all about it and become Earth Scientists!





So one day Wizee and his friends jump on their spaceship and head to Earth!

They land on Earth but they don't know anything about Earth, the people, the

Figure 23. A storyboard of Wizee's story that is told to children before they step into the robotic lab

4.3 Integration of story with the interaction

What kind of things can be taught to Wizee such that it is also educational to children?

The Sphero online repository contains a variety of suggestions for math, science and coding lessons with the sprk+ robot. An activity was selected out of this repository, one about Ocean food chain - a subject that is relevant to Museon's theme and also a subject that children might know about (assumption). Two 'protagonists' were introduced -Max and Anne and the story was detailed and mapped out from their perspective - what they do and learn at Museon. The main aim of the storyboard is:

- To assess how the story of Wizee integrates with the experience.
- To evaluate (with museum educators) the nature of the activities, children will learn through Wizee.

The story starts at school (pre-museum visit) and ends at the museum. Throughout this journey, the interaction touch points are highlighted.

The storyboard was presented and evaluated with educators at the museum to gain preliminary insight into what fits and what doesn't, Due to the circumstances of the project (working in isolation and the absence of context), the evaluation options was narrowed to museum educators and peers. Because of their experience with teaching and their long association with the museum, the museum educators are a reliable source for evaluating the experience of the lab.

Feedback : + The concept of self- discovery is relevant and very much in sync with the current lessons at Museon.

+ The story of Spark is captivating and immediately connects with children
- Ocean food chain is a complicated topic for children to relate to, in addition to programing for it, this could lead to cognitive overload.
- The interaction within the museum with this set up is not dynamic enough. It need to be made more rich in its approach.

Second iteration and evaluation

Taking into account the feedback, a second interaction was created, this time focused on the

Figure 25 Interaction storyboard - first iteration to highlight the touch points and map out how the experience could look

interaction, touch points and the activities the user will do.

The storyboard maps out a single user experience and the interaction included the following :

- A combination of physical and digital interactions : This was done in two ways - One by introducing 'a takeaway', children get a coded a message that they can decode and take home with them. Two by including activities that require 'assembly' before instructions are given to Wizee.

- The instruction/steps for Wizee to move appear on the interaction panel scrambled and the children choose the right order of instructions depending on what they want Wizee to do.

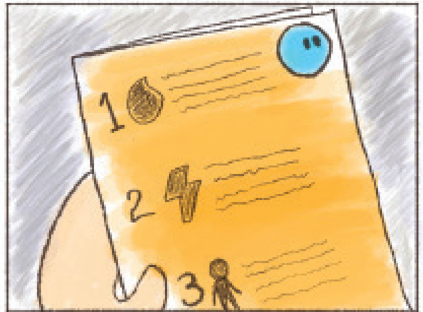
Feedback : + The takeaway is a nice to have.

+ The theme (urban city) fits well into Spark's story

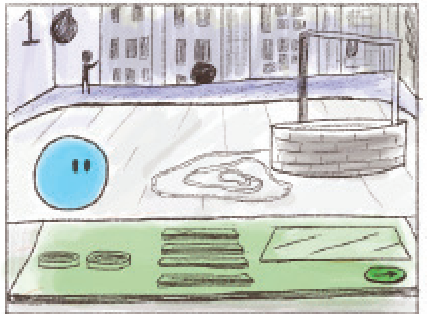
- While the interaction is dynamic, the activity itself is still complex for children.

It became apparent that there is a need to go an extra mile to understand what activities would be simple, relevant yet interesting to children. To achieve this, an ideation session was conducted with peers and a worksheet was designed for children. This is detailed in the next chapter.

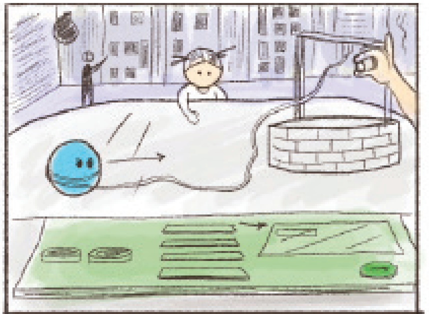
Max receives a map on entering the lab



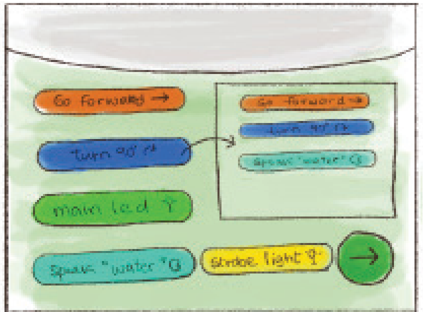
The map has description of activites and suggested activities to do



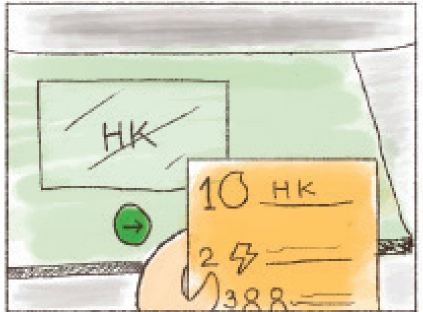
First activity is to teach Wizee to draw water from a well



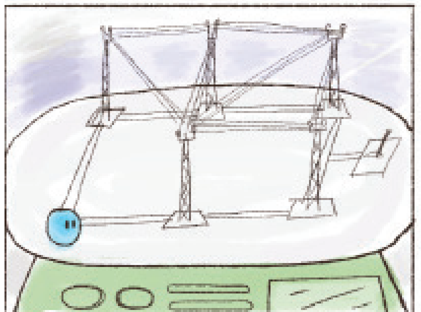
Max first assembles the pulley and ties it to Wizee.



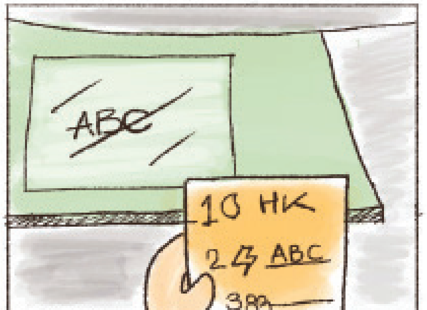
Next, Max inputs the right sequence of steps so Wizee can move



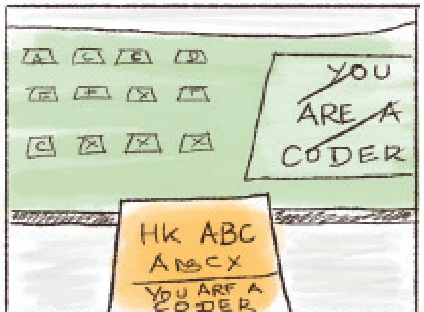
Upon completion Max receives a code to decode at the end of the experience



Next activity is to supply electricity to all houses. Max has to input instructions to Wizee, from a set of jumbled steps.



Max enters the code that he got at the end of each activity.



He enter the code and follows instructions to decode the message. It reads, "you are a coder"

4.4 Ideation : What would you teach Wizee?

What would children teach Wizee?

What do children relate to and what would they teach wizee about Earth?

To get inspiration for the ideas and in a quest to make the activities simpler, a short worksheet was designed and shared with children. The story of Wizee was presented and the question "What would you teach Wizee?" was posed to the children. The detailed worksheet and the answers can be viewed in the appendix E.

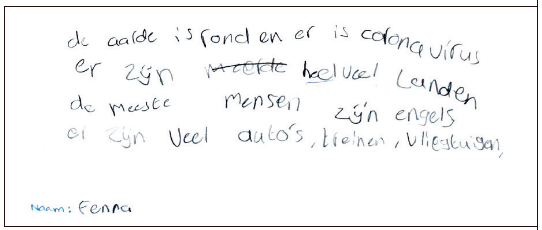
The answers were as follows:

- *"The moon comes out when it dark, we have houses where we live, when it gets dark, we see stars. We go to school to learn , there we learn writing, math, English."*
- *"The Earth is round and has Corona virus. There is a lot of land, most men are English. There are many cars,train and planes."*
- *"The Earth has plants and there is also lot of sand and stone, there are also people and animals"*

From the answers it is evident that children share with Wizee how they perceive Earth. Almost all mention nature such as the plants, animals, stars,etc. But also mention school, transportation and also concept of learning ("we go to school").

Takeaway

For the activities, it would be nice to stick to the simple concepts such that the programming part of the activity is more focused on.The assumption so far has always been that the activities should be related to science (ex: water, or the foodchain). But from the answer it became evident simple topics of nature, math or transportation are also engaging to children.In addition, it can also be noted that topics are only a means to an end, in essence the subject of the activities should be easy to digest and even obvious in a way.



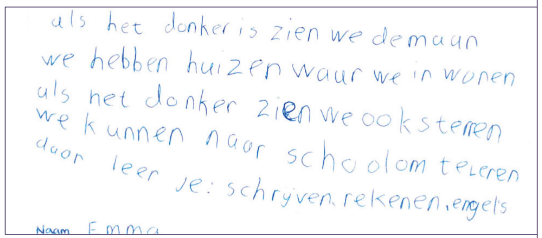


Figure 26 An example of children's answers. the detailed sheets can be viewed in Appendix E

What would other designers teach Wizee?

At this stage in the project, a new perception was needed, from someone who would view it with a fresh perspective. Who better people than other enthusiastic designers to tap into that creative reserve and get some ideas for the robotic lab!

A virtual ideation session was conducted, to gather ideas. This session was a brain storm over a zoom call lasting for an hour with four participants. Two such session were conducted - one with peers and one with fellow museum interns (non-designers). To maximise the output of the session and to trigger ideas, the story of Wizee was introduced and three questions were asked to my audience.

- Why do you think Wizee came to Earth?
- What would you teach Wizee about Earth?
- What would you teach Wizee if you found him at a science museum?

Sorting and Analysis

The session paved way for new ideas and new perceptions. The designers got into the 'creation' mode with ease and the group threw in ideas beyond the questions asked. This proved to be useful in seeing patterns in the ideas. Some of the ideas for the robotic lab included, "making it a treasure hunt", or "a game and introduce the concept in levels, increasing in difficulty or an experimentation lab with test tubes".

Upon looking closely at these ideas, patterns started emerging. The ideas could be categorised into three different groups - themes, activities and topic.

Themes and topics are not to be confused with each other, a theme refers to the setting of the lab, while topic refers to the subject. For instance, the theme is treasure hunt, the topic is about food chain and the activity is drawing a food chain.

It became clear that these three elements are co-related to each other , for example, a theme would determine the topic which in turn would determine the activity that a child would do.

This is the skeleton on which the experience of the lab will be built on. This is further explored in detail in the next chapter.

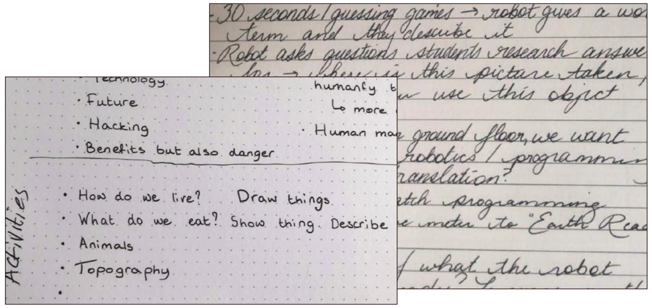


Figure 28 Some notes of the participants.

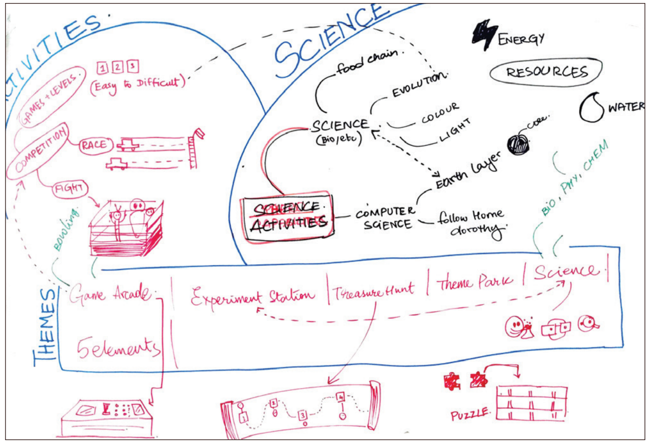


Figure 27 Summarising the discussion from the two brain storm sessions.

4.5 Analysis: Outlining a framework for the experience

Revisiting the research learning and bringing together elements that make up the experience.

The ideation session brought about a new insight and a new perception to the experience. As seen the previous chapter ended on this insight that an experience at the robotic programming lab is driven by the story, theme and the activities of the space. What does this mean for the robotic lab and is this still in sync with the original intent of the lab.

Touching on some theory and strengthening the framework for the lab.

The aim of the lab is to introduce children to programing and engage them in activities related to programming. This is to be done in a way that the user sees relevance of programming in real life as well. However, it is also known that a user experiences relevance over time and it is a process by itself. (Vemeeren,Calvi,2019).

So to say, the children might not see the relevance immediately however if the experience triggers and engages the user (ignite a spark), it could become more meaningful at a later time (recall value). (Vemeeren,Calvi,2019)

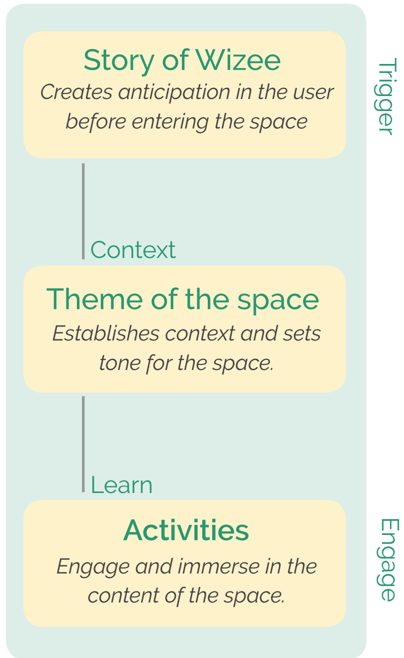
How does this theory translate to the experience of the robotic lab? As illustrated in , the story of Wizee and the theme of the space act as triggers for the activity and finally the activities themselves engages the user, also learning occurs at this point.

Alternatively, the experience of this space can be seen has a nested circle, where the core of this experience is the activities that children would do. But the theme and the story of Wizee surround the activities, allowing the user to gradually immerse in the activities.

These three elements are interdependent on each other and form the basic framework for the robotic lab.

Usefulness of this framework

The framework is adaptable to any kind of education tools, themes and activities. It is not dependent on a specific kind of tools, themes or activities. This is especially advantageous considering the rapidly changing technology.



Elements of the Experience

Figure 29 Framework of the experience at the robotic programming lab.

What themes and activities should the lab have?

As seen in the previous chapter, the ideation with children also threw new light on the nature of the activities to consider for the lab. Topics such as plants, animals, transportation ,etc.

Looking closely at the themes and the activities, in spite of it being closely related to science , the very nature of these still seemed random.

What is the driving force behind the themes and the activities. What are they going to be based on?

It was a crucial aspect to consider, especially because basing activities off a pedagogy, for example ensures its quality, relevance and sustainability on the long run.

This realisation made me step back and re-look at my learnings so far.

Re-look at Computational thinking and using it to develop a pedagogy in the lab.

As discussed in chapter 2, Computational Thinking (CT)" is a way of solving problems, designing systems and understanding human behaviour"(Sheldon, 2017) and is very much in sync with STEM education system and can also be integrated with components of the regular education system.

The aspects of CT are Decomposition, Pattern Recognition, Abstraction and Algorithm. In essence, these aspects are built into us and we perform everyday tasks such as tying shoe laces(deciding on what to wear (pattern recognition) or finding the best route to a cafe (decomposition) without realising it falls in the parameters of CT.

Thus, I deemed it to be very valuable that these aspects of CT be inter-lapped with the topics/ theme of the space. The following topics and themes were chosen as examples for the space - Theme - Urban City and the topics that can included in this, for instance is nature, energy, water, transportation and people.

Figure 30 Illustrates the topic under the theme Urban city (above). (below) Outline of the CT and ways that they can be explored - physical and digital interactions.

4.6 Framework and design decisions

The framework of the experience

As seen in the previous chapter, the framework for the lab constitutes of the story of Wizee, the theme and the activities.

Detailing out each of these aspects makes up for the flesh and skin of the lab, thus becoming the experience of the robotic programming lab. Firstly, the theme was decided to be “Urban City”, as it is in sync with Museon’s theme of sustainability and global awareness. The theme is also relevant to the location of the museum, The Hague, an urban city.

The second step was to choose topics relevant to the urban city theme. The findings from the ideation session helped to take a decision on this and the final topics selected are - water, energy, transportation.

It should be noted that these topics and themes are used as an example to illustrate the process of conceptualising the space. This framework can easily be adapted to be used for another theme and topics as per the need and demand of the schools.

The framework beings with story of Wizee, Choosing a theme.
Once the Theme is chosen, the Level two process begins, of selecting topics and outlining the nature of the activities (what pedagogy will it follow?).

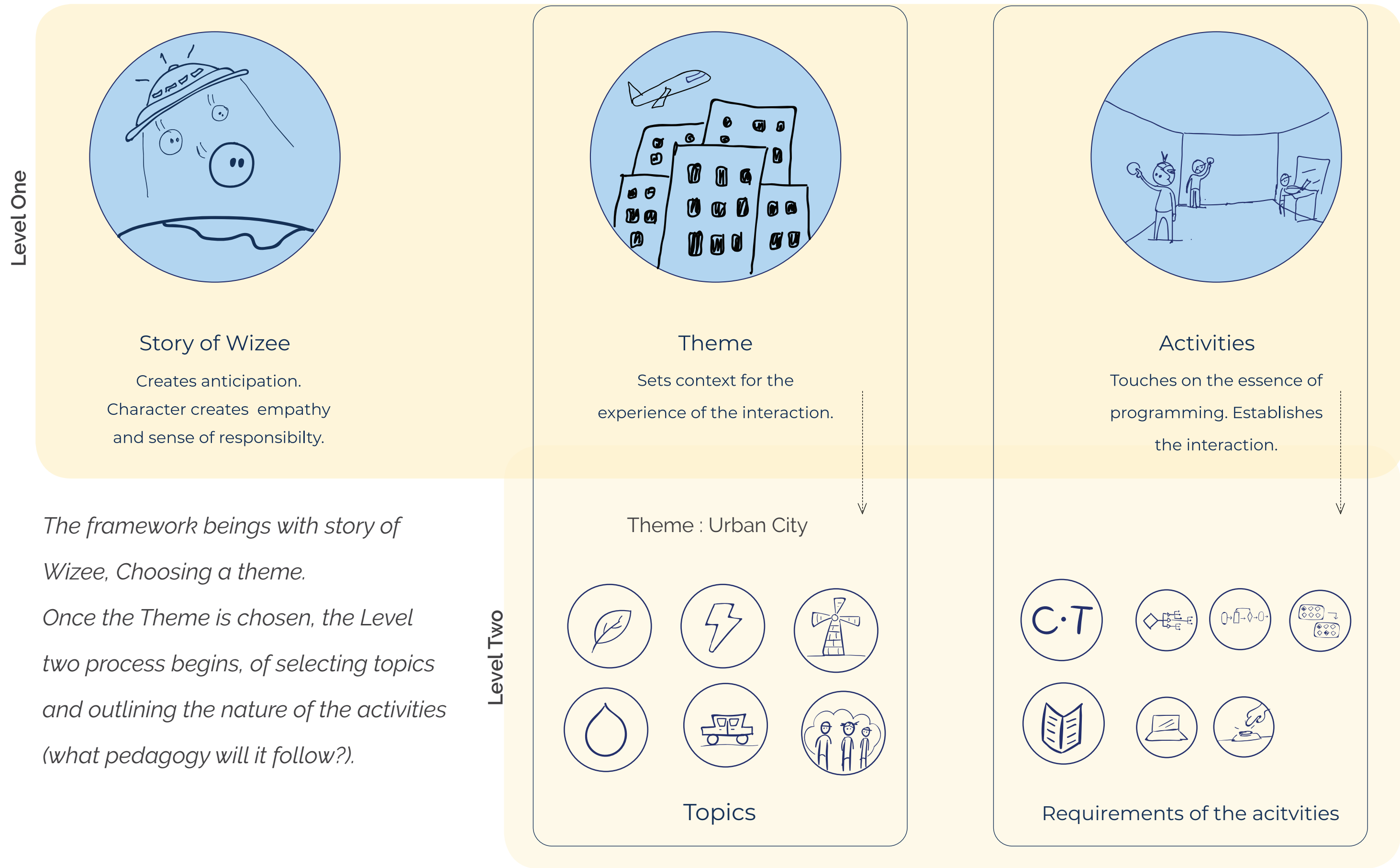


Figure 31 Framework for the experience broken down to explain how topics and activities for the lab are derived.

05 Final Design

The framework of the experience and the decision to include the Computational Thinking elements became the skeleton of the robotic lab. With this strong framework , the next step is to dive into detailing out the activities of the space. What would children really do in this space, what will they interact with?

This chapter titled 'final design' dives deep into these aspects to finally establish a concept of the robotic lab. It includes the thought process behind the activities of the lab and a story board of the visualised interaction in the museum.

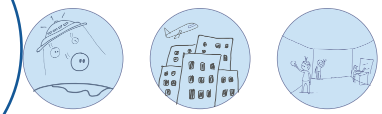
5.0 Overview

This phase converges and dives into creating activities based on computational thinking. These activities are adapted from sources specifically designed for school children. These were sorted based on the type (pattern recognition or decomposition, etc).

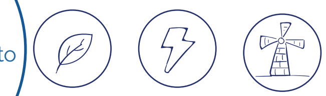
Further each activity was adapted to fit the topics of the space. For instance, the activity of getting through a maze is adapted to the topic of energy simply by adding that "help Wizee get throght the maze is less than ten steps, to save fuel".

These activities are designed only as a reference point, to give an idea of the nature of activities the robotic lab could have.
The chapter ends with visualisation of these activities.

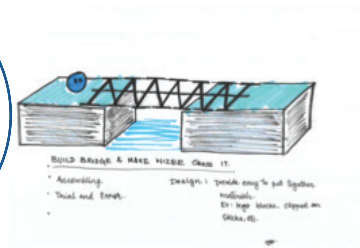
Framework
Choosing the tool, the theme and the pedagogy for the activities



Detailing
Borrowing activities from CT and adapting to theme and robot



Visualising
Creating interaction stations and defining interaction touch points



5.1 Adapting activities to the space

Activities for the lab

The process of creating activities for the lab was intensive and it needed to dive into pedagogies and teaching methods. This process helped to understand the crucial role teachers have in designing lessons for children.

