Children and sustainability in the household

A bachelor graduation project under Storytelling with Data

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Creative Media & Game Technologies

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Colophon

Title

Children and sustainability in the household

Research question

How can gamification elements be used in data visualizations that are aimed at children ages 6 – 12 in The Netherlands, to communicate the most current topics of sustainability within the household?

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Abstract

With many countries pursuing more sustainable livelihoods due to the SDGs, governments around the world are trying to find new ways to educate citizens about sustainability. This is also the case in the Netherlands. However, due to its complexity, some demographics are still not very well-versed with this topic. One of these demographics are young elementary children.

In this report, the question *"How can gamification elements be used in data visualizations that are aimed at children ages 6 – 12 in The Netherlands, to communicate the most current topics of sustainability within the household?"* is answered through extensive desk research, surveys, and brainstorm workshops with the target demographic.

Using that answer, a proof of concept is developed and tested with the target demographic. The results of this test show a connection to the initial research and further reinforce the findings. The results also show a positive outlook towards the concept from the target demographic. These results are then used to suggest future recommendations for both the prototype and the research.

Keywords: Sustainability, children, education, gamification, data-visualization, the Netherlands

Preface

The report you are currently reading: “Children and Sustainability in the household”, was written for my Bachelor of Science graduation assignment from the Creative Media and Game Technologies course at Saxion University of Applied Sciences. This report was written as part of the Storytelling with Data project from the research group Smart Cities from February 2023 to June 2023.

During my time working on this report, I had the opportunity to meet and work with many inspiring people who pushed me to build myself even more as a professional and prepare me for what comes after graduation. I was able to learn about sustainability and data-visualization from my colleagues and tried things I had never done before during my field research. Even though I was given the freedom to structure my project in my own way, I still felt supported by my supervisors who provided insightful feedback every week.

For this, I want to formally show my appreciation to my supervisors Mark Melenhorst and Timothy Geesing. I also want to extend my gratitude to the rest of my colleagues at Smart Cities who were always there if I needed anything.
I would like to thank my graduation coach, Lukas Malec for his guidance during this project and to my graduation circle peers for always offering their insights during our meetings.

A huge thank you to the Dr. Martin Luther Kingschool for offering to participate in the workshops and testing, with an even bigger thank you to all the participants. And to Morlay Souaré for organizing the meetings with the school. I would also like to show my gratitude to all the parents and teachers who participated in the surveys. I also want to thank my peers who participated in the group brainstorming session.

Lastly, I would like to offer a special thank you to my friends and family who were there for me even when I wasn’t there for myself. You never stopped supporting me and pushed me to keep going. Without each and every one of you, none of this would be possible. And for that, I thank you from the bottom of my heart.

Thank you, reader, for picking up my report. I hope you enjoy your reading.

Nicolle Louiza
Enschede, 20 June 2023

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Glossary

Sustainability

The practice of maintaining an ecological balance by fulfilling our societal needs while still conserving the planet's natural resources to ensure the well-being of future generations.

Data literacy

The ability to read, understand and communicate data.

United Nations (UN)

The world-wide organization that focuses on maintaining peace, cooperation, and friendly relations among nations.

Proof of concept

An (early stage) demonstration for a concept or design.

HUB

The central point of something. In computing, it refers to the point where data from different directions cross paths.

Vector art

A form of computer graphics that creates illustrations from geometrical shapes.

Carbon footprint

The indicator of the total greenhouse gas emissions generated by an individual or individuals.

1. Introduction

1.1. Company particulars

The research group Smart Cities is one of the 29 research groups from Saxion University of Applied Sciences and falls under the "Smart Industry" research field of Saxion (Egbers - Zoetebier, 2023). It was established in 2016 under the lectureship of Mettina Veenstra and has 16 employees and various interns. Before that, the research group was known as Media, Technology and Design (Veenstra, 2023).

They work with municipalities on various projects about smart technology, societal challenges, and the quality of life in a technologically advanced city. Their primary focus is to involve citizens in the discussions and design processes regarding these topics (Geesing, 2023).
There are two research fields within Smart Cities: *"Improving quality of life with smart city applications"* and "*Guiding government policy based on data*". The latter being the field of this research paper (Saxion, n.d.).

1.2. Problem orientation

1.2.1. Current situation

The Smart Cities research group from Saxion Hogeschool, is currently working on a project called *'Storytelling with data'*. The goal of this project is to create a toolbox *'Eerste hulp bij datagedreven inwonerparticipatie aan duurzaamheidsbeleid'* (First aid for data-driven citizen participation in sustainability policies) using data-visualizations, to address the challenges that a lot of Dutch municipalities face when trying to communicate sustainability policies to their citizens (Saxion, 2021). Namely, that they primarily get the usual demographic (often those specifically interested in these topics), to be involved with sustainability policies. Meanwhile these policies are relevant to- and affect all of the public. Therefore, the municipalities seek to find ways of involving other target demographics and especially those with differing levels of data literacy. That is where the 'Storytelling with data' project comes in. As it aims to not only discuss these challenges, but also find suitable solutions (Melenhorst & Veenstra, 2020).