CT and STEM education have a large source online where lessons for children of all ages are posted by teachers implementing this in their classrooms. Using these lessons as reference, a list of activities (view appendix J) were created and categorised in the three elements of computational thinking (pattern recognition, decomposition and algorithm). These activities were then used as a reference point, to adapt to activities relevant to the theme of the lab.

The table on the right details out some of these activities. The activities were also segregated on if they need to be done with Sphero or not.

It is to be noted that these activities are borrowed from worksheets and workshops designed for primary school kids between 1st to 3rd grade (6 to 8 years). This is considering the fact that not all Dutch school expose their student to technology or science. So the starting lesson in the lab wouldn't

Not in the scope of this project

Topics	With Sphero	Without Sphero
Water	Use sphero to design a boat and clear the oil spill. 🟣 🟠	Learn Water cycle. Rearrange the tiles to match the process of water cycle 🔵 🟠
Energy	Show Sphero important buildings of a city but use the shortest way to see all buildings and save fuel. 🔵 🟠 🟢	List of living and non-living things. Question :Where does it get its energy? 🔵 🟢
Transportation	Create a vehicle for Sphero with minimum materials. It should also be able to work on water and cross the bridge. 🟣 🟠 🔵	Categorise modes of transportation depending on their fuel efficiency levels. If good for environment green,else red. 🔵 🟢
Miscellaneous	Teach sphero math (addition, subtraction, and complex math). 🟠 Help sphero find it's vehicle in the parking lot to get back home. 🟠 🔵	Make music. Choose certain patterns to emit a specific sound. 🟢 Decode what sphero is trying to say - decode an image, decode a messsage 🔵 🟢

🟣 Involves assembling of parts 🟠 Algorithm 🔵 Decomposition 🟢 Pattern recognition

Figure 32 . Table with the contents of the lab's activities.

5.2 Requirements of the space

With the outline of the activities, a host of other questions started emerging. For instance, what is the difficult level of these activities? Are they only designed for beginners, what about children who already know a little about programming?
How is the lesson going to be in Museon? What are the learning outcomes for children, what do they take away with them.
The answer to these questions came in the form of requirements made for the lab. The following are the requirements/decisions taken that enrich the experience for the lab.

Requirements

The following are the requirements/decisions taken that enrich the experience for the lab.

Activities

- The activities should be a mix of topics related to science but also topics from hobbies or activities children do on a daily basis.
  Ex: math or music.
- The activities should be able to adapt to levels of difficulty, depending on the users choice and ability.

Space

- As mentioned earlier, the space is envisioned as a tinkering lab and an interactive playground. Where children can do, learn and play around.

Lessons

- Most lessons at Museon are done in a typical school setting, with the teacher delivering and the student listening. This is followed by an activity. (as observed in chapter 2)
  For the robotic lab, it would be nice to change this format as a topic such as programming is better learnt through doing. The suggested format is to give an introduction or a brief to familiarise with the space, and then leave the children to tinker, play and discover in this space. The educator could step in to guide where required.

Outcomes of the lessons.

What would the children takeaway from this lesson. This question is two fold. From the user's perspective, the takeaway is teaching Wizee various things about Earth and helping it do certain activities. In general all activities incorporate elements of CT that teach creative thinking and problem solving. However, the activities are interlaced with more specific learning outcomes and touch upon aspects of programming through the activities. These outcomes include, binary codes, if/else, loops, debugging (trial and error), categorisation based on similarity, input/output, and assembly. These learning outcomes can be filtered to fit the purpose of the lessons. For instance, lessons for beginners wouldn't contain an 'if/else' activity. The following image illustrates this alongside activities.

Introduction

Binary Trial and Error Assembly Input/ Output Decoding	*- Decode what Wizee is saying. - Use least amount of fuel, visit all the landmarks - Teach Wizee about plan cycle. - Reach Destination.*

Pre- knowledge

Binary + complex instruction Trial and Error Assembly If / else Decoding	*- Decode what Wizee is saying and do the activity. - Teach Wizee about what energy to use depending on weather. - Build a bridge and take wizee to the other side safely.*

Figure 33 An example of how the outcomes of specific activities can determine the level of difficulty.

5.3 Visualisation of the activities

Detailing out the activities

With the requirements formulated and the activities detailed out. The next question that arises is how does this activity look and work? What are the interaction touch points and what would children actually do in the space.

With this mind, a library of activities were created. The reference for this was taken from various museum interactions gathered during the research phase about museum (chapter 2), and also borrowed from the type of interaction currently at Museon. The moodboard and the inspirations can be viewed in appendix I.

Some of the lessons and activities are also inspired from the Sphero Edu repository. However, these were adapted to fit the museum context.All sketches of the activities were designed keeping in mind the requirements. Another category that came up during this phase is “non-sphero activities”. These activties aredetailed out in the following page.

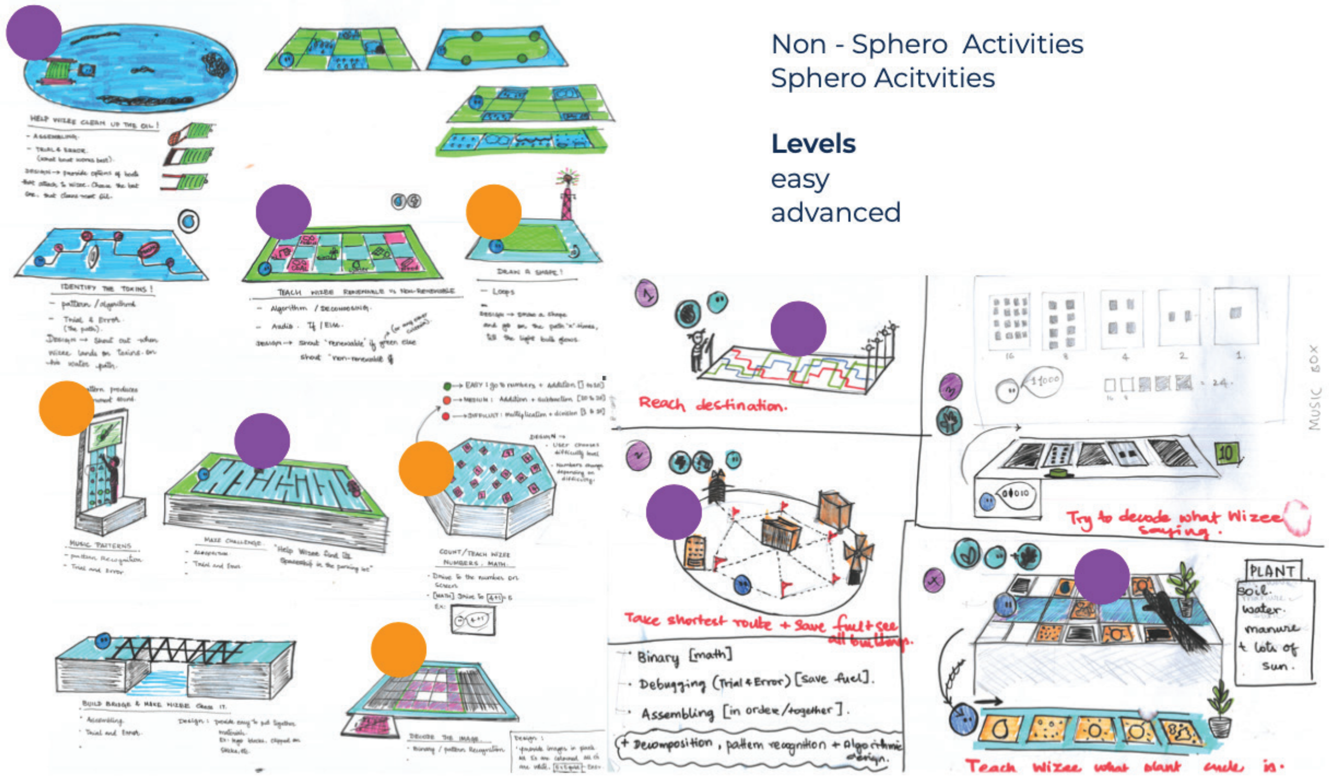


Figure 34 An example of how the outcomes of specific activities can determine the level of difficulty.

5.4 Visualisation of activities : An Example

Detailing out the activities

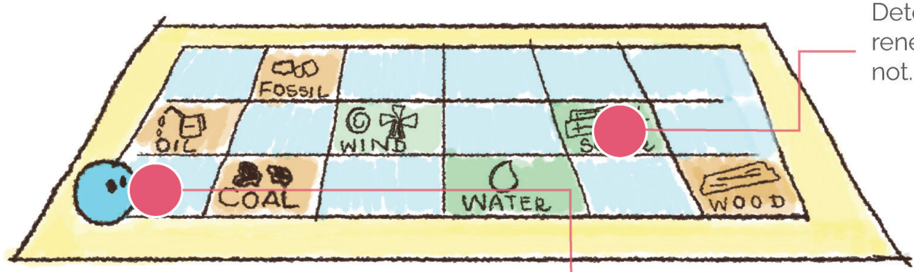
The detailing out of the activities consisted of bringing together various factors such as design, learning outcomes, the difficulty, the use of tools and the interaction touch points.

An infographic was created for each activity with detailed information of what the activity is, what the touchpoints are and the learning outcomes of the activity. This is mainly to done to illustrate what the activity entails, the goal and the outcomes, to help make sense of it at a glance.

In addition, an alternate idea, that is easy or more difficult is also suggested to emphasise how these activites can be adapted to the user or the lesson.

An example of such an activity is illustrated in figure 34 and in figure 35 in the following pages. Detailed infographic of all the activities can be viewed in the appendix I

Difficult : Beginner



Determine if renewable or not.

CT outcomes -
If Else
Algortihm
Decomposition

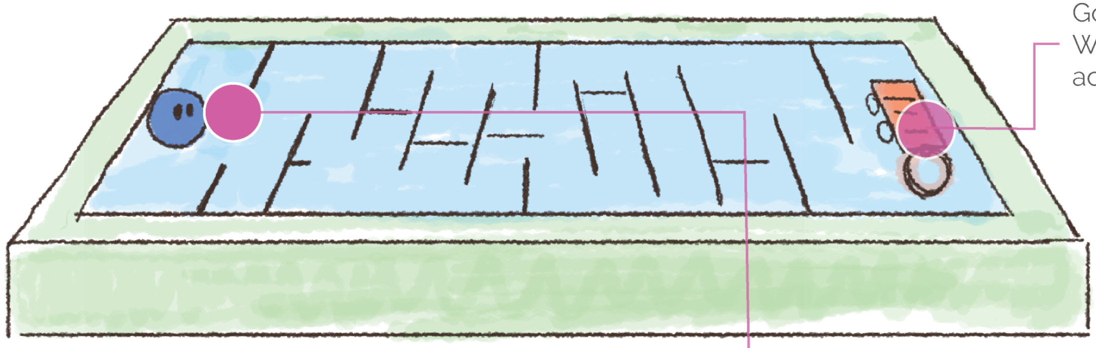
Move Wizee in the grid.

Renewable and Non-Renewable Resources
Goal : Program Wizee to across the grid and stop at energy sources. Make Wizee say 'renewable' or 'non-renewable' depending on the source.

Alternate ideas
The pattern for the resources can change depending on the difficulty level. The learning will then be two fold - movement of Wizee and the assessing what is renewable and non-renewable.

Figure 35 Detailed info-graphic of an activity.

Difficult : Beginner to Advanced



CT outcomes -
Algorithm,
Decomposition.
Trial and Error.

Steps for the user to perform this activity :

1. User selects level of the maze (if applicable). This determines if the maze challenge is going to be easy or difficult.
2. User must now program Wizee to ger through the maze and to the watermobile.
3. The program uses loops, and direction, delays and precision of turns.

Help Wizee find its lost vehicle
Goal : To help Wizee go through a parking lot maze to reach its watermobile.

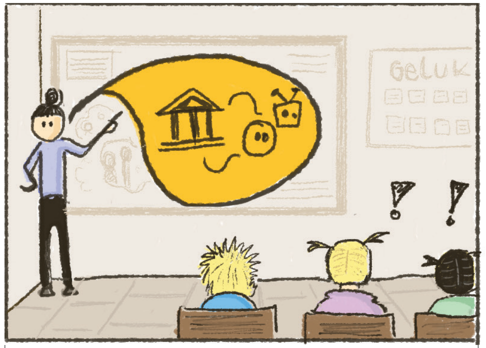
Alternate ideas
The maze can be projected on a surface, the structure of the maze depends on the level selected. This helps to keep the activity constantly challenging.

Figure 36 Detailed infographic of an activity with description of steps for the user to perform this activity, an example

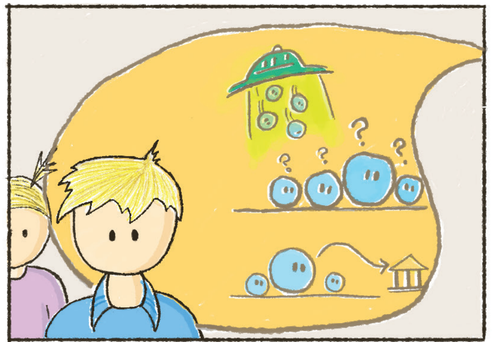
5.5 Visualisation of the interaction in context

Once the activities were detailed, the next question is “how do the users interact in the space?”. To illustrate the interaction, a detailed storyboard was created. It shows the story of Max and Anne, or protagonists who visit Museon’s robotic lab.

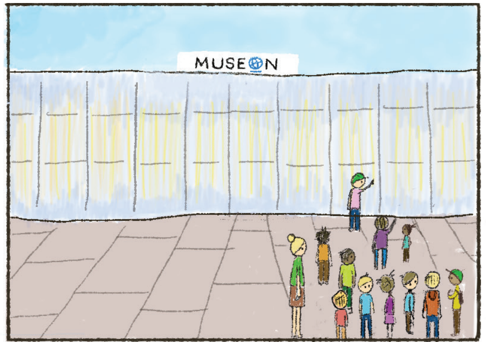
The storyboard begins with Max and Anne at school and their teacher announces the school’s visit to Museon and shares Wizee’s story before their visit. The rest of the storyboard outlines the interaction at Museon in detail.



Max and Anne find out they are going to Museon’s robotic and programmin lab soon!

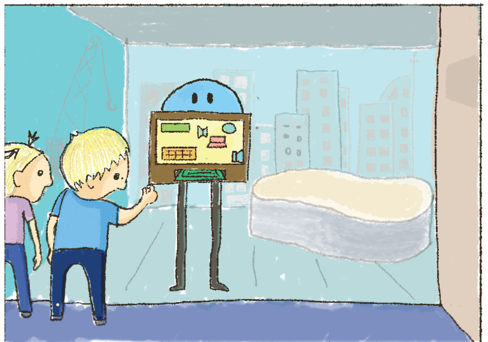


They hear about Wizee, who wants to know more about Earth. They are excited to meet it.

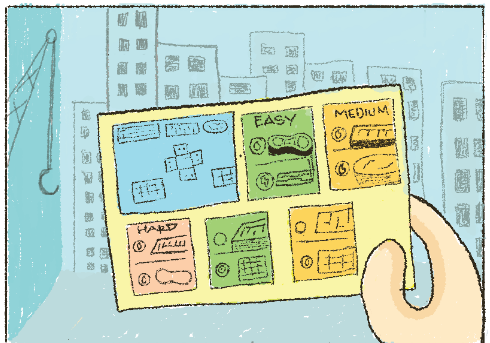


They arrive at Museon and are received by a Museum Educator

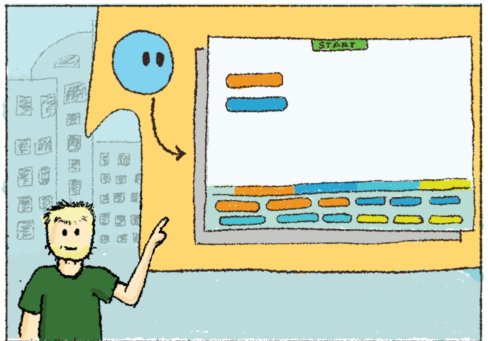
Educator introduces children to the lab and explains what the lab contains.



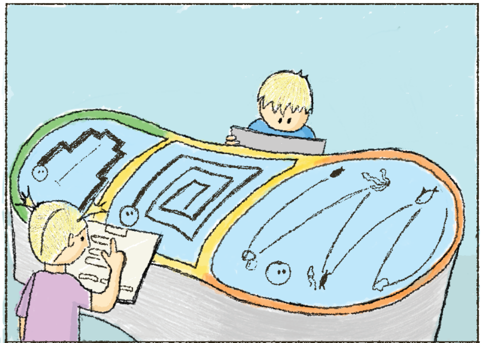
The children pick a map at the entrance of the lab to help them orient to the lab.



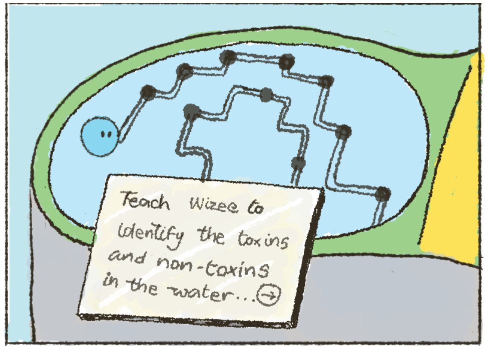
The map is a reference to the lab. It indicates what activities can be done depending on interest or diffficult



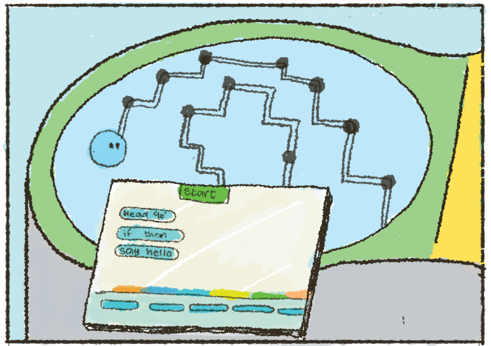
Educator explains how to communicate with Wizee (program) and introduces to basic block coding,



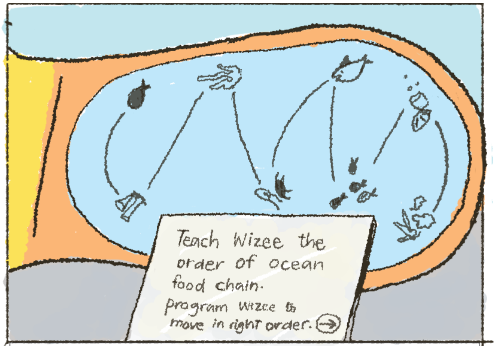
Max and Anne start off at the water island. Each choosing their own difficulty



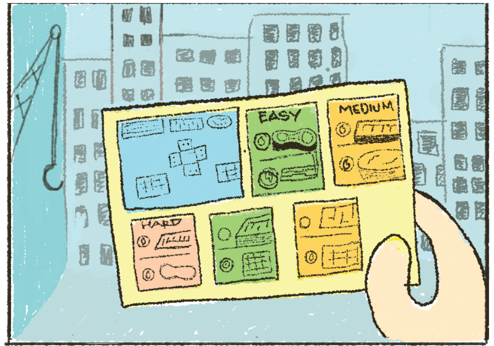
The activity is about water, and prompts are given on the interface. The activity is to teach Wizee to identify toxins and non-toxins.



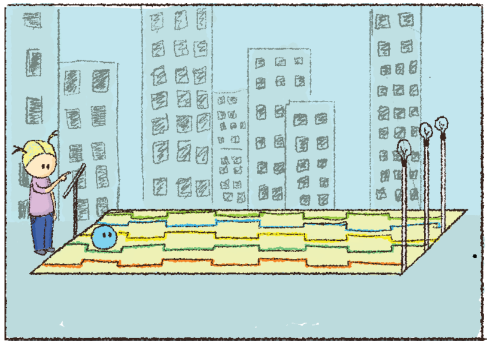
Anne programs Wizee using the blocks. This helps Wizee know how to move.



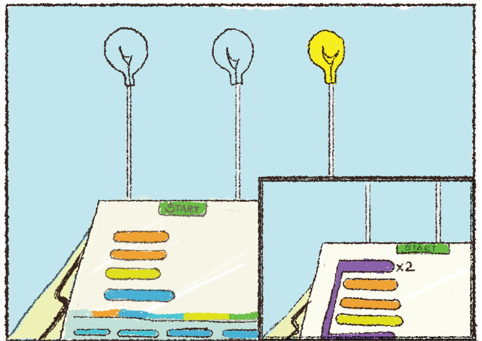
The next activity is to learn food chain. This one is more challenging than the previous



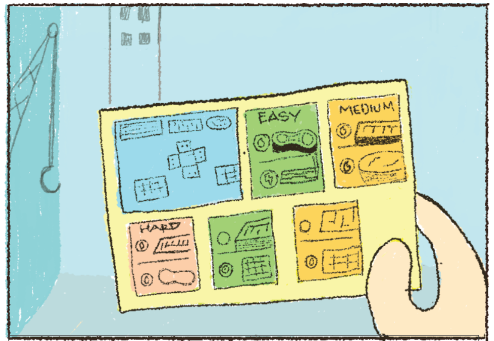
On completing Max looks at his map to determine where to go next.



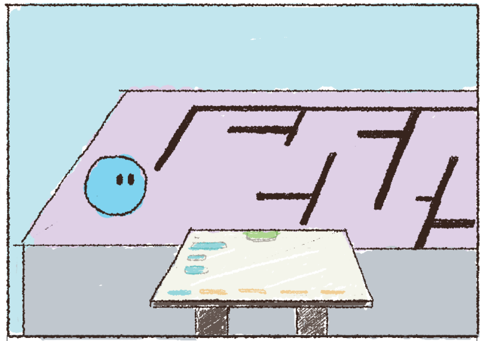
Anne at the energy activity programming Wizee to follow a certain parth to generate energy to light a bulb.



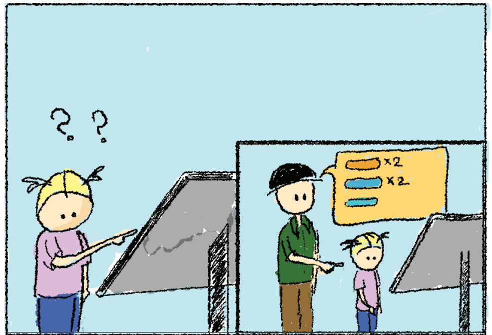
The close up of the interface that is used to commmunicate with Wizee.Anne learns loops, repeating information.



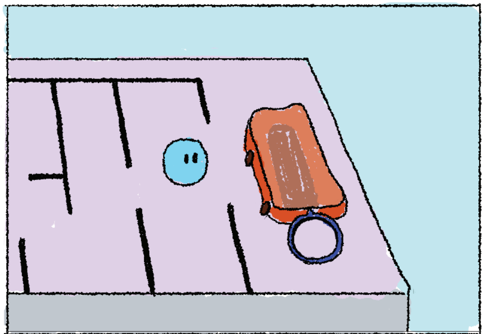
Again user chooses their choice of next activity.



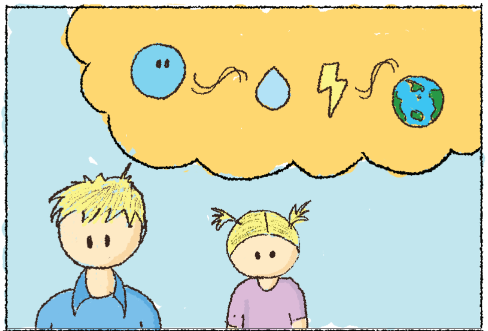
The next activity is to help Wizee find his watermobile in a confusing parking lot.



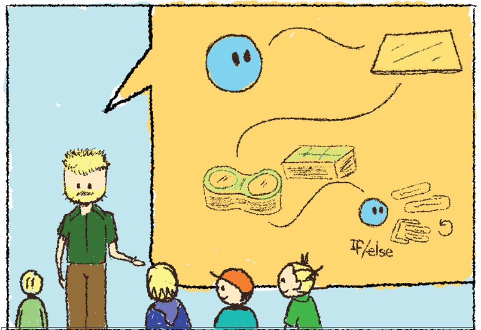
This is challenging and Anne requests the educator for help. Educator facilitatos the program for Wizee



Wizee get acorss the maze and find his watermobile.



The children have taught Wizee about water and energy. And learnt more about programming.



The educator recaps the learnings and also gives idea for programming if they want to try at home

Figure 37 An sketched out concept of the robotic lab, in a 100sqm room.

5.6 How can Museon use this design and next steps?

How can Museon use this design?

The final design illustrated in this report is the very first detailed idea of what the robotic lab could entail. The decisions taken in this project were independent of a budget or a sponsoring client. There is a possibility that these factors, once they become more apparent ,could affect the design decisions and the outcomes of the project. Museon can either use the design of the activities as is and develop it or it can use the framework of experience to develop activities more suited to the need or demand. To expand on this, here is a detailed explanation of how Museon can make use of the process in such a situation.

Situation: Museon considers to use a different tool such as Lego Mindstorm and not Sphero.
Solution : This decision takes the process back to the frame work of the experience (chapter 5.2). It is also important to identify and outline these three elements and that determines the activities for the user. In addition, it would be important to consider the capabilities of Lego Mindstorm to make the experience more relevant. Once these factors are identified, the activities can be adapted to the new tool. For instance, the main feature of the Lego Mindstorms is that it can be assembled and anything can be created. This can be adapted to the activity "Take a tour of the city using minimum fuel and assemble a robot to do this'. The physical aspect (interaction station) of how this activity is visualised essentially (Appendix I) remains the same.

Different parts of the framework and the current design can be adapted for the need. This makes the framework a very fluid and flexible one. Thus, fulfilling the initial challenge of creating an "adaptable design".

Next Steps

With the content of the lab in place, the next step is to evaluate the nature of these activities. How do children interact in this space, are the activities challenging enough? Do children enjoy the activities with Sphero and understand it easily? Is the story of Wizee still relevant at the end of the experience as well?

The ideal way to test this concept would be in the form of a pilot test with schools visiting Museon. This would be at the museum using Sphero with a controlled group of users in the setting of a museum lesson. This specific setting aligns with the intentioned aim of the final design and would help gain insights into the interaction of the activities in groups and in the context of a lesson.

However, the number of constraints to do such a test is currently very high. This includes the constraints of time and context (schools no longer visit Museon), imposed because of the COVID - 19 measures.

Framework
Choosing the tool, the theme and the pedagogy for the activities

Detailing
Borrowing activities from CT and adapting to theme and robot

Visualising
Creating interaction stations and defining interaction touch points

06 Conclusion

The last phase of this project is to conlcude, evaluate and reflect on the design process pursued. This final chapter is a reflection of what the Robotic lab now means and to what exten the initial goal was achieved.

In addition, I also reflect on my personal goals and the things I learnt in the course of this project.

6.1 Conclusion

Conclusion

The initial objective of this graduation project was to design and conceptualise the robotic and programming lab at Museon. This lab only existed as an idea before the start of this project and designing the content and the interaction of the lab made this idea more concrete. The end of this project gives a concrete conceptualised design of what the robotic lab entails. The use of a framework to create the experience ensures that the content is relevant, rich in its interaction and is holistic (not only about programming but also about science) in its core.

The strength of the design lies on the fact that it borrows from various tried and tested pedagogies. These aspects ensures that the learning of the lab are relevant irrespective of changing technologies.

This is a crucial aspect of the design and for this reason, I recommend the museum to stick to the framework. In addition, I also suggest that the lessons for the programming lab be designed such that it affords for self discovery. The ideal way to achieve this is to break away from delivering lessons in the traditional set up of the classroom,where the teacher is the center for knowledge transmission and instead change the focus to the space and Wizee as the source of learning.

The initial research phase brought to light a main systemic problem - the lack of skilled teachers to be at the forefront of such a big change. While directly addressing this is outside the scope of this project, it should be noted that the robotic lab could be the bridge that is pivotal to this change.

The lab can grow to be much more of a 'centre for programming' and that has the potential for revolutionising STEM education in the Netherlands.

With this in mind, the initial brief has been met, the design and this project does bring to light a much needed way of teaching and including STEM concepts in a child's learning.

The question "What constitutes the robotic and programming lab?" is answered and the conceptualised design exemplifies this.

6.2 Reflection

Reflection

When I started this project, I had little clue what I was taking on and what it entailed but somewhere half through this project, I had a moment of serendipity. It dawned on me that this project touched upon various subjects that have always interested me and that I personally felt strongly about - education, museums, learning and pedagogies (in a way).

The moment that I had this realisation, the meaning of this project increased two fold - not only was I working on this to get my thesis but could it possibly be the start of pursuing a new career path? (I don't know, time will tell).

Did I achieve my goals?

In short, this project, like any thesis project has been pivotal to my life as a student designer. The initial reason for choosing this project was to explore the domain of technology alongside museum experience design. The goal was to push myself to explore experience design in depth, ideally in connection to learning as a key element in it and this project was exactly that.

A crucial learning for my master's courses was that adopting new skills in technology - such as programming the arduino, is beneficial in the sense that it empowers an otherwise "dependent" designers to be "independent" and actually gives wings to their designs. This project not only helped me see technology and programming in new light, I am definitely more comfortable and open to the prospect of learning to code.

I started with an open mind and followed my instincts and inclination in this project. While the lock down situation threw me out of my initial momentum of working on the project. I can conclude that this is more or less how the project would have shaped despite the unforseen circumstances. Of course, it is safe to say that certain aspects such as user research and interaction would have been very different.

Some learnings

Always follow your gut -

In the chaos of working from home and trying to make sense of what the thesis should entail, I have from time and again got carried away in my process based on the standards of other people. This created a conflict between what was right for my project and my pre-conceived notion of what is right. It was not until the greenlight that I took a step back and took decisions based on my instinct. This immediately felt liberating and right, and much more close to heart.

It is okay if things do not go as planned -

The pandemic is the best/worst experience to teach one to adapt and be okay when things don't work out as planned. For so many reasons, the initial planning made for this project came crashing down hard. In these new circumstances, my new motto became "one day at a time". The motto pacified me and motivated me especially when the lockdown started and I had no clue what to expect of this project anymore. This project was not well planned to completion, but well adapted to completion, a crucial lesson that will echo throughout my life as a designer.

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07 Appendices

The inital design brief

A. Observing children at the museum

B. Science museums globally - inspiration board

C. Questionnaire (Parents and Teachers)

D. Worksheet to children

E. What would you teach Wizee?

F. Storyboard - Interaction Development

G. The website prototype

H. Experiments with Sphero SPRK+

I. Detailed sketches of the visualisations

J. Computational Thinking Table (basis for the final activities)

Initial Design Brief

DESIGN FOR our future

TU Delft

3998

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Padmasola

initials: S   given name: Shreya

student number:

street & no.:

zipcode & city:

country: Netherlands

phone:

email:

Your master programme (only select the options that apply to you):

IDE master(s): ( ) IPD   (★) Dfl   ( ) SPD

2nd non-IDE master:

individual programme: - - (give date of approval)

honours programme: ( ) Honours Programme Master

specialisation / annotation: ( ) Medisign

( ) Tech. in Sustainable Design

( ) Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: A.J.C Van Der Helm   dept. / section: HCD/DCC

** mentor: A.P.O.S Vermeeren   dept. / section: HCD/HICD

2nd mentor: Friso Visser

organisation: Museon

city: Den Haag   country: Netherlands

comments (optional): Judith Aartsen, educator from Museon is also part of the team and she has been a part of all the meetings and discussions so far.

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

Procedural Checks - IDE Master Graduation

TUDelft

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair A.J.C Van Der Helm date 18.03.2020 signature Aadjan v.d. Helm

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 29 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 29 EC

List of electives obtained before the third semester without approval of the BoE

☒ YES all 1st year master courses passed

☐ NO missing 1st year master courses are:

name ______ date 23-3-2020 signature CB

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ☑ APPROVED ☐ NOT APPROVED

Procedure: ☑ APPROVED ☐ NOT APPROVED

comments

name Monique von Morgen date 30-3-2020 signature MvM

IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30 Page 2 of 7

Initials & Name S Padmasola Student number 4816579

Title of Project Robotic Lab -An immersive and interactive experience design for children

Initial Design Brief

Personal Project Brief - IDE Master Graduation

TU Delft

Robotic Lab -An immersive and interactive experience design for children — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 24 - 02 - 2020 — 04 - 08 - 2020 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money, ...), technology, ...).

Technology is everywhere, it has become an integral part of societies and economies we live in and will continue to play a large role in the future as well . Sectors including healthcare , food, energy, sport are becoming increasingly depend on the technology. This means there will be an increase in the demands for technologically inclined skills and knowledge in various sectors. However, there is a dearth of people to take up the large number of available technical jobs in the market. The Netherlands government saw this as a crucial aspect to consider, as a boost in technology means a direct boost in economic prosperity, resulting in the Technology Pact in 2013. By 2016, the pact was revisited and 12 concrete goals were formed that shaped the coming future of technology . The goals aim to make technology an integral aspect of businesses and the economy by promoting lifelong development in technology. The first goal is thus "choosing technology", focusing on science and technology in the classroom. One of the concrete solutions in doing this is to form a learning program with the network of science museum and science partners (VSC) in the Netherlands. Science Museums have long been the forefront of 'learning outside of classroom', many museums tailor their exhibitions and their guides to fit the curriculum and the lessons taught in schools.

One such popular museum is the Museon, an interactive museum for culture and science with an educational mission and an interdisciplinary approach. Located in The Hague, it becomes an important hub bringing together aspects of internationalism and global themes. Museon's primary audience is schools and families with children. It is quite active in both primary and secondary fields of education and schools often visit Museon as some topics at the museum space are closely related to the educational lessons at school. The staff at the museum actively guide the schools through these exhibition spaces making it a holistic learning and interactive environment. Museon thus becomes a bridge between the purpose of the pact and reaching its goal in the long run. The museum aims to be in sync with the current education model, but at the same time strives to set a benchmark in encouraging an interest for technology amongst children. It would like to achieve this by starting a new lab called the robotica programming lab which would be realised in a 100 square feet room on the first floor of the museum building.

The context of this project is thus systemic, involving the government of Netherlands, the museum, the schools, the children and their families. While the vision is long term and for the future, the lab acts as a source to plant a seed of interest in young mind, that could affect the percentage of youth in technical studies and eventually those who would take up technologically skilled jobs leading to a more rounded and balanced economy. In this system, the main focus for this project would be on the lab, where the experience is conceptualized and designed with an intention to sustain this long term goal. The realisation of this lab would be in the form of an immersive experience. It is crucial to have an experience that is relatable and relevant, captivates and piques the interest of children. This can be achieved through holistic design supported by interactive design elements as opposed to standalone installations.
This holistic immersive experience could be termed "interactive playground" which brings together sensory elements such as visual,audio in addition to the tactile interactive elements.

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Initials & Name S Padmasola — Student number 4816579

Title of Project Robotic Lab -An immersive and interactive experience design for children

Initial Design Brief

Personal Project Brief - IDE Master Graduation

introduction (continued): space for images

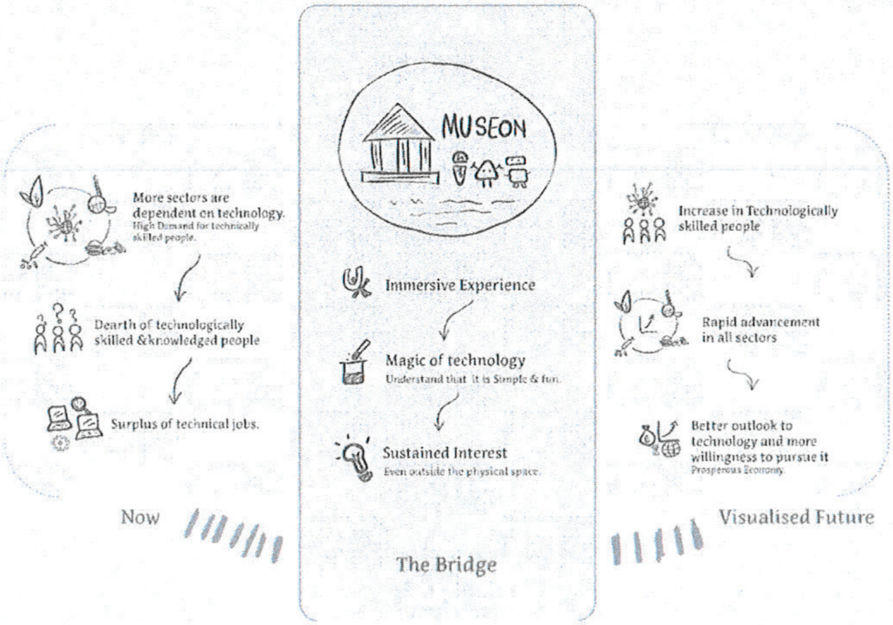

image / figure 1: Detailing the context and ecosystem of the project.

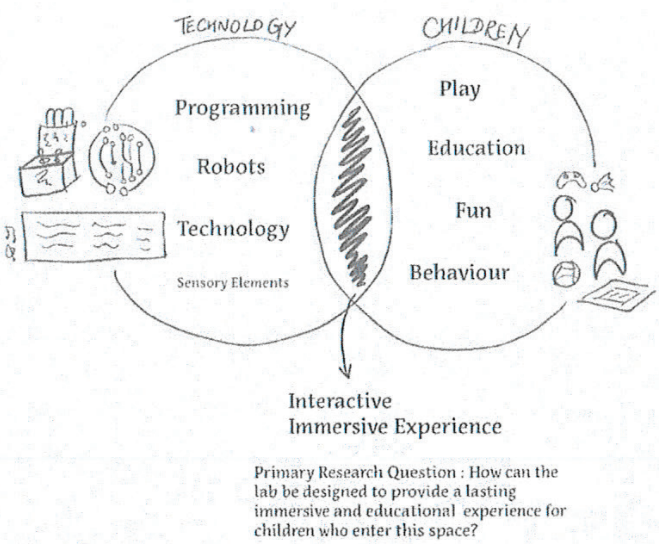

image / figure 2: Focus of the project and elements that lead to the experiential design

IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30

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Initials & Name S Padmasola

Student number 4816579

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PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

Topics such as robots and programming seem complex but also enthrall children equally. While science museums are interesting to children and hold their curiosity, the question is, does the interest sustain over time? If not, how do you design in a way that it sustains over time. The short term aim and one that falls within the scope of this project is to design an interactive space that plants a seed of interest in child's mind as well as simplifies technology and programming for children.

The issues and challenges that rise in this scope would be :

1) The current relevance of school education with technology (also Museon's lessons for children) and how the design can shape this into a sustained interest for the future.

2) The physical experience in the space itself is a main aspect and understanding the behaviour and needs of children in terms of play, need for mastery, challenge, excitement,etc will determine the design of the space. So what is relevant and relatable to children's play and how can the space align to this?

3) Children aged 6 to 12 years are the possible target audience for this lab, this is a varied age group with varying cognitive abilities. How do different age groups interact with things and can the design be made relevant across these age groups or is the subject more relevant to one age group than the other?

4) Currently, Museon has two kinds of audience - families with children (individual exploration), children with schools (group exploration). The needs of both are different and the challenge would be in creating a suitable design, how do these differ from one another and will this effect the design?

5) Technology is fast changing and this means the lab also needs to be up to date to stay relevant. Over time, How can the elements be updated with minimal revamp in the space?

6) The educators at Museon are a big part of its ecosystem, How can the lab ensure their engagement and sync with their method of facilitating lessons? Lastly, how can the design add value to Museon?

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Design an immersive and interactive experience around the subject of Robotic and programming in a way that it provides an educational and lasting impression for children (aged between 6 to 12 years) who enter and engage within this space. This experience would be conceptualised in a physical space termed the Robotic - Programming Lab in Museon.

The project would have two aspects that basically form the research, which would then lead to conceptualisation of the lab.

1)Children - To gather insights on children's play and the needs for children's immersive experiences.

To understand what fascinates children and what do they find interesting? Additionally it would be crucial to consider the diverse age group and how the interests and capabilities differ with age.

2 Technology - To understand the existing technology and the relevance it would have for the varying ages and their learning approaches within the lab.

These aspects of research will help in determining what experimental and experiential elements can be used to conceptualise this holistic and immersive experience. In short the project would be to develop a vision for the future robotic lab in Museon, determine examples of the interactive elements in this space and design in a way that it leaves a lasting and educational effect on children who enter this space.

IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30 Page 5 of 7

Initials & Name S Padmasola Student number 4816579

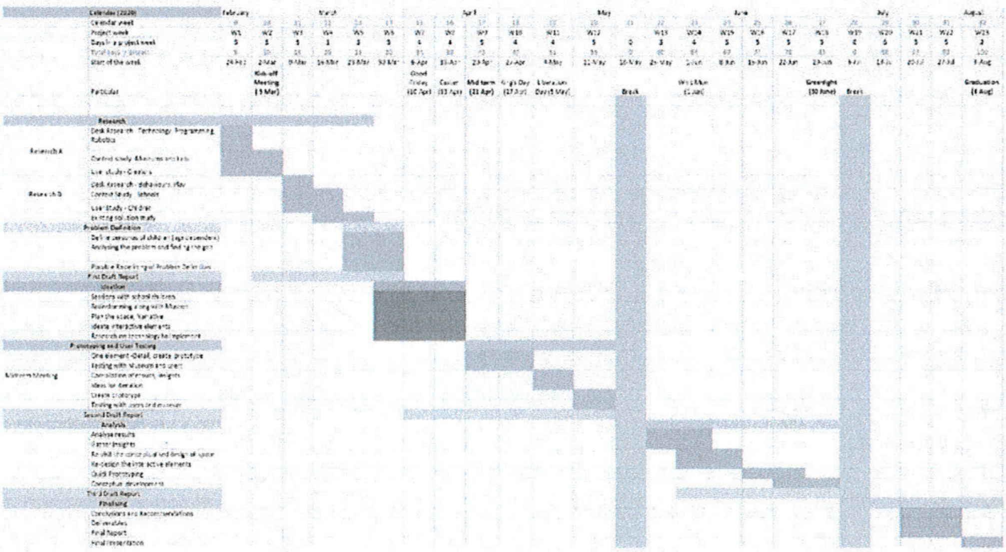
Title of Project Robotic Lab -An immersive and interactive experience design for children

Initial Design Brief

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 24 - 2 - 2020 4 - 8 - 2020 end date



The project is planned with equal time allotment for the research phase and the conceptualisation phase.
The initial research would be split into two aspects, one is research related to technology, programming, existing toys for children, etc and the other involves research about children, their play and what they learn in school. This initial research would be for the first five weeks at the end of which, the problem definition is revisited and rephrased, if needed.
This research and user study will give me the initial ideas and knowledge needed to conceptualise the space and the immersive experience. I start my project on the 24th Feb but the kick off meeting is scheduled to be on the 5th March (most suitable date for the supervisory team). This would already give me a chance to discuss a weeks progress during the meeting.
The mid-term meeting is planned in Mid- April, just after the ideation phase. It is a good moment to report progress and to see next steps of the project.

I have scheduled two breaks, in my planning (Week 21 and 28). One is half way through the project, to unwind from the project and another just after the greenlight (Week 27, in June) and before the final presentation, this break is because my parents might be visiting me in Delft, so it is to spend time with them.

Initials & Name S Padmasola Student number 4816579

Title of Project Robotic Lab -An immersive and interactive experience design for children

Initial Design Brief

TUDelft

Personal Project Brief - IDE Master Graduation

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology. ... Stick to no more than five ambitions.

For my graduation project, I wanted to bring together my interest in information design, interaction design, and designing for spaces or systems. This seemed possible with Museum Futures lab and hence I was immediately drawn to doing a project with the lab. The robotic - programming lab in that sense brings together my existing interest but also creates a new challenge for me to venture in a space I am unfamiliar with - technology. It is in that sense a leap into the unknown and something that I have been meaning to do but not been able to entirely.

The past year and a half has been a huge learning curve for me as I moved from a visual communication designer to an interaction designer. With this move, it brought about some new interests, learnings and new skills. One new lesson is to develop the ability to design alongside technology. This I realised is particularly useful during the prototype testing phase, knowing some tinkering tools helps create something closest to the actual design and even gets useful results.