Due to the complexity and size of *"Storytelling with data",* it was divided into smaller categories. This division was made to work with different target demographics and have a better overview of the general public (Scheepmaker, 2023). One of these sub-categories is young children in The Netherlands. That is the category in which the project of this research paper resides.

1.2.2. Problem definition

Currently, Smart Cities does not have any experience working with children on any of their previous projects. Within the *"Storytelling with data"* project there is also no existing project that tackles this target demographic yet. Therefore, they currently do not know how to make data visualizations that are suitable for young children and communicate the topic of sustainability within the household (Scheepmaker, 2023). Furthermore, they also want to get more acquainted with video games and other creative media technologies and how these can be used to communicate complex topics to the public. Most specifically, to children (Scholten, 2023).

Therefore, the "Children and sustainability in the household" project will focus on answering the research question:

"How can gamification elements be used in data visualizations that are aimed at children ages 6 – 12 in The Netherlands, to communicate the most current topics of sustainability within the household?"

1.3. Project objective

The aim of the *"Children and sustainability in the household"* project is to research into and develop suitable data visualization(s) for young children in the Netherlands. These visualizations should communicate the topic of sustainability within the household by using gamification elements. This research can then be referenced when the Smart Cities research group has future projects involving this target demographic.

The research findings would be derived from a combination of desk research: theoretical background, published studies, reports and field research: focus groups, personal communications, and surveys. With these findings, one or multiple concepts will be created which illustrate examples of data visualizations that engage children using gamification. These visualizations will also be used to directly test with the target demographic to reinforce the findings, the design choices and to extract future recommendations.

1.4. Target demographic

1.4.1. Direct target demographic

The target demographic for this project are elementary school children (Scholten, 2023). According to the Dutch law, children can start elementary school (Basisschool) at age 4 in the Netherlands. Elementary schools are divided into 3 sub-categories: "onderbouw" (year 1 and 2; age 4 to 6), "middenbouw" (year 3 to 5; age 6 to 9) and "bovenbouw" (year 6 to 8; age 9 to 12) (Anstadt, 2022). However, because children in the onderbouw are still preparing to start learning once they reach year 3, this project will focus on children from year 3 to 8 (age 6 to 12) who have already started learning from the school curriculums (Peters, 2009).

1.4.2. Indirect target demographic

There are two indirect target demographics for this project. The first one is parents or guardians of the direct target demographic. These are the people who are responsible for raising their children. Their parenting ways will be crucial in the child's development and knowledge (National Academies Press (US), 2016). The second indirect target demographic are teachers and those who work with children. Teachers and educators have significant influence on the development of children and their knowledge of the world (Seth-Smith, 2006).
Therefore, the input of both of these demographics can be valuable to this project. And they are both crucial for eventual questions that may arise from this project. Due to their importance on [their] children's development, as mentioned above.

2. Main and sub-questions

2.1. Main question

"How can gamification elements be used in data visualizations that are aimed at children ages 6 – 12 in The Netherlands, to communicate the most current topics of sustainability within the household?"

2.2. Sub-questions

I. *Which gamification elements are the most suitable for applications meant to educate young children in The Netherlands?*
II. *What are the most suitable techniques for data-visualizations aimed at young children in the Netherlands?*
III. *What topics of sustainability are currently communicated to young children in The Netherlands?*

2.3. Scope

2.3.1. Deliverable

Below is a list of deliverables for the Smart Cities database and the graduation curriculum of Saxion.

1. A final research paper which contains all the research findings, the design and development process as well as the test sessions and results. Documented in a professional format.
2. Proof of concept: One or multiple (interactive) visualizations developed in Figma. These concepts were tested with the target audience at least once. With the results documented in the research document.
3. A library of original assets created by Nicolle Louiza for the purposes of this project.

2.3.2. Inclusions

The research paper contains both an analysis of existing academic papers, and an overview of the self-conducted field research regarding the sub-questions at hand. The field research is comprised of workshops with the target demographic, surveys and personal communications with the indirect target demographics and workshops with other professionals outside of the target demographics. Aside from this, it also contains an overview of the development process for the proof of concept and the testing results with the corresponding recommendations and discussions.

The scope of the proof of concept encompasses an interactive prototype in Figma with self-made assets and a gamified data visualization that illustrates the findings of the research paper.

2.3.3. Exclusions

The scope of the research paper excludes an extensive analysis of the impact of the proof of concept on the target demographics and does not explore the cognitive process of the direct demographic during the workshops and testing sessions. This is because these do not fall within the scope of this research paper and would require their own research.