I got introduced to technology aspect of design in the course Interactive Technology Design (ITD) and it helped me understand how it provides a new meaning to the design process. While I do not consider myself a technologist, this course helped me equip with some basic knowledge of the arduino, etc. But I am still a novice and I would like to learn and develop the ability to adapt to a challenge such as this during the course of the project.

During the course of the masters, I got introduced to different processes, an in depth linear process, with minimal iterations in UXAD while a more iterative cyclical approach in ITD. For my project, I would like to find a tailor made process that fall between both these approaches.

The main target group for this project is children, while I have not particularly designed with/for children, I am familiar with certain aspects of child's play and always had an keen interest in the education space. In an elective course Experience and Persuasion, I gathered some theories for behaviour change, including gamification and I am looking forward to using this.

For the project, I would like to implement the framework "Relevance by Play" (Vermeeren & Calvi, 2019) specifically designed for museum experiences. It would be interesting to see how this works, especially in this context of designing for play.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

-(2020). Retrieved 17 February 2020, from https://www.techniekpact.nl/cdi/files/e3bd421f98a0f362b6a13091de60d08978df34e9.pdf
-Vermeeren, A., & Calvi, L. (2019). Relevance by Play. Extended Abstracts Of The 2019 CHI Conference On Human Factors In Computing Systems - CHI EA '19. doi: 10.1145/3290607.3312960

Initials & Name S Padmasola Student number 4816579

Title of Project Robotic Lab -An immersive and interactive experience design for children

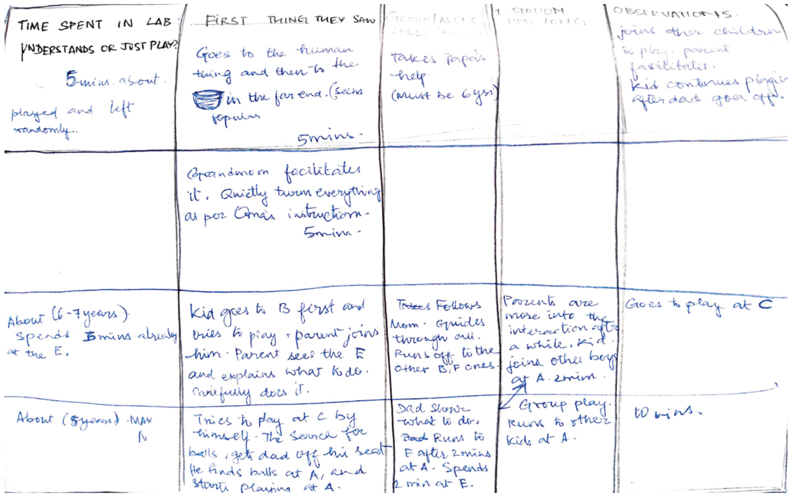
A. Observations

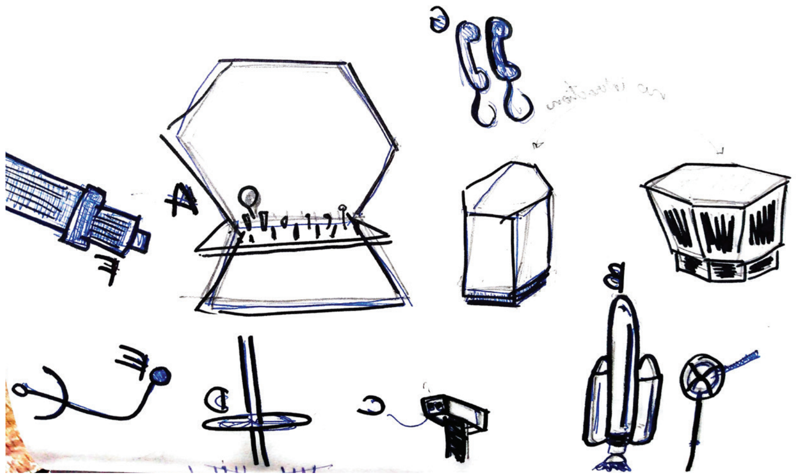
Raw data from observations. Notes and drawings made during the observation session

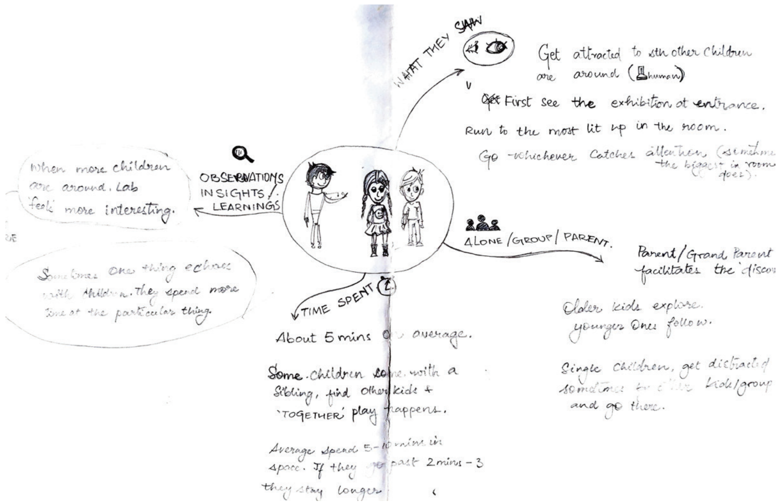
Processs : The interaction elements (touchpoints) in the space were first were first mapped out and assigned an alphabet.

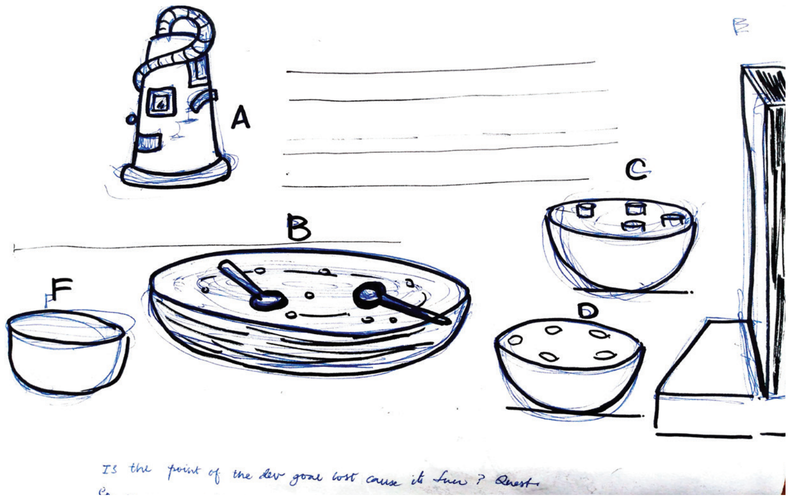
The notes of the observations got chaotic, as more and more people visit the space.

Finally, I made a mindmap of all the findings. The observations were categorised as, people, time spent, child behaviour and miscellaneous.
These observations are in chapter 2.1









A. Observations

Time spent in the lab : understands or just plays?	First thing they saw	Group/Alone. Adult/By self	Observations
5 minutes, played and left randomly. Didn't understand in detail	Goes to the large human thing and then to the far end - A and leaves	Takes fathers left. (approx 6 years old)	joins other children in the lab to play. parent facilitates. kid continues playing after father goes off.
Spends about 5 mins at the human exhibit	kid goes to the centre of the room, tries to play. parent joins, sees the human (e) and explains the kid what	Follows mother, parents guides throughout the entire space. Runs off to the other exhibits suddenly.	6-7 years. parents are more into the interaction. **Kid joins other boys of the same age** and they play together
Girls 8-10 years. walk in and play at c, at the game for 2 mins and later go to E.(human).	plays with father's help. tries to do it together... they all try D first and then move on	makes sense to them. by themselves.	girls spend time at F and go to A. and go away. Older child sees the entire space , and takes a seat at the far end.
About 8 years, maybe 10. spends 2 mins in the lab	tries to play at c (waterlab) by himself and then searches for the ballls, pulls his dad off his seat and starrts playing with the balls	Along by himself. but pulls dad. dad shows what to do and sits down again. Spends more time by himself	Wanted compnay and attention from parent. Was more into the activity after parents stepped in and left.
Boy walks in to the telescope, hurts himself so walk out of the lab. Comes back in with opa,	Telescope, The satellite is the next to catch his eye and is exciting to see other person on camera	Boy goes to E and tries to figure out with Opa's help	First gave up, cause he hurt himself but came back with adult feeling more confident.
Girl 10 years, older kid walks in. Goes to the satellite first.	Satellite	Alone, by self.	Super bored, and is not intersted. Scans the room and leaves soon.

B. Science museums globally - inspiration board

Science Museum, London.
Exhibition, non-interactive, stories of robots, school lessons, interesting soundscape story,

(Museum - https://www.sciencemuseum.org.uk/what-was-on/robots)
(intersting sound scape story - https://blog.sciencemuseum.org.uk/robots-coda-to-coda/)

Science Museum,Boston
(Wicked Smart Hub) Exhibition, interactive, simple,playground, strong STEM education

(Museum - https://www.mos.org/exhibits/wicked-smart)

City of Robots, Europe and Russia
Multiple exhbitions, interactive, multiple kinds of robots. Flexible exhibition in multiple cities.

(Website - http://cityofrobots.io/)

Museum of Science+Industry, Chicago
Interactive, transparent exhibition (toy making) , school trips/workshops.
(Museum - https://www.msichicago.org/explore/whats-here/exhibits/fast-forward/)

Engineer your Future.
Science Museum, London.
Actvities - Rugged Rovers, build and test electrical grids, play FutureVille.

(Lab-https://www.sciencemuseum.org.uk/learning/engineer-your-future-school-info)

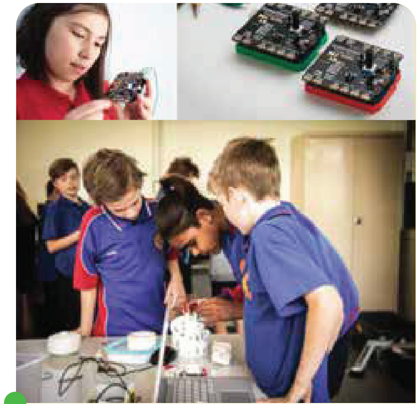
EiE, Wee Engineer, curriculum.
Science Museum, Boston.
Integrated with the school education, classroom + museum related lessons. Lessons ranging from kindergarten to middle school. STEM.

(Lab-https://www.mos.org/15-years-of-engineering-education)

Learning Labs
Science Museum, Chicago
Workshop and lab . Lessons ranging from kindergarten to middle school. STEM.
(Lab-https://www.msichicago.org/education/field-trips/learning-labs/home-school-labs/)

Tinkering Lab
Deustsches Museum, Munich
Workshop and lab . Lessons ranging from kindergarten to middle school. STEM.
(Lab-https://www.msichicago.org/education/field-trips/learning-labs/home-school-labs/)

B. Science museums globally - inspiration board

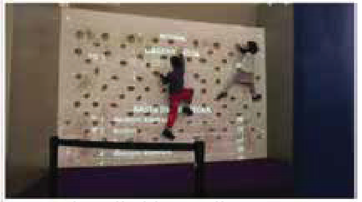


Engineer your Future.
Science Museum, London.
Actvities - Rugged Rovers, build and test electrical grids, play FutureVille.

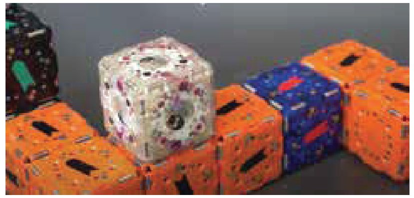
(Lab-https://maas.museum/program/stage-3-technology-game-design-with-scratch/)

Tinkering Studio
Exploratorium,San Francisco.
Independent workshops, techno enthusiasts,

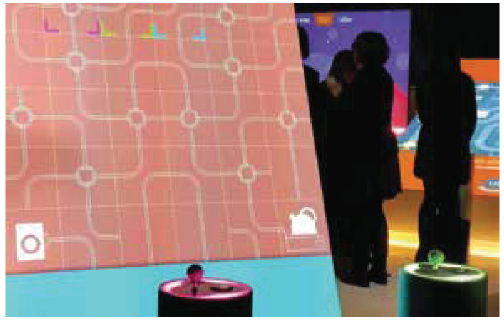
(Lab-https://www.mos.org/15-years-of-engineering-education)



Interactive Climbing Wall, Stockholm Technology Museum

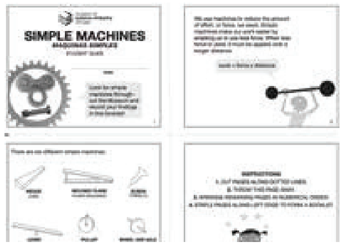


M-Blocks 2.0 Modular Robots



Menno Meeldijk, science museum (LN), game/interaction

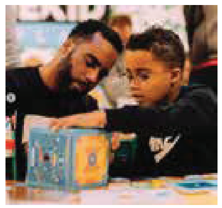
Wonderlab at the Science Museum, London.



Format of science lessons in chicago science museum

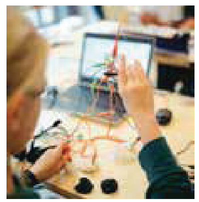
Mirakain, Science museum, Japan

Jade Robots, workshops as well.



DoIt Europe

WAAG Society Amsterdam

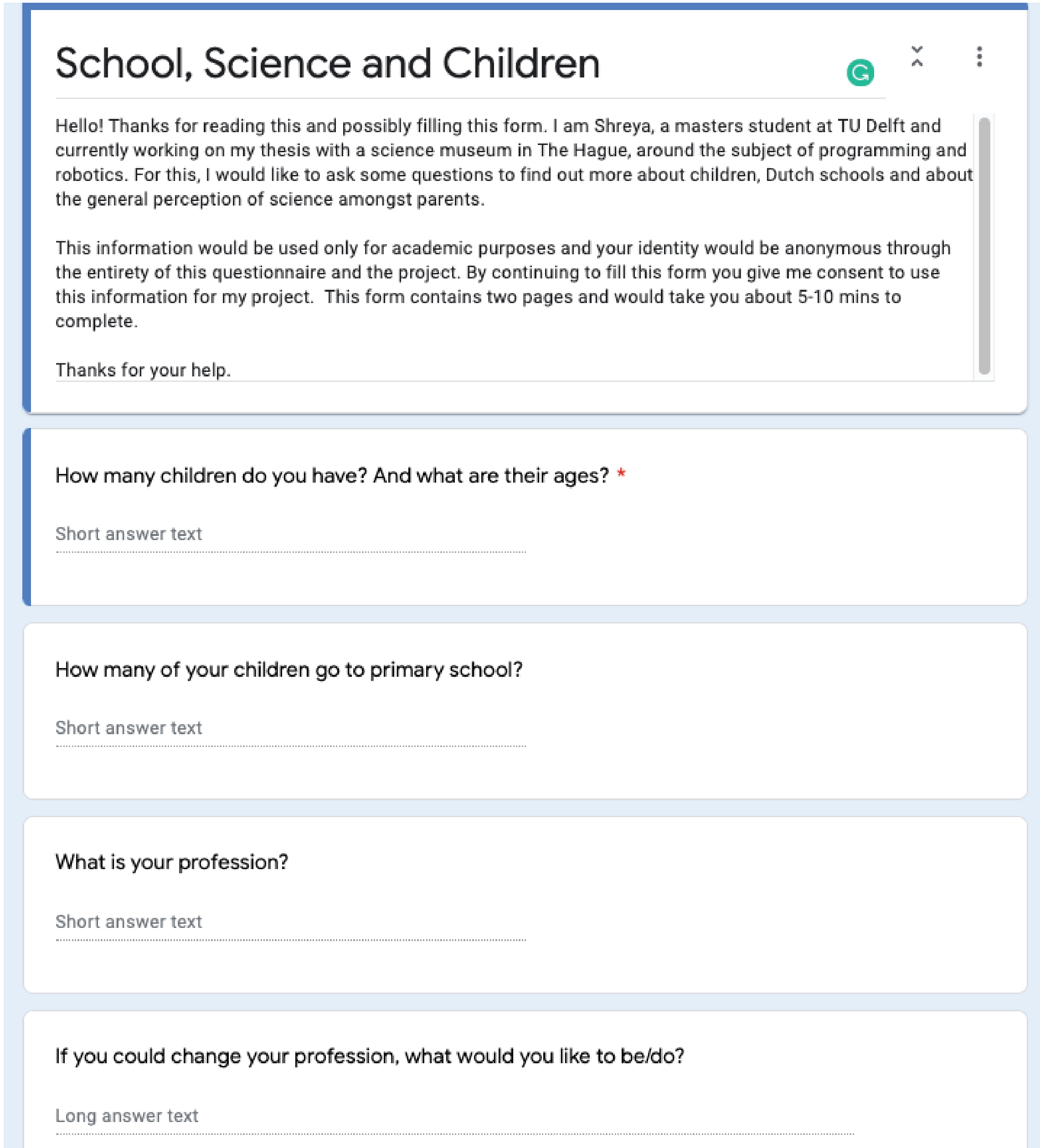


Markplaats 021

C. Questionnaire to Parents

Screenshots of the online questionnaire for parents.

This was sent to about 10 participants, some through facebook and some through friends. Only 2 responses were received for this.
Reason : It was really difficult to reach out to parents and teachers online.
I then moved on from this method of interviewing and getting insights. These kind of "failures" were a huge learning lesson. In normal conditions this would have been super easy to get done, as I would be in the museum and parents most commonly visit with their children.



School, Science and Children

Hello! Thanks for reading this and possibly filling this form. I am Shreya, a masters student at TU Delft and currently working on my thesis with a science museum in The Hague, around the subject of programming and robotics. For this, I would like to ask some questions to find out more about children, Dutch schools and about the general perception of science amongst parents.

This information would be used only for academic purposes and your identity would be anonymous through the entirety of this questionnaire and the project. By continuing to fill this form you give me consent to use this information for my project. This form contains two pages and would take you about 5-10 mins to complete.

Thanks for your help.

How many children do you have? And what are their ages? *

Short answer text

How many of your children go to primary school?

Short answer text

What is your profession?

Short answer text

If you could change your profession, what would you like to be/do?

Long answer text

School, Science and Children

* Required

School, Robotics and science.

This section is about the things your children learn in primary school. Please be as honest as you can and feel free to add in your thoughts and opinions around science and the Dutch Education in the last part of this form.

Does your child learn science in school? (science includes lessons such as sound, light, water) *

- Yes
- No
- Maybe

What kind of topics do they learn under science? *

Your answer

Do you think primary schools should teach more science? *

- Yes, schools should teach more science concepts
- No, the science in primary schools is sufficient
- Maybe

Do the science concepts that the children learn now vary now differ greatly from what you learnt when you were in school? *

Your answer

Do you know what STEM education is? *

- Yes, I know what it is
- I heard of it but don't really know what it is
- Never heard of it

There are a lot of educational toys/robots that can be programmed and played with. Ex: Lego Mindstorms, Has your child been exposed to these kinds of toys in school? *

Your answer

Would you like your child to learn programming ? *

	1	2	3	4	5	6	7	
Not really	○	○	○	○	○	○	○	Would love them to

The Netherlands government has mandated schools to include more science and STEM education in the curriculum. Do you think this is a good choice? Why? *

Your answer

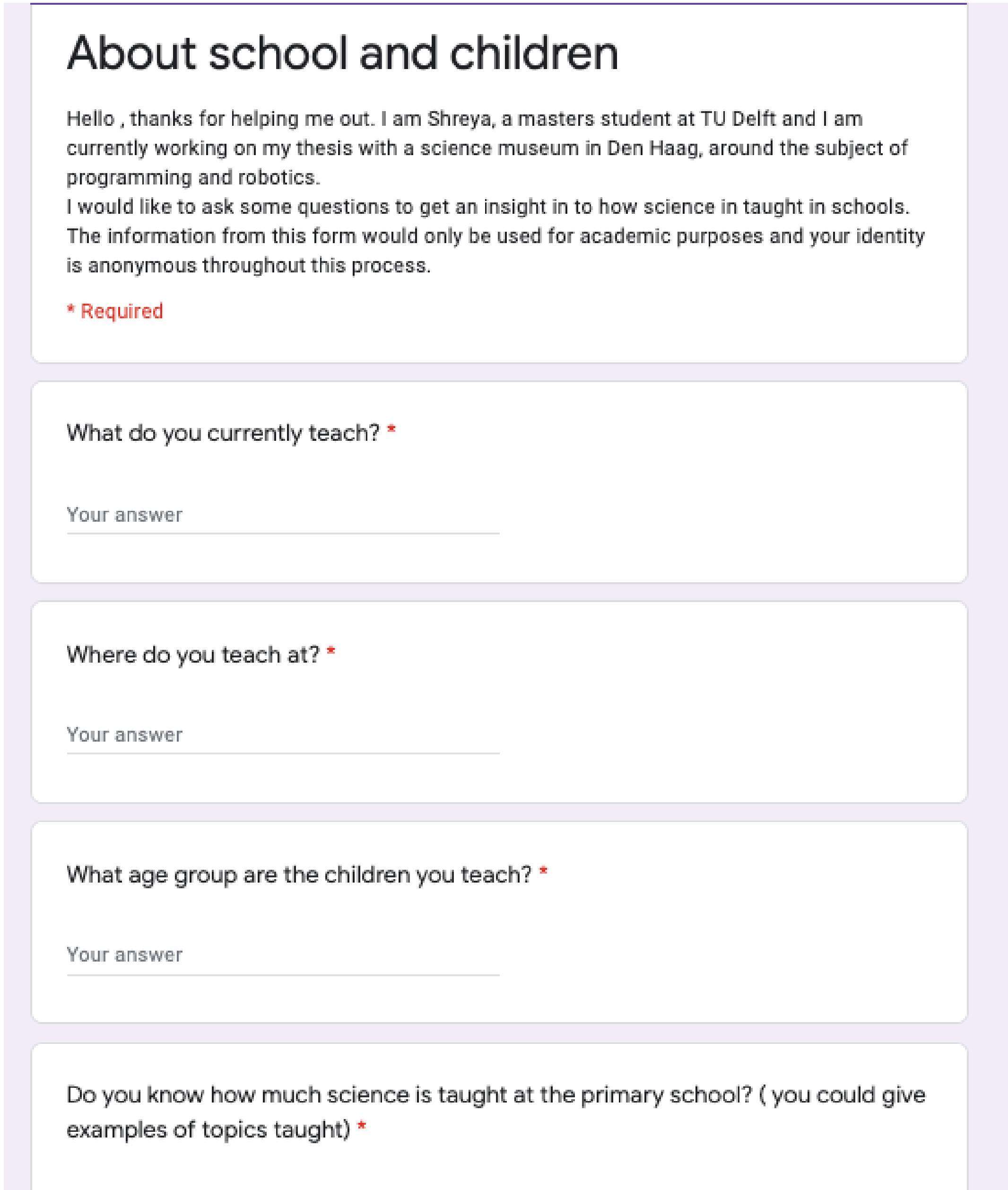
Because of this mandate, science museums are also designing exhibitions and lessons to fit the STEM requirement. Would you like your child to be more exposed to science, in and outside school? *

Your answer

C. Questionnaire to Teachers

Screenshots of the online questionnaire for teachers

This was sent to about 6 participants, some through facebook and some through friends. Only 1 responses were received for this.
Reason : It was really difficult to reach out to parents and teachers online.
I then moved on from this method of interviewing and getting insights. These kind of “failures” were a huge learning lesson. In normal conditions this would have been super easy to get done, as I would be in the museum and parents most commonly visit with their children.



About school and children

Hello , thanks for helping me out. I am Shreya, a masters student at TU Delft and I am currently working on my thesis with a science museum in Den Haag, around the subject of programming and robotics.
I would like to ask some questions to get an insight in to how science in taught in schools. The information from this form would only be used for academic purposes and your identity is anonymous throughout this process.

* Required

What do you currently teach? *

Your answer

Where do you teach at? *

Your answer

What age group are the children you teach? *

Your answer

Do you know how much science is taught at the primary school? (you could give examples of topics taught) *

The Netherlands government has mandated that science should be actively taught at primary schools. Do you think this is a good idea? *

Your answer

A lot of schools depend on museums for their science lessons. As a teacher, what would your expectation be when you take your class to a museum to learn something? *

Your answer

Do you think it is nice for young children to learn more about robotics and programming? *

	1	2	3	4	5	6	7	
No, I think its too early	○	○	○	○	○	○	○	Definitely, it is a necessary skill for future

With respect to robotics and science, do you think children would be curious to know more about it? Why? *

Your answer

Do you know what STEM is? *

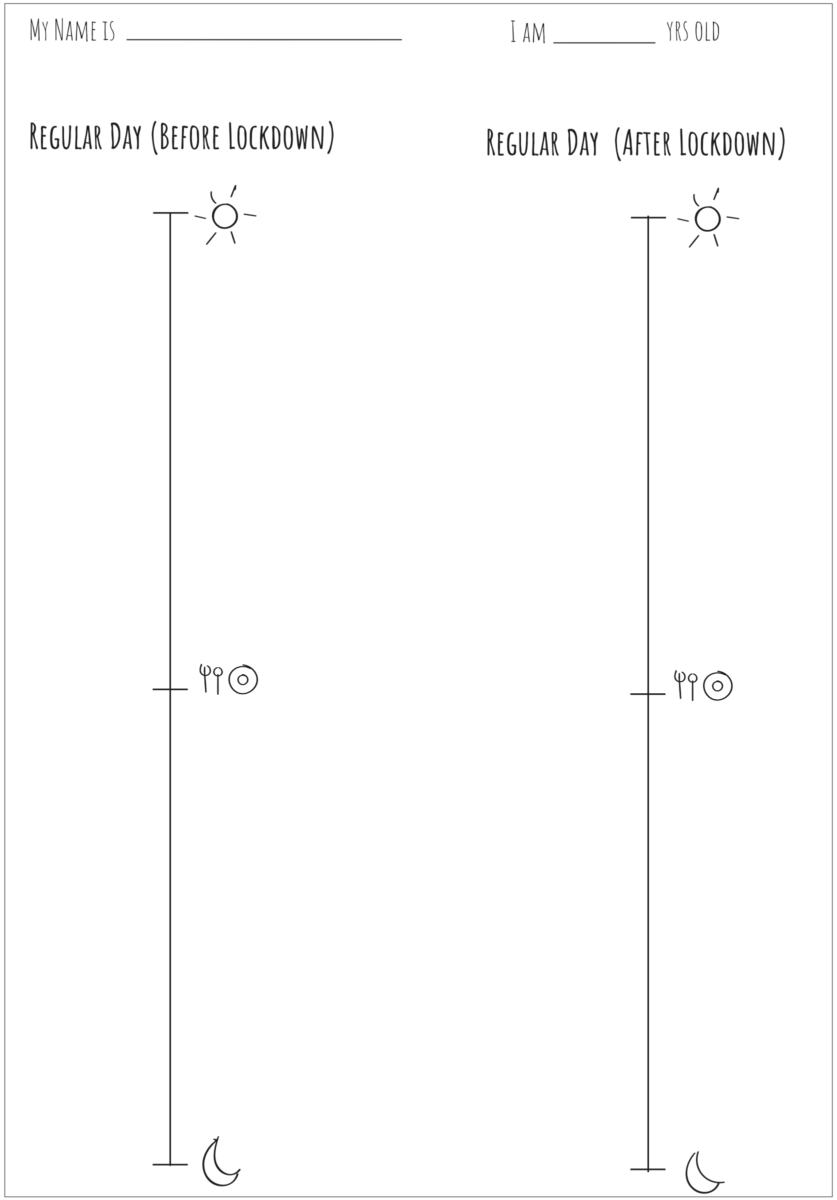
- ○ Yes, I know it
- ○ Not really, I heard of it but not sure what it is
- ○ No clue what that is

Do you think the STEM education in the Netherlands in on par with global education? *

D. Worksheet to children

Screenshots of the online questionnaire for teachers

This was sent to about 6 participants, some through facebook and some through friends. Only 1 responses were received for this.
Reason : It was really difficult to reach out to parents and teachers online.
I then moved on from this method of interviewing and getting insights. These kind of "failures" were a huge learning lesson. In normal conditions this would have been super easy to get done, as I would be in the the museum and parents most commonly visit with their children.



If a robot is my friend, It would look like this :

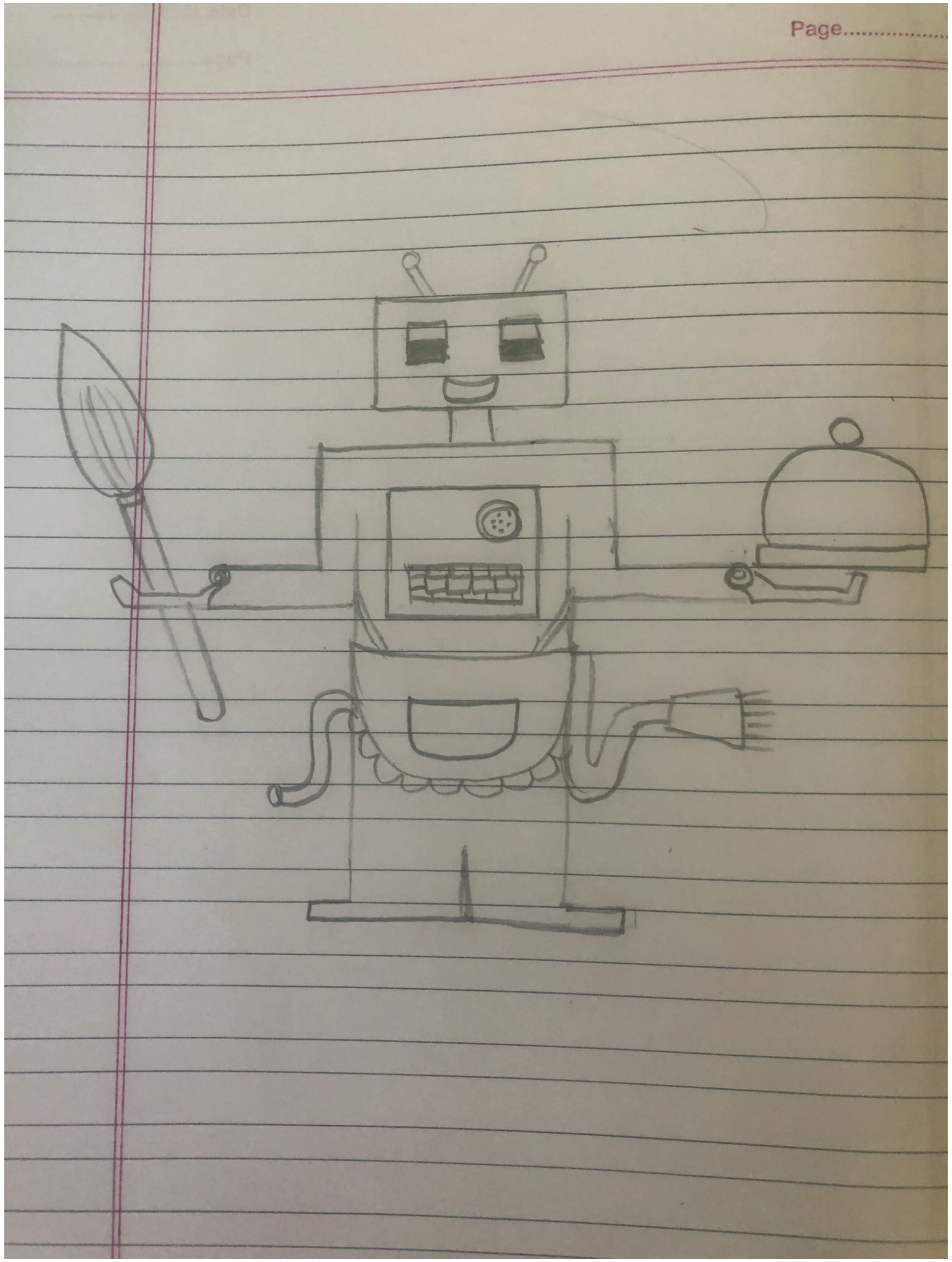
My new Friend's Name is : ____________________

What are the things you and your Robot Friend would do together?

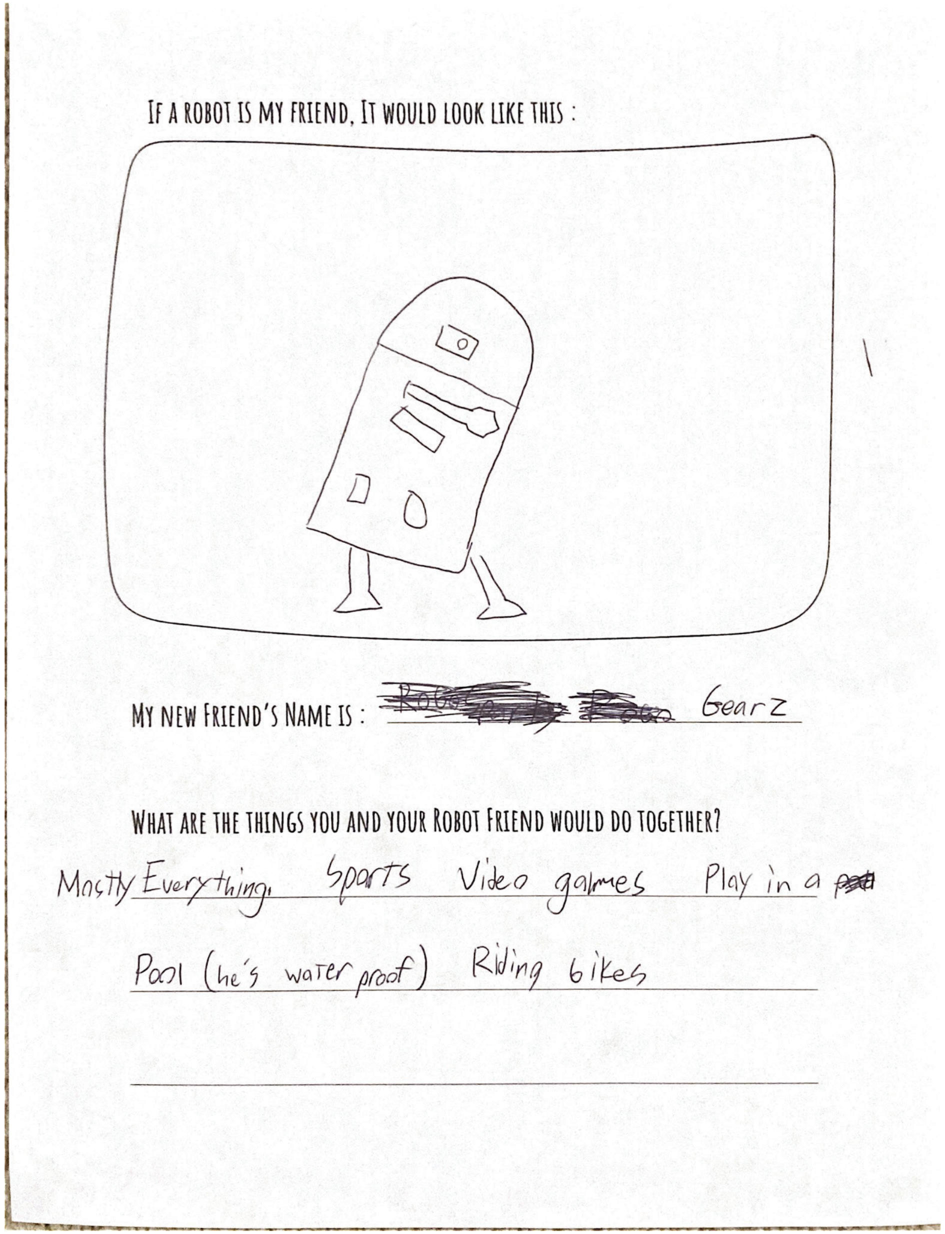
____

____

____



D. Worksheet to children

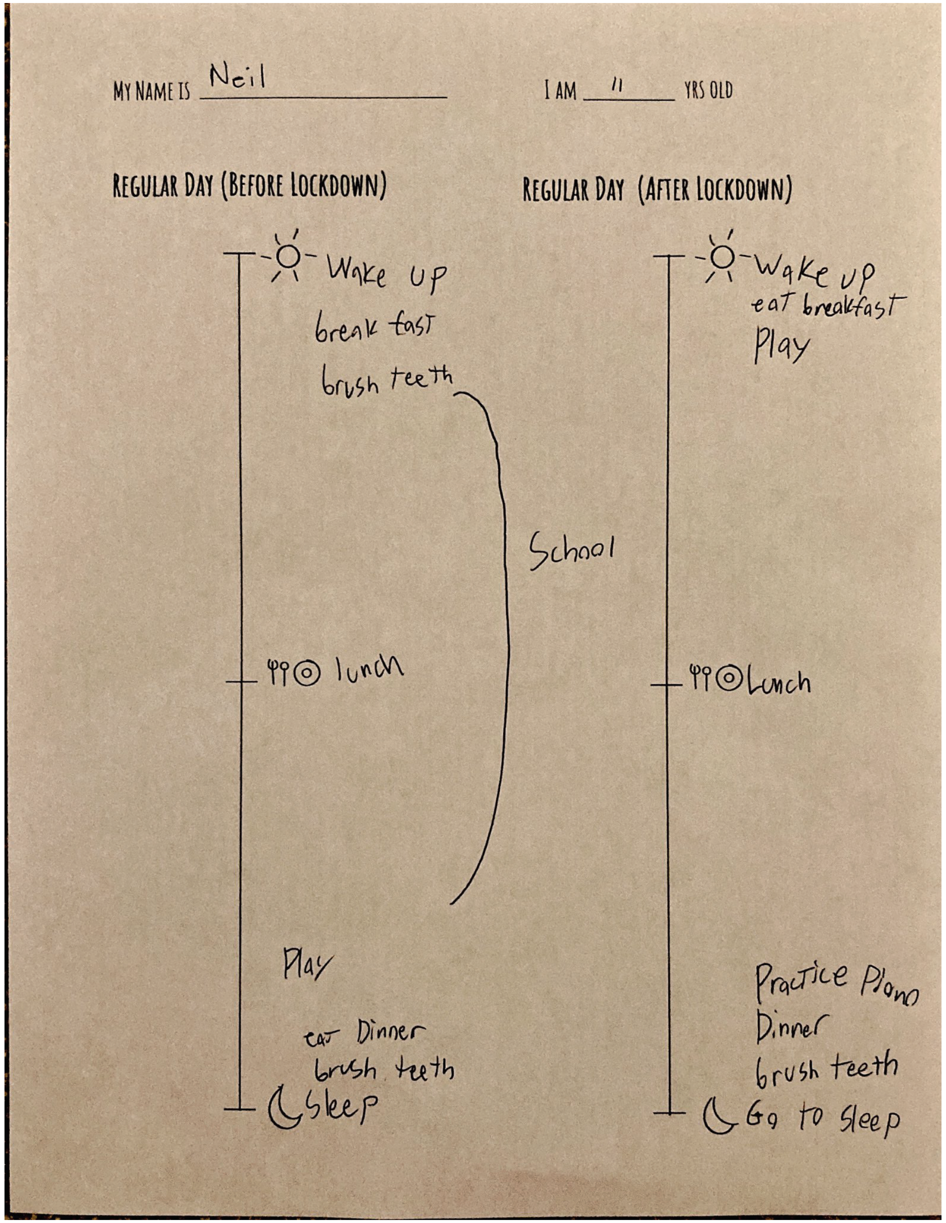


IF A ROBOT IS MY FRIEND, IT WOULD LOOK LIKE THIS :

MY NEW FRIEND'S NAME IS : Gearz

WHAT ARE THE THINGS YOU AND YOUR ROBOT FRIEND WOULD DO TOGETHER?

Mostly Everything, Sports Video games Play in a Pool (he's water proof) Riding bikes



MY NAME IS Neil

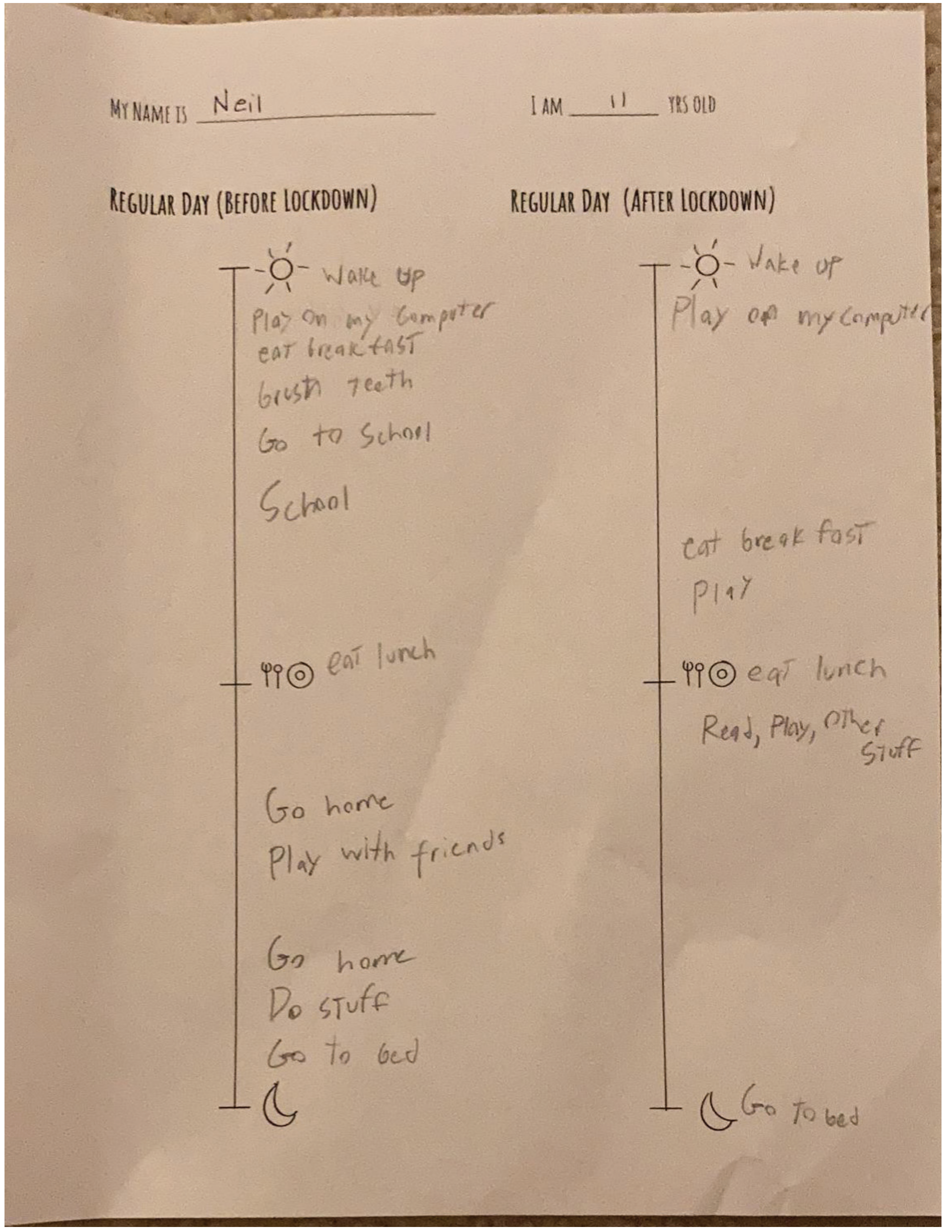
I AM 11 YRS OLD

REGULAR DAY (BEFORE LOCKDOWN)

Wake up
break fast
brush teeth
School
lunch
Play
eat Dinner
brush teeth
Sleep

REGULAR DAY (AFTER LOCKDOWN)