The proof of concept excludes an extensively researched and factual database of information and also excludes other medias of data visualization as these require more time and expertise outside of the scope of this project.

2.3.4. Constraints

Due to the short timeframe, lack of budget and the project consisting of only 1 person, the scope was constrained within these boundaries. Smart Cities does not have many employees with expertise working with children, therefore this project relies on existing literature, limited self-conducted field research, and outsourcing of information and materials. The proof of concept is also limited to a prototype in Figma with minimal interactivity.

2.3.5. Assumptions

The assumption was that if the current lack of engagement in sustainability from the direct target demographic could be identified, it could guide both this project and the research group Smart Cities on how to communicate sustainability topics to children. Another assumption was that the lack of engagement in sustainability from the direct target demographic stems from the indirect target demographics (parents, guardians, and teachers) and if the gap on the topic of sustainability between the demographics could be narrowed, this would increase the engagement of the direct target demographic.

3. Research methodology

In order to answer the main question of this research paper and to achieve the deliverables, the methodology was a combination of desk research and field research. The analysis of existing literature served as a starting point and guideline for making both practical and design decisions regarding project *"Children and sustainability in the household".*

Substantial data was collected from existing literature to answer the sub-questions and structure the design process. This data was then used to create concepts which were tested with the target demographics. Alongside this, various types of field research were conducted to check the literature findings and iterate on both the research and design of the project.

In the end, the research results, the design, and the conclusion of this project are based on the iterative findings of these methods.

3.1. Sub-question I

Which gamification elements are the most suitable for applications meant to educate young children in The Netherlands?

***Table 1** – Sub-question I methods*

Desk research
• Extracted applicable data from existing literature on educative games for children. • Conducted a market analysis on similar projects to extract their approach. • Analysed the work and research of similar peer projects and their findings.
Field research
• Brainstorm session with peers • Personal communications with other professionals • Focus groups with the direct target demographic to test the developed concepts.

3.2. Sub-question II

What are the most suitable techniques for data-visualizations aimed at young children in the Netherlands?

***Table 2** – Sub-question II methods*

Desk research
• Extracted applicable data from existing literature on data visualization for children. • Conducted a market analysis on similar projects to extract their approach.
Field research
• Brainstorm session with peers. • Personal communications with other professionals. • Focus groups with the direct target demographic to test the developed concepts.

3.3. Sub-question III

What topics of sustainability are currently communicated to young children in The Netherlands?

***Table 3** – Sub-question III methods*

Desk research
• Extracted applicable data from existing literature on sustainability and children.
Field research
• Survey for parents and guardians (Indirect target demographic 1). • Survey for teachers (Indirect target demographic 2). • Personal communications with other professionals and the indirect target demographics. • Workshops with the direct target demographic to empathize with them and gain insight into their understanding of the topic of sustainability.

4. Theoretical framework

An overview of the background knowledge gathered regarding the topic at hand.

4.1. What is gamification?

In a broad sense, gamification is the application of game elements to an otherwise non-game related context. This is typically done to enhance user engagement, user experience (UX) or to create more compelling designs (Deterding et al., 2011).

There are many elements that can be classified as gamification elements when talking about the design and theories of game development. However according to Werbach and Hunter (2012), these can be divided into 3 main categories as shown in *Figure* 1:

1. **Game components:** The specific features required to carry out the mechanics and dynamics of the game. These usually serve as the building blocks and tools to ensure the game mechanics and dynamics can be achieved.
2. **Game mechanics:** The processes and actions that push the game and the player forward while pulling user engagement.
3. **Game dynamics:** The general overarching elements that create the "big picture" of the game. These are the elements that drive the user to develop over time. If well designed, game dynamics can be used to manipulate and steer users to achieve (their) goals within the game.

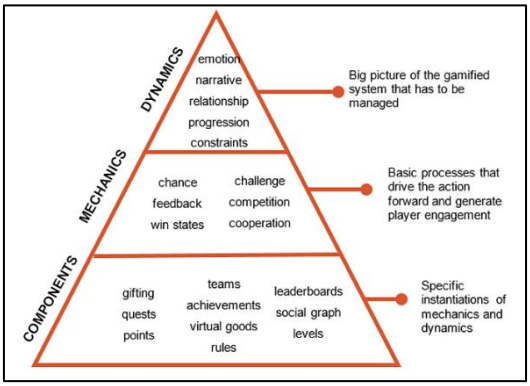

Figure 1 - Hierarchy of game elements [Graph]. S. P. Adams (2019)

In recent years however, there have been many different iterations and branches to further define what qualifies as game elements and what it takes to create a gamified system. For example, the addition of game aesthetics to the hierarchy (Man, 2021).