Wake up
eat breakfast
Play
Lunch
Practice Piano
Dinner
brush teeth
Go to sleep



MY NAME IS Neil

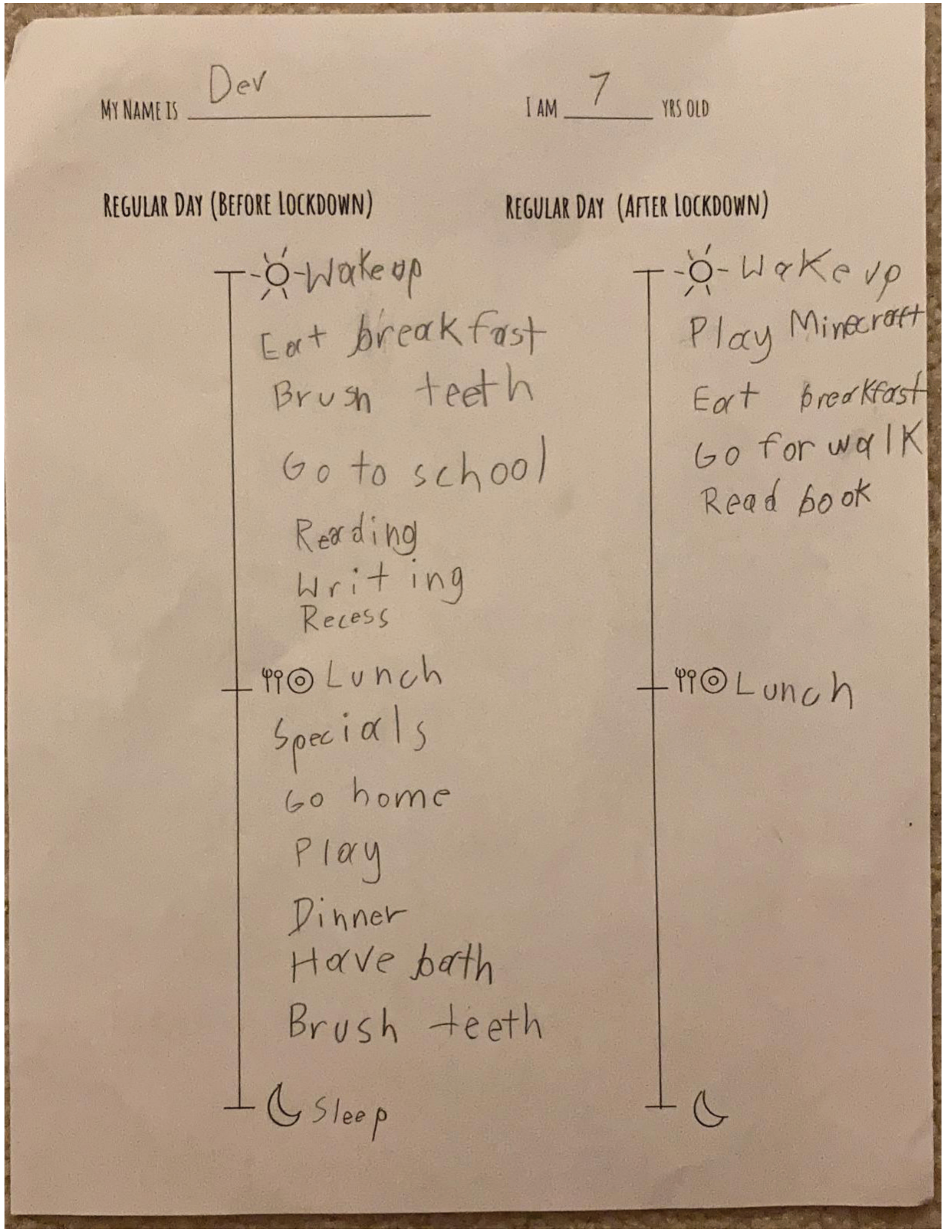
I AM 11 YRS OLD

REGULAR DAY (BEFORE LOCKDOWN)

Wake up
Play on my Computer
eat breakfast
brush teeth
Go to School
School
eat lunch
Go home
Play with friends
Go home
Do stuff
Go to bed

REGULAR DAY (AFTER LOCKDOWN)

Wake up
Play on my Computer
eat breakfast
Play
eat lunch
Read, Play, other stuff
Go to bed



MY NAME IS Dev

I AM 7 YRS OLD

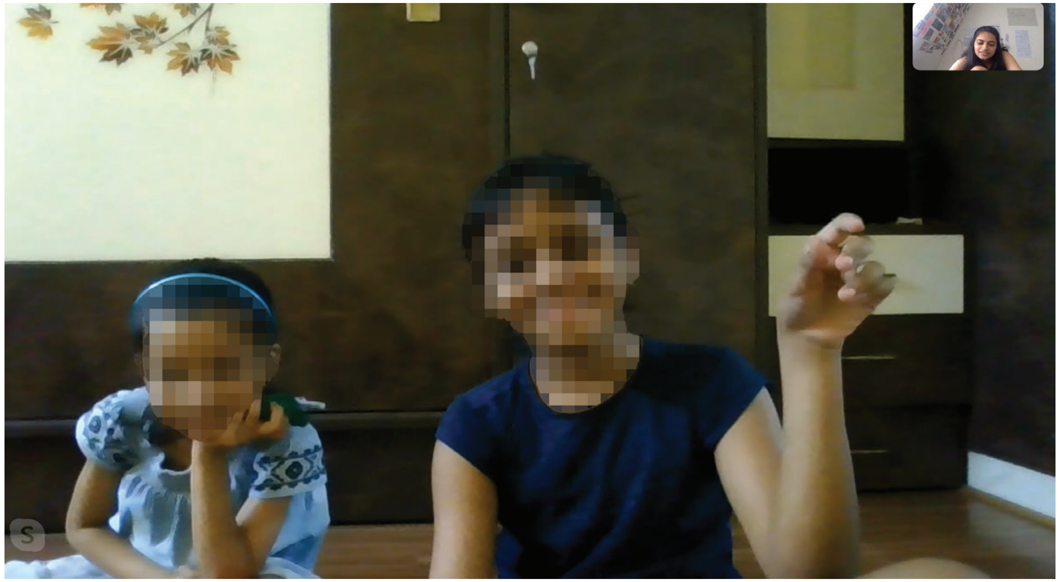
REGULAR DAY (BEFORE LOCKDOWN)

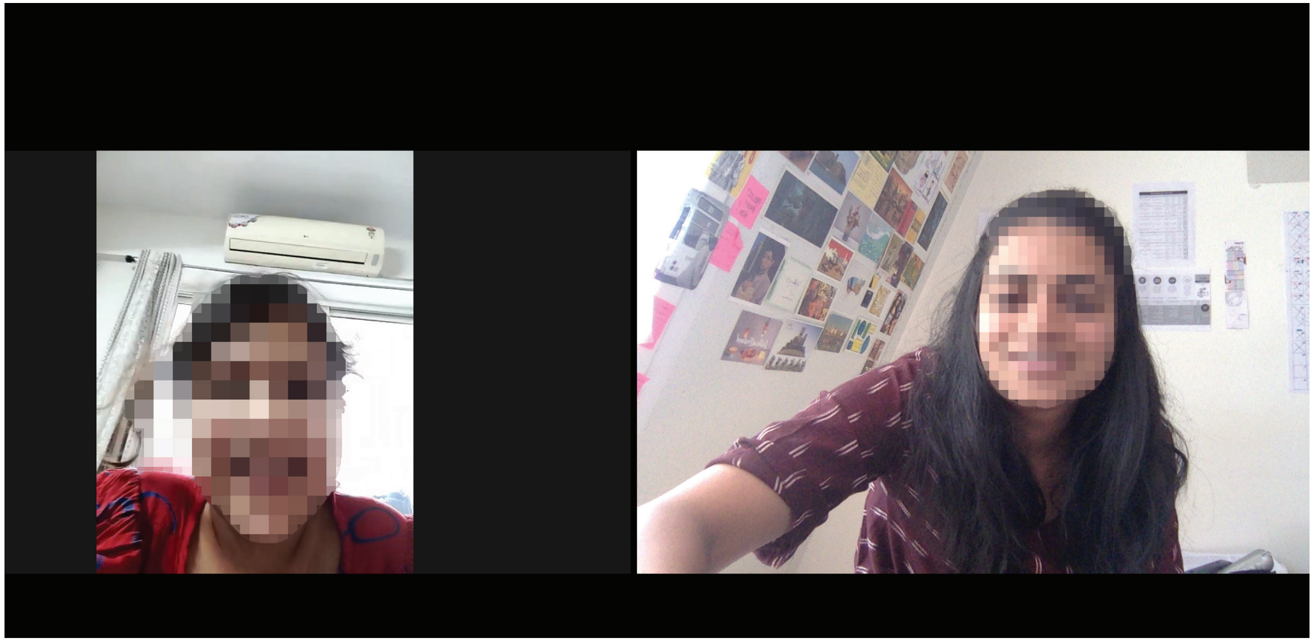
Wake up
Eat breakfast
Brush teeth
Go to school
Reading
Writing
Recess
Lunch
Specials
Go home
Play
Dinner
Have bath
Brush teeth
Sleep

REGULAR DAY (AFTER LOCKDOWN)

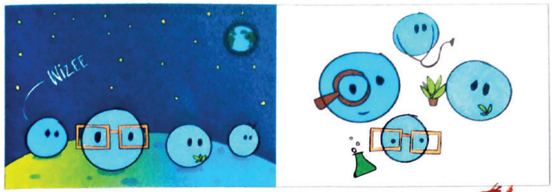
Wake up
Play Minecraft
Eat breakfast
Go for walk
Read book
Lunch

D. Worksheet to children





E. Worksheet to children- 2

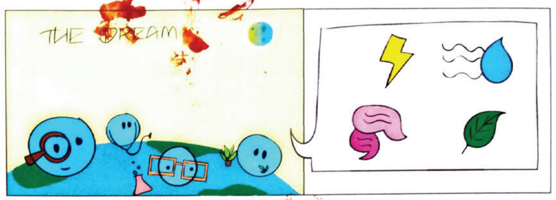


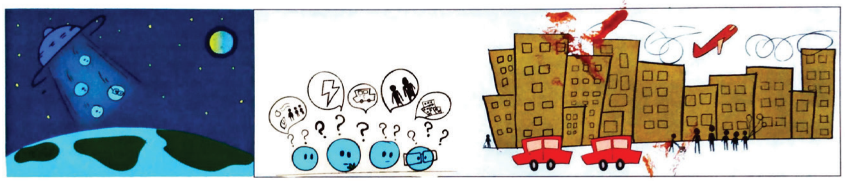
Dit is Wizee met zijn vriendjes.
Ze leven op de planeet Titan

Ze willen alles over wetenschap leren.

Sammen hebben ze een droom.

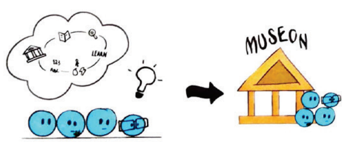
Ze willen naar de aarde reizen en Aardewetenschappers worden





Dus op een dag springen Wizee en zijn vriendjes in hun raket en gaan naar de aarde.

Ze landen op aarde, maar weten helemaal ~~neits~~ niets over de Aarde en de mensen,die erop leven

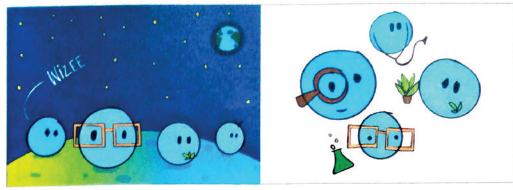


Ze zijn naar het museum gekomen om meer over de aarde te leren

Als je Wizee in ons museum zon zien, wat zou jij hem kunnen leren of vertellen over de aarde?

leuke planeet, je kan veel doen!
wandelen in de bergen bijvoorbeeld
naar zwitserland of Frankrijk
je kan werken en geld verdienen. zodat je
dingen kunt kopen en iets kunt bereiken.

Naam Marijn 11 jr

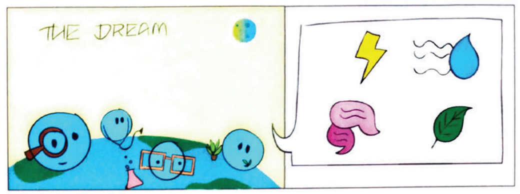


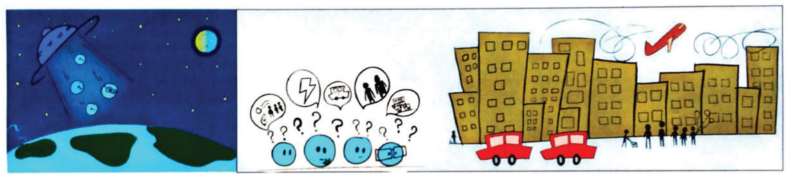
Dit is Wizee met zijn vriendjes.
Ze leven op de planeet Titan

Ze willen alles over wetenschap leren.

Sammen hebben ze een droom.

Ze willen naar de aarde reizen en Aardewetenschappers worden





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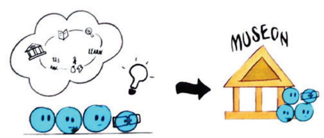
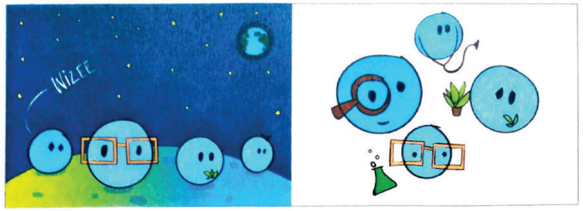


Ze zijn naar het museum gekomen om meer over de aarde te leren

Als je Wizee in ons museum zou zien, wat zou jij hem kunnen leren of vertellen over de aarde?

de aarde is rond en er is corona virus
er zijn ~~meeste~~ heel veel landen
de meeste mensen zijn engels
er zijn veel auto's, treinen, vliegtuigen,

Naam: Fenna

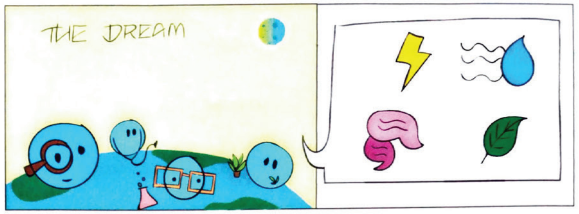


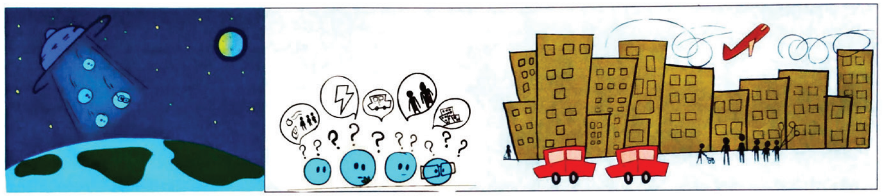
Dit is Wizee met zijn vriendjes.
Ze leven op de planeet Titan

Ze willen alles over wetenschap leren.

Sammen hebben ze een droom.

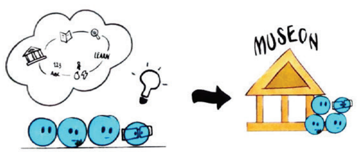
Ze willen naar de aarde reizen en Aardewetenschappers worden





Dus op een dag springen Wizee en zijn vriendjes in hun raket en gaan naar de aarde.

Ze landen op aarde, maar weten helemaal ~~neits~~ niets over de Aarde en de mensen,die erop leven

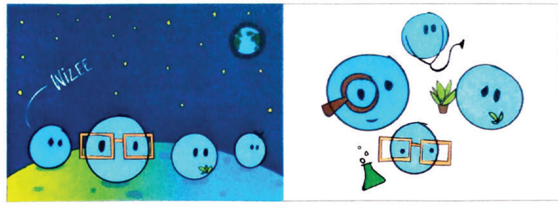


Ze zijn naar het museum gekomen om meer over de aarde te leren

Als je Wizee in ons museum zon zien, wat zou jij hem kunnen leren of vertellen over de aarde?

als het donker is zien we de maan
we hebben huizen waar we in wonen
als het donker zien we ook sterren
we kunnen naar school om te leren
daar leer je: schryven, rekenen, engels

Naam Emma

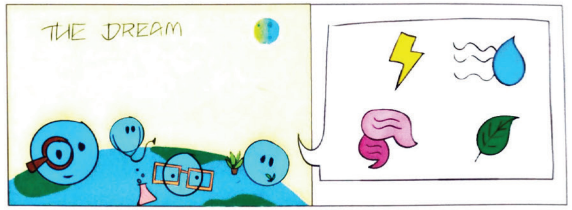


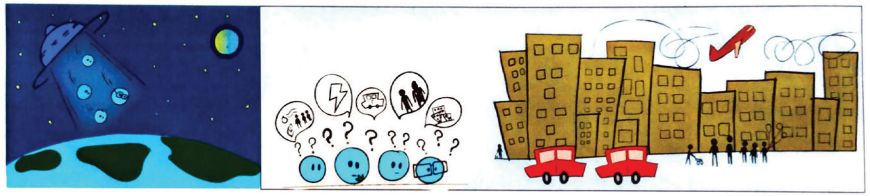
Dit is Wizee met zijn vriendjes.
Ze leven op de planeet Titan

Ze willen alles over wetenschap leren.

Sammen hebben ze een droom.

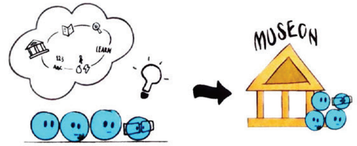
Ze willen naar de aarde reizen en Aardewetenschappers worden





Dus op een dag springen Wizee en zijn vriendjes in hun raket en gaan naar de aarde.

Ze landen op aarde, maar weten helemaal niets over de Aarde en de mensen,die erop leven



Ze zijn naar het museum gekomen om meer over de aarde te leren

Als je Wizee in ons museum zou zien, wat zou jij hem kunnen leren of vertellen over de aarde?

op de aarde leven heeeel veel
dieren zoals dolfynen, apen en
geiten en natuurlijk mensen

Naam :

F. Storyboard developed after ideation

This storyboard was developed keeping in mind two aspects, children can choose what they want to teach Spark, and they can choose what level they want to teach Spark.

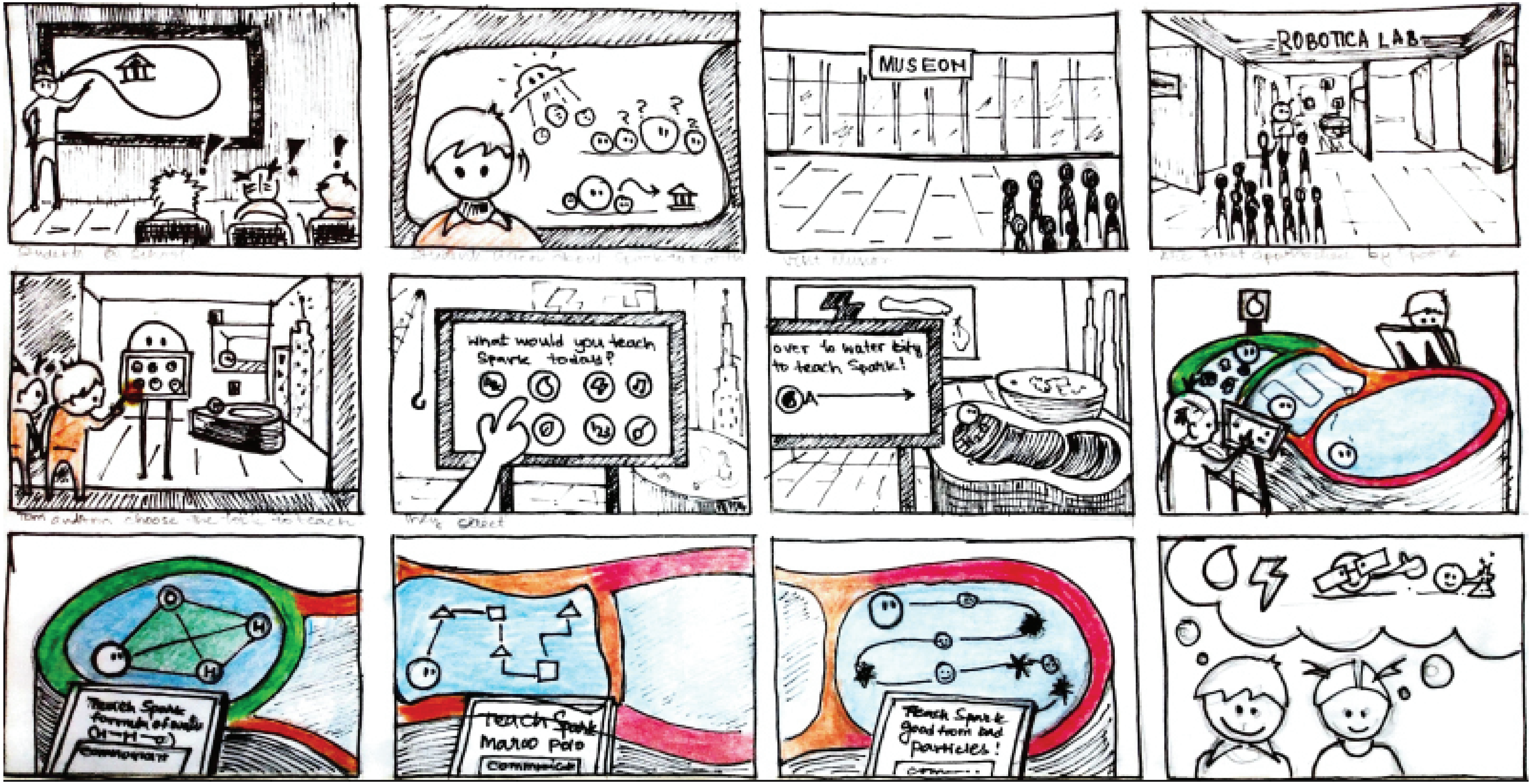
The topics that the children can teach Spark range from simple things such as painting, words or music to water, energy, nature.

The storyboard starts with Tom's teacher telling the class that they would go to Museon, and goes on to introducing Spark and explains his quest on Earth. Tom and his friends are already anticipating the visit to the museum. On coming to the museum, Tom and his teammate are greeted by another robot that asked them to select what they want to teach Spark. They choose to teach him about "water". Automatically they are guided to the "easy" part of the water island. The first task is to find teach Spark, h2o, and the second is to make Spark play Marco Polo, and the third is to help Spark identify the toxin from the good elements of water.

This completes the storyboard.
The various activities for water are designed keeping in mind increasing levels. For instance, in the second activity, to play Marco Polo, is designed to be a simple pattern recognition. As seen in the image, the triangle and the squares are alternate, on each triangle Spark should say Marco and on each square Polo. Thus borrowing from the elements of computational thinking.

This storyboard details out the interaction of the children visiting museon and an example of the activity they can do. However, it is not clear yet if children find this easy difficult, boring or too complex. For this, it is crucial to test with children.

Evaluation : The storyboard was close to the final visualisation of the interaction however, the activities were not detailed out at this point, hence the story board slightly altered after the activities were developed.


MUSEOM
ROBOTICA LAB
what would you teach Spark today?
over to water city to teach Spark!
Teach Spark
Marco Polo
Teach Spark good from bad particles!

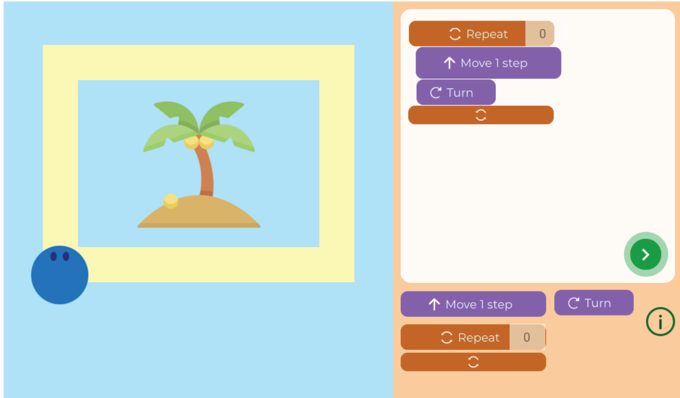
G. Website prototype

The prototype was created after the storyboard interaction was designed. The main aim of this prototype was to see how children use the blocks and respond to activities.
This was inspired from the games online such as Lightbot. This was also designed as attempt to mirror the physical space and interactions of the robotic lab. The prototype was designed in Readymag, an online tool to create websites. The interaction tools were inspired from Scratch and Sphero's software, but simplified for beginners.

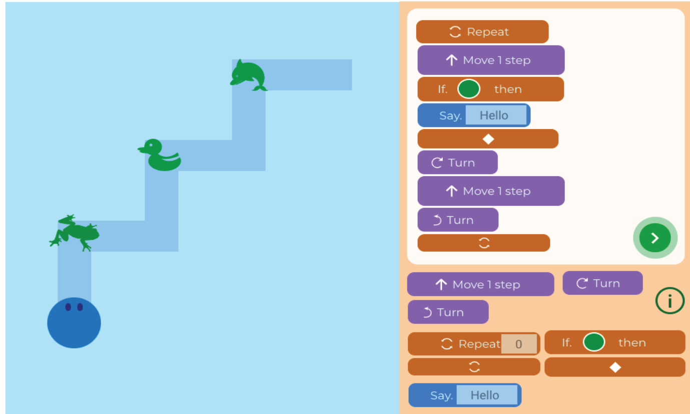
The website can be seen in the following link :
https://readymag.com/u1430918488/2047784/

The prototype was only tested with two children who found it easy. But the protoype was not designer further or tested further for the following reason -
Designing this was unusually glitchy and caused errors even for the simplest of activities. The process was time taking and it did not really fetch relevant data for the process of designing the lab. This might be a good option for a later stage of the project .

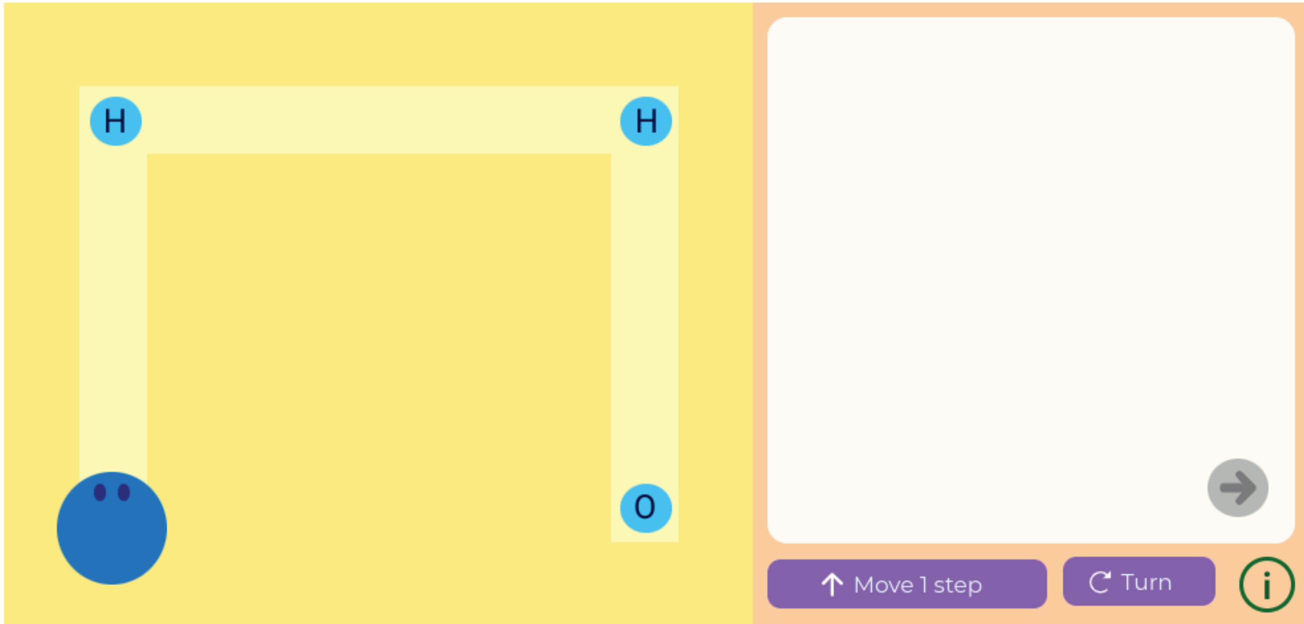
Help Wizee take a trip around the island

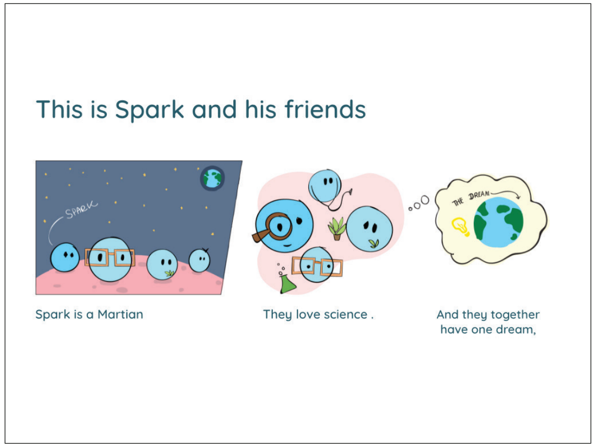


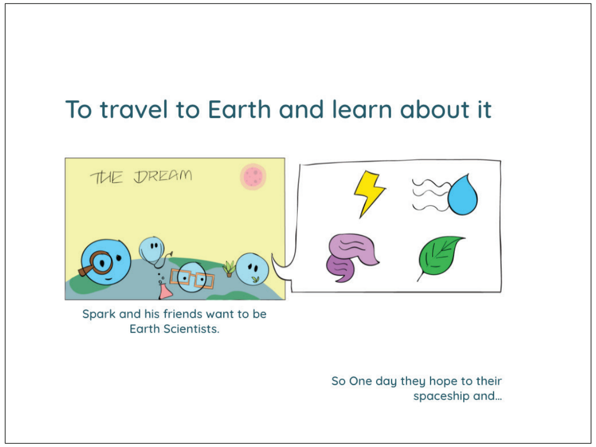
Lead Wizee to the Animal and say "Hello".

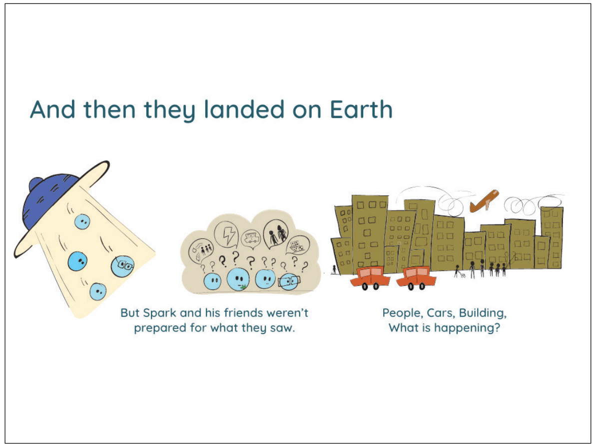


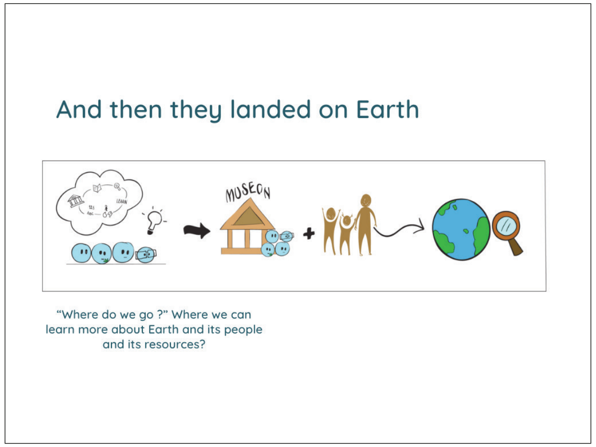
Lead Wizee to the hydrogen and oxygen atoms

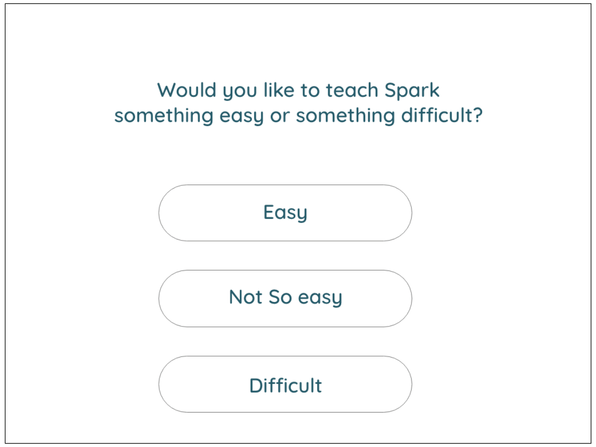


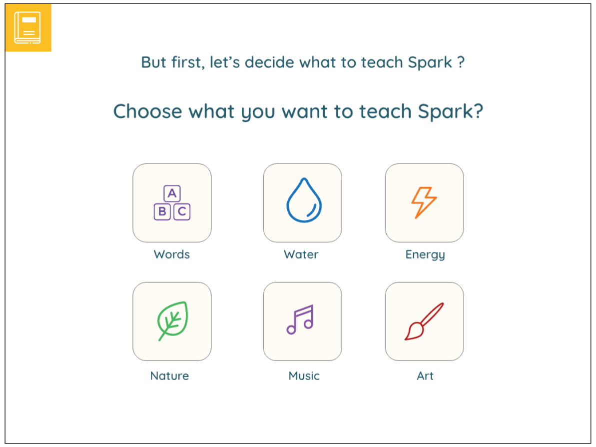

This is Spark and his friends
Spark is a Martian
They love science .
And they together have one dream,

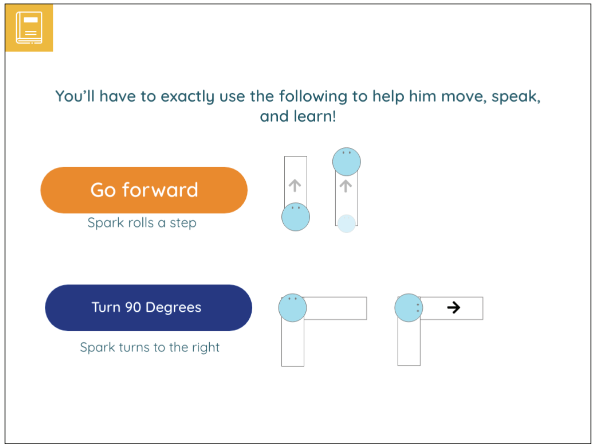

To travel to Earth and learn about it
THE DREAM
Spark and his friends want to be Earth Scientists.
So One day they hope to their spaceship and...

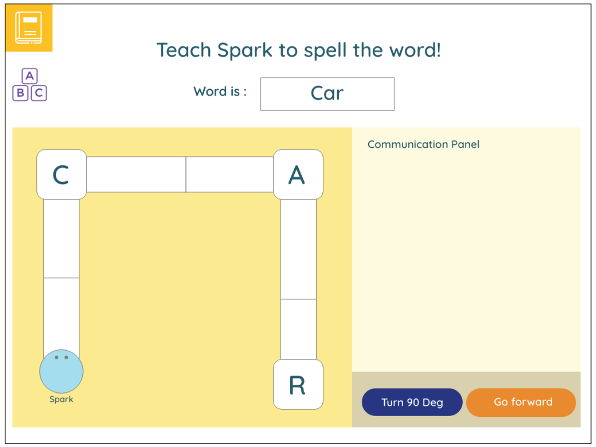

And then they landed on Earth
But Spark and his friends weren't prepared for what they saw.
People, Cars, Building, What is happening?

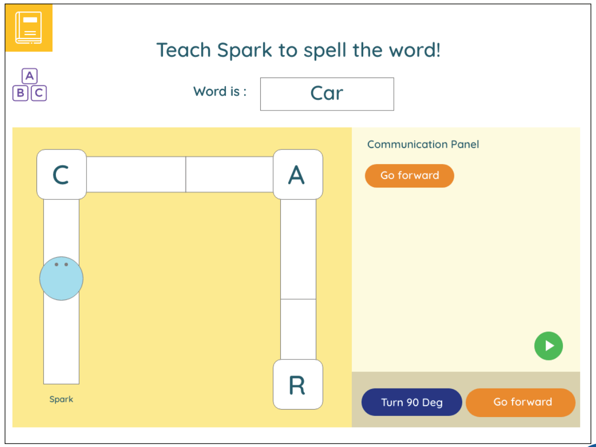

And then they landed on Earth
MUSEUM
"Where do we go ?" Where we can learn more about Earth and its people and its resources?


Would you like to teach Spark something easy or something difficult?
Easy
Not So easy
Difficult

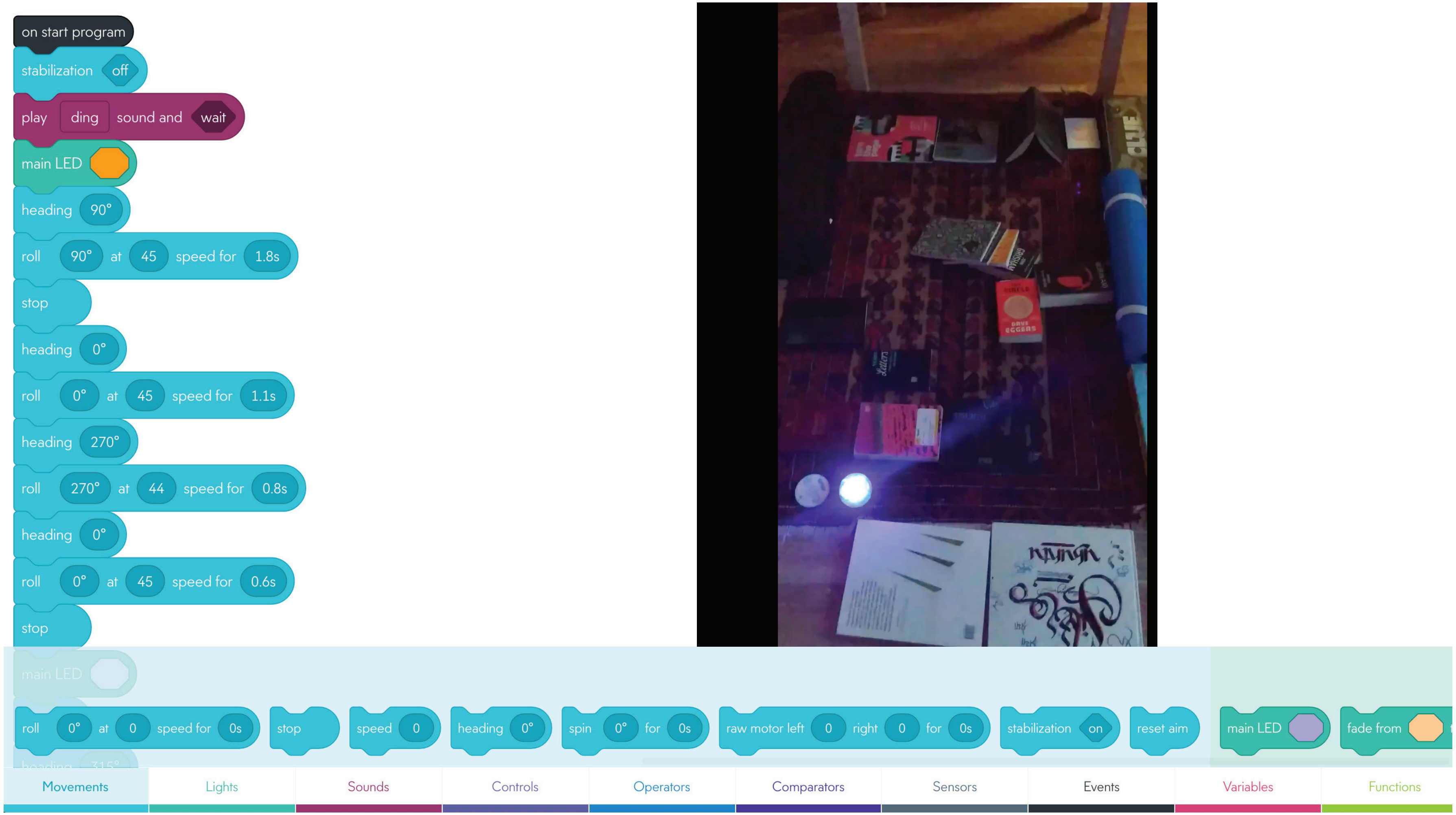

But first, let's decide what to teach Spark ?
Choose what you want to teach Spark?
Words
Water
Energy
Nature
Music
Art

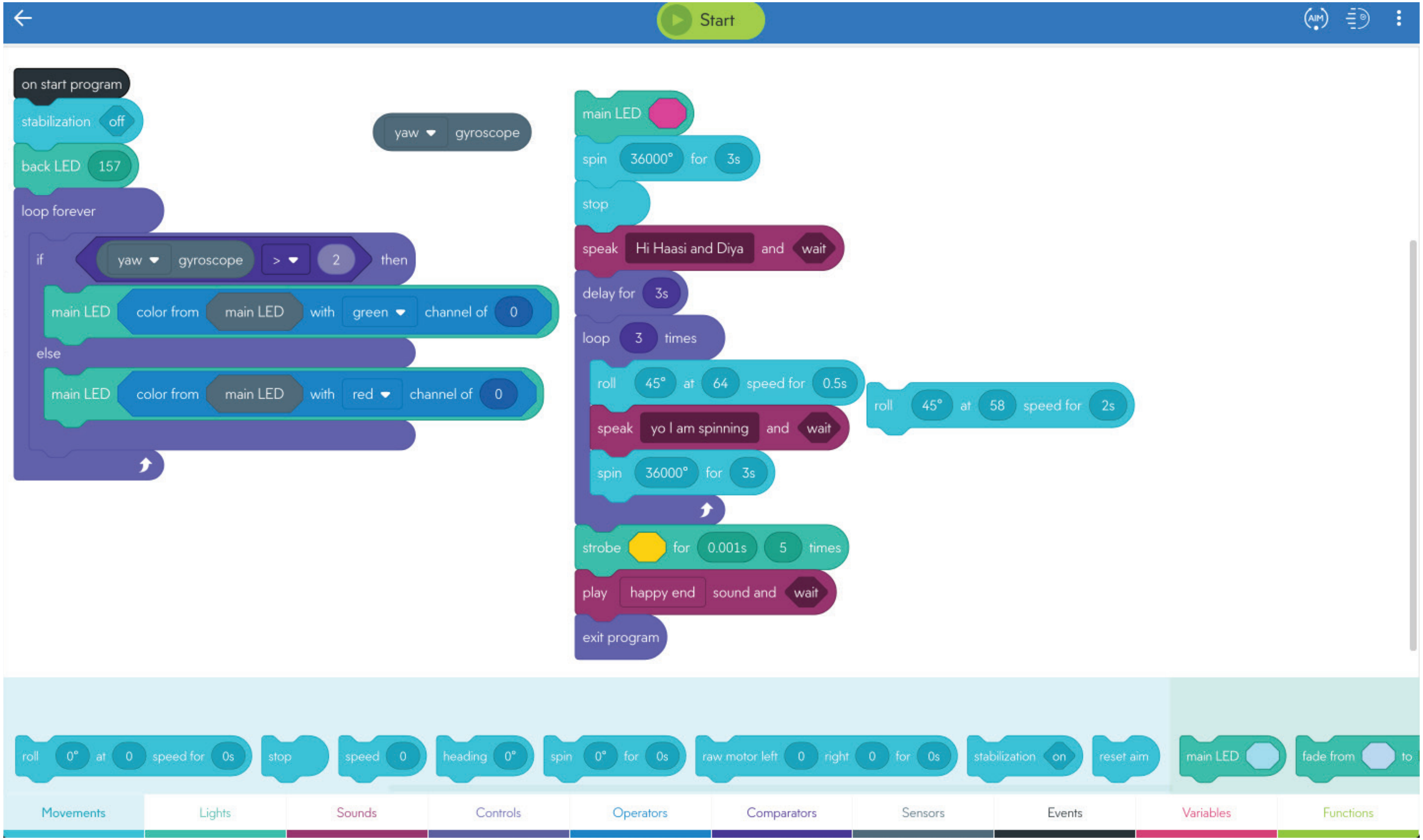

You'll have to exactly use the following to help him move, speak, and learn!
Go forward
Spark rolls a step
Turn 90 Degrees
Spark turns to the right


Teach Spark to spell the word!
Word is :
Car
C
A
R
Spark
Communication Panel
Turn 90 Deg
Go forward