Just like the previous categories, aesthetics in gamification has many variations. However, for this research paper, the definition of aesthetics according to Goethe (2019), will be applied. In his writing, Goethe refers to **aesthetics** as: The sensory experience of the game that the user undergoes in the form of visual, aural, haptic, and embodied senses. In other words, how the game experience appeals to the user and how it affects their perception and emotions.

4.2. What is data visualization?

According to the SAS Institute (n.d.), data visualization is the graphical presentation of data and information which uses visuals such as tables, charts, and graphs to compile and illustrate data. It can be beneficial for industries working with large amounts of information that they need to translate to users or other parties, as it helps make complex information more accessible. This is especially evident in fields such as education, marketing, government, and finances (Tableau Software, n.d.).

In the Smart Cities research group, data visualization is one of the main focuses for many of their projects. One of their goals, as mentioned before, is to aid municipalities in communication with different target demographics of the general public by using data visualizations. Therefore, the data visualizations created must be easy to understand even for citizens with low data-literacy (Lectoraat smart cities, 2022).

This in turn poses a challenge for the research group: creating data visualizations that can easily be understood by citizens of different levels of data literacy can be complicated and requires a lot of research, testing and iterating (Melenhorst & Veenstra, 2020). Not only that, but there are many different techniques for visualizing data as shown in *Figure* 2. So, it is crucial to determine which method is most effective to deliver the message as clearly as possible for the intended demographic(s) (International Business Machines Corporation, n.d.).

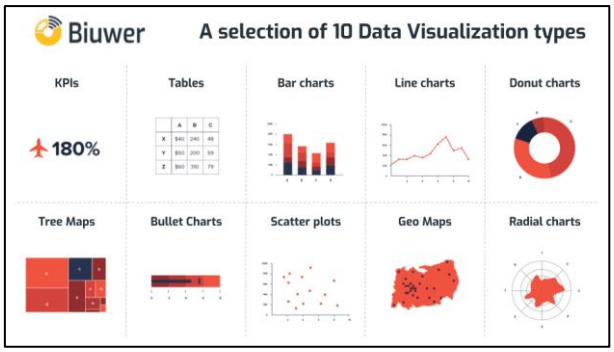

Figure 2 - Examples of Data Visualization types [Graphs]. Biuwer (2020).

4.3. What constitutes as sustainability within the household?

In 2015, all the Member States of the United Nations (UN) agreed to try and achieve the 17 Sustainable Development Goals (SDGs), previously discussed in a 2012 Sustainable Development conference, by year 2030 (Department of Economic and Social Affairs, n.d.). These 17 goals were then broken down into 169 targets which each country is responsible for integrating into their policies (Martin, 2018).

The sustainable Development Goals (*Figure* 3) and targets are guidelines that serve as a "to-do list" for the United Nations countries. The ultimate goal of them is to end poverty, world hunger, discrimination and to protect the planet so that all of humanity can live in peace and prosperity (UNDP, n.d.).

Because of this, many countries have policies or regulations which encourage the public to pursue more sustainable behaviour in their daily lives (Department of Economic and Social Affairs, n.d.). However, to

Figure 3 - Sustainable Development Goals (SDGs) [Image]. Global CSR Foundation (2019)

understand what constitutes as sustainability in the household, it is first important to note that not only do regulations differ from country to country, but each household is also different. Things such as location, capital, the household composition, and lifestyles have a large impact on how different households handle sustainability and what is capable within their means, even under their government's regulations (Pérez-Sánchez et al., 2022).

However according to Wisner (2022), there are still a few general activities that classify as sustainability in the household:

1. Reducing plastic waste
2. Reducing food waste
3. Re-use and recycling of products
4. Rational and responsible consumption
5. The use of low-emission transportation

5. Research findings

The research findings prior to the development phase in relation to the sub-questions.

5.1. Which gamification elements are the most suitable for applications meant to educate young children in The Netherlands?

As established in the theoretical framework in chapter 4.1, there are numerous gamification elements with more coming out every year. Therefore, the elements that are most suitable for a project, will heavily depend on the design, target, and purpose of the project (Mullich, 2015).

In a study conducted with 120 elementary children, it was observed that the top 3 gamification elements that children were most interested in were: **Challenges**, **Visuals (aesthetics)**, **User Feedback** (Nand et al., 2019). These elements were also used to prove their effectiveness in an educational game during the study. Though, it is important to note that other gamification elements were also used to create the game that was tested in said study, as seen in the table below.

***Table 4** - Game elements as described in the report of Nand et al.*

Components	Mechanics	Dynamics	Aesthetics
Levels	Transient feedback	Progression	Bold colors
Score	Permanent feedback	Education	Transient dialogues
Questions	Challenges	Collaboration	Color contrast
	Win states		Highlights
	Hints		Loop music
			Feedback sounds

In another article, Nanda (2021) lists the following gamification elements for creating effective educational games: **Conflict, Strategy and chance, Visual aesthetics