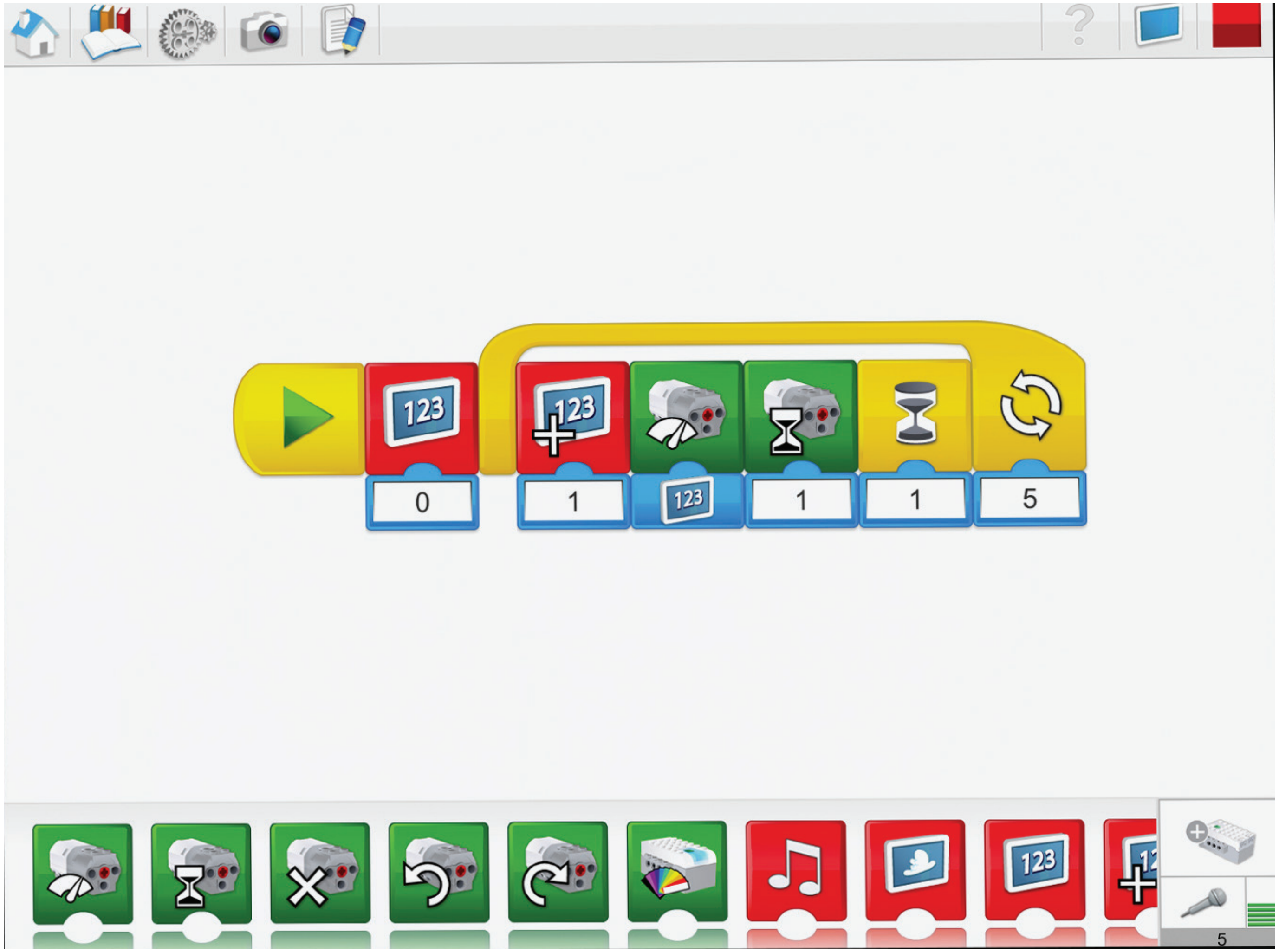

Teach Spark to spell the word!
Word is :
Car
C
A
R
Spark
Communication Panel
Go forward
Turn 90 Deg
Go forward

H. Experimenting with Sphero SPRK+

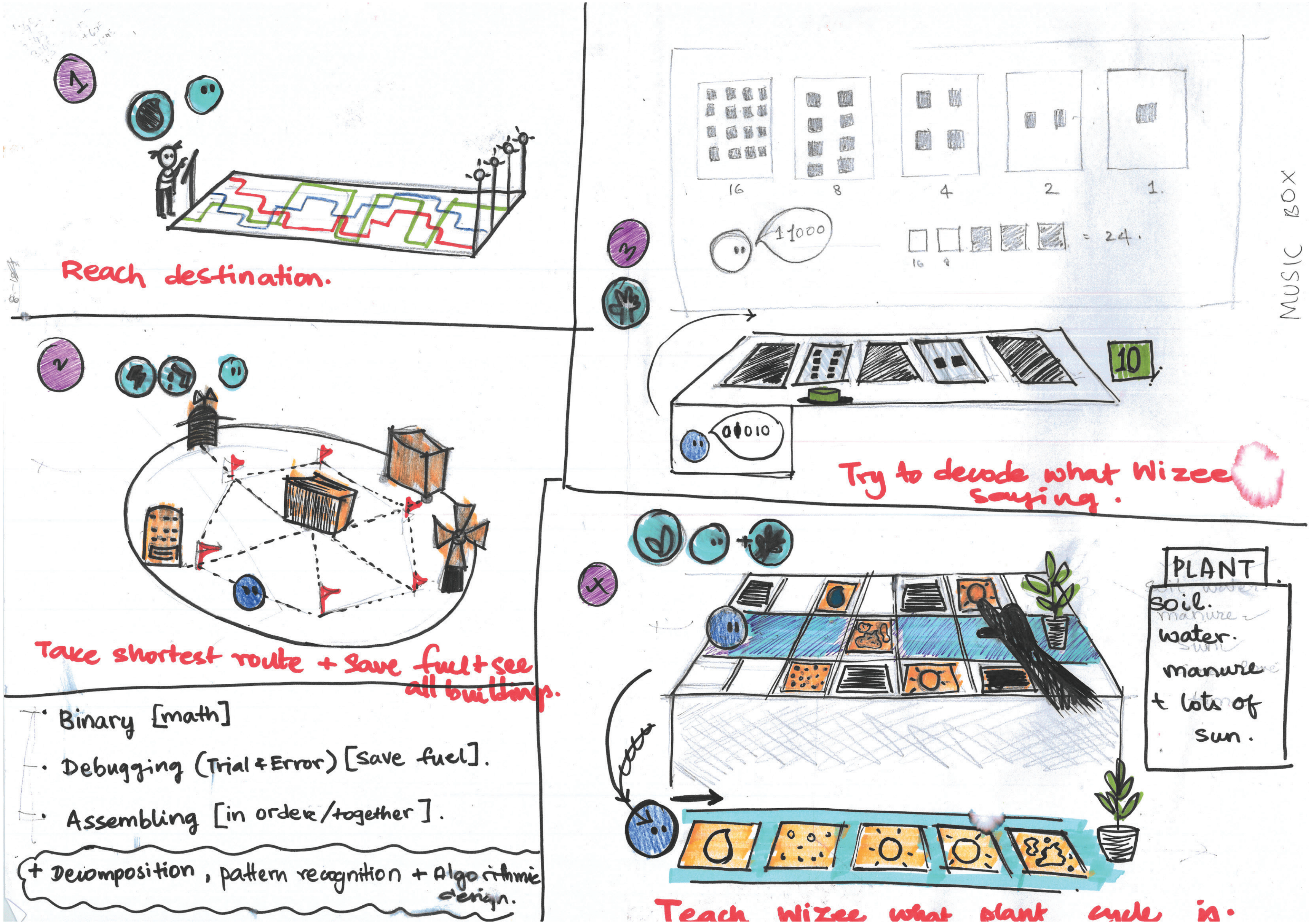



Start
on start program
stabilization off
back LED 157
loop forever
if yaw gyroscope > 2 then
main LED color from main LED with green channel of 0
else
main LED color from main LED with red channel of 0
yaw gyroscope
main LED
spin 36000° for 3s
stop
speak Hi Haasi and Diya and wait
delay for 3s
loop 3 times
roll 45° at 64 speed for 0.5s
speak yo I am spinning and wait
spin 36000° for 3s
roll 45° at 58 speed for 2s
strobe for 0.001s 5 times
play happy end sound and wait
exit program
roll 0° at 0 speed for 0s
stop
speed 0
heading 0°
spin 0° for 0s
raw motor left 0 right 0 for 0s
stabilization on
reset aim
main LED
fade from to
Movements
Lights
Sounds
Controls
Operators
Comparators
Sensors
Events
Variables
Functions

H. Experimenting with Lego WeDo



I. Detailing out the activities - sketches



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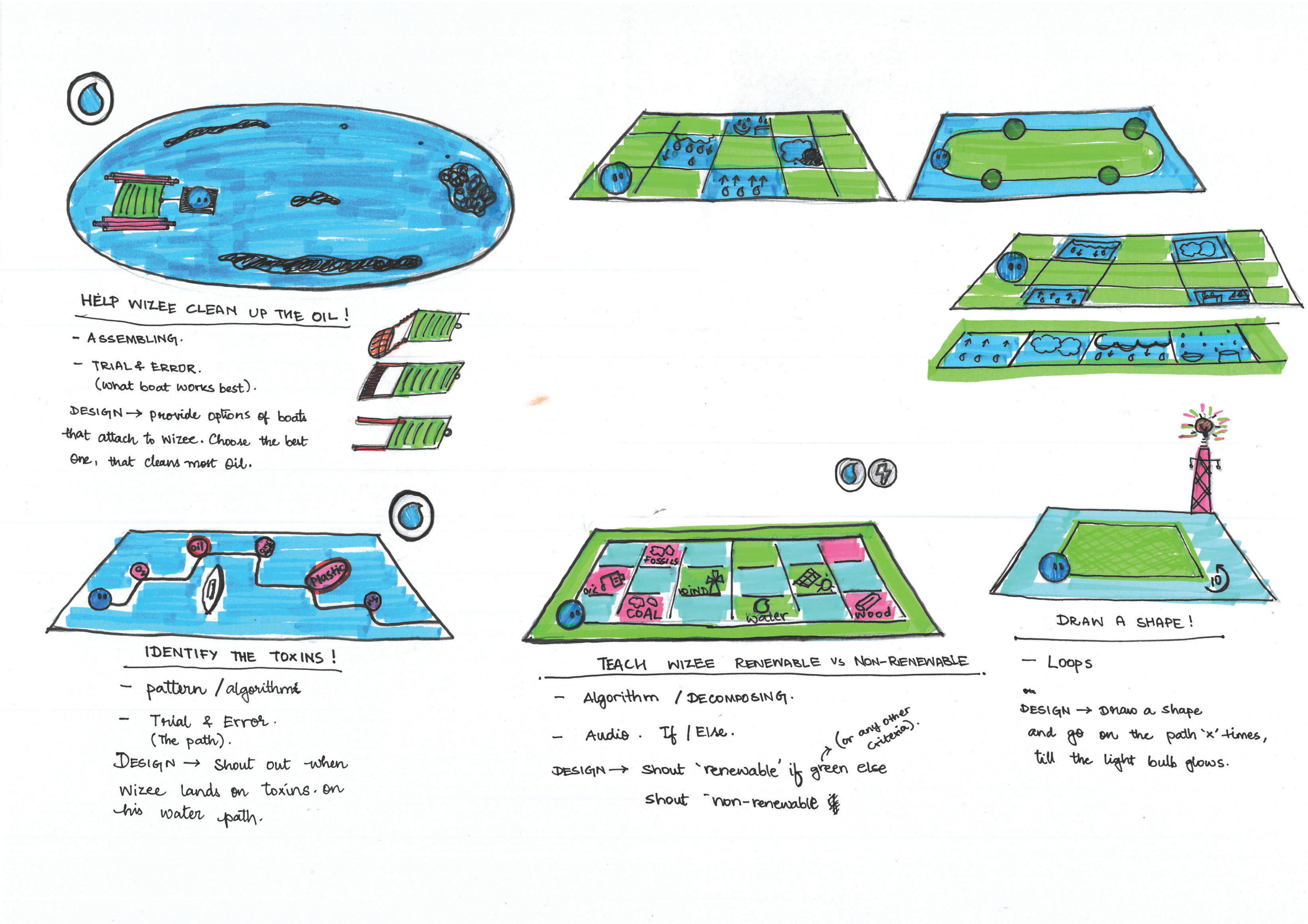

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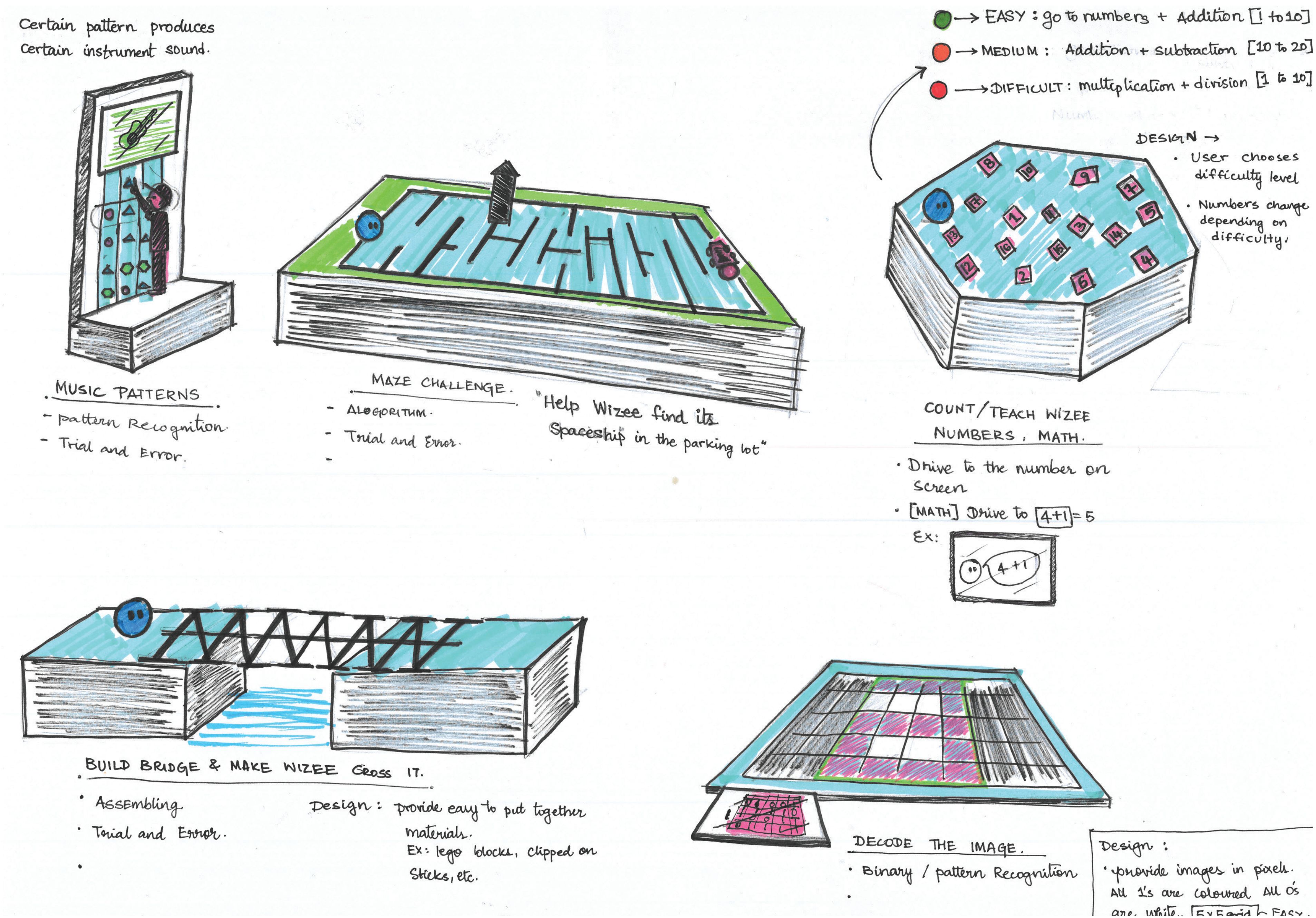
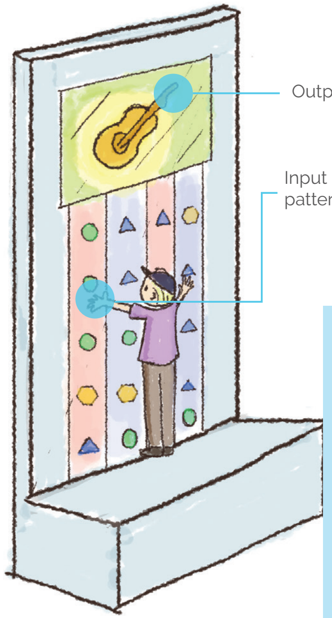


J. Detailing out the activities - infographics

General activity - no sphero . Difficulty - easy . Adaptable to different levels



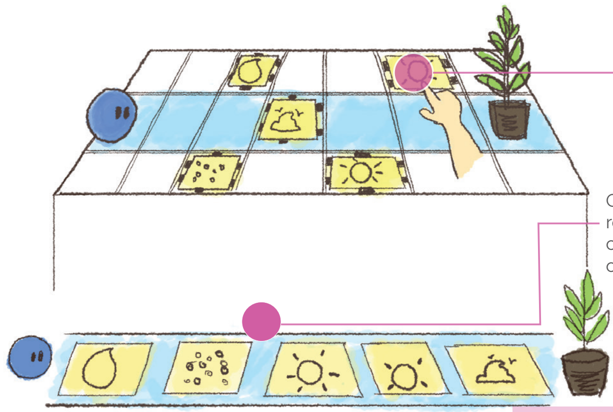
CT outcomes -
Pattern Recognition,
Decomposition.
Trial and Error.

MUSIC PATTERNS
Goal : To find the right combination of shapes such that sound of a particular instrument is produced.

Ex: User needs to find what combination of shapes produces the guitar noise.

Alternate ideas
The game can be interactive with two users. Each shape has a specific sound. User 1 creates a sound and teaches the machine to remember it. Ex: two circles, a triangle and a square. User 2 tries to guess the combination based on the sound being played

Difficulty - easy



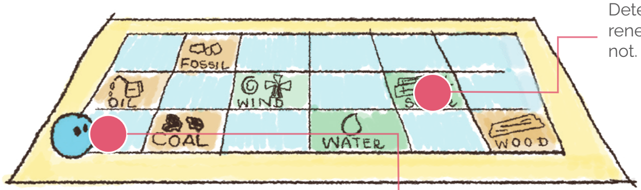
CT outcomes -
Algorithm,
Decomposition.
Trial and Error.

Plant Life
Goal : To rearrange the tiles, move around in order of what are the elements a plant needs to thrive.

Alternate ideas
Any 'cycle' can be incorporated into this, for instance, the food cycle, the water cycle. The moving tiles give a tactile feel and helps to remember later , and learn faster in the moment.

J. Detailing out the activities - infographics

Difficult : Beginner



Determine if renewable or not.

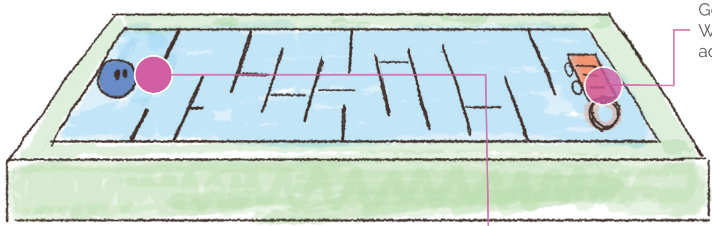
Move Wizee in the grid.

CT outcomes -
If Else
Algortihm
Decomposition

Renewable and Non-Renewable Resources
Goal : Program Wizee to across the grid and stop at energy sources. Make Wizee say 'renewable' or 'non-renewable' depending on the source.

Alternate ideas
The pattern for the resources can change depending on the difficulty level. The learning will then be two fold - movement of Wizee and the assessing what is renewable and non-renewable.

Difficult : Beginner to Advanced



Goal for Wizee to achieve

Input pre determined steps for Wizee to move

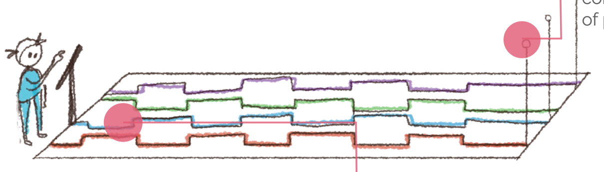
CT outcomes -
Algorithm,
Decomposition.
Trial and Error.

Help Wizee find its lost vehicle
Goal : To help Wizee go through a parking lot maze to reach its watermobile.

Alternate ideas
The maze can be projected on a surface, the structure of the maze depends on the level selected. This helps to keep the activity constantly challenging.

J. Detailing out the activities - infographics

Difficult : Beginner

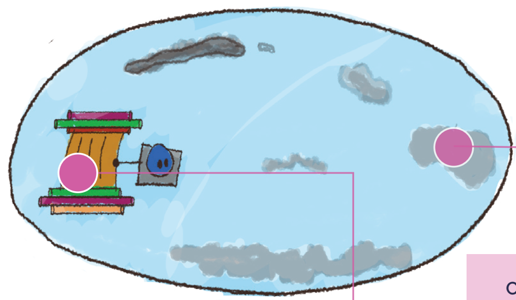


CT outcomes -
Algorithm,
Decomposition.
Trial and Error.

Light the bulb
Goal : To use Wizee, and move along the circuit such that it generates energy to light a bulb. Each line is a pattern and the circuit is finished when Wizee reaches the end of the line.

Alternate ideas
Any 'cycle' can be incorporated into this, for instance, the food cycle, the water cycle. The moving tiles give a tactile feel and helps to remember later , and learn faster in the moment.

Difficult : Beginner



CT outcomes -
Assembly
Trial and Error.

Clean the oil spill
Goal : To assemble a boat, and use Wizee to drive the boat and clear the oil spill from the water body.

Alternate ideas
To make it easy or difficult and depending on time, the users can be provided with pre-exisiting design of boats to assemble or provide user with materials and let them figure out the design. Example of materials include ice creams ticks, straws, rubber bands

J. Computational Thinking table

Decomposition	*Pattern Recognition*	*Algorithm*
Breaking down a problem into smaller parts. E.g 20 questions or guess who.	Observation of patterns,similarities in drawing conclusions from it. E.g Enigma Machine, spot the difference.	A plan, set of steps, by step instructions to solve aproblem.
Water cycle - one after other, evapouration to infiltration. How to clean your teeth, step by step instruction.	Function Machines - See input and out put and try to work out the middle. Traffic patterns - Find best way to travel to visit all the major tourist attractions. https://www.bbc.co.uk/bitesize/guides/zxxbgk7/revision/3 https://sites.google.com/isabc.ca/computationalthinking/pat	Maze challenges - step by step way to reach the goal , get out of the maze. Lost something - How to look for it? Retrace steps.

General Ideas from science cirriculum and Sphero Edu repository

Layers of the Earth's suface. Water cycle Plant life River course Butterfly life cycle PollutionL earning numbers and spellings

https://www.education.com/worksheets/science/ https://life-lab.org/how-it-works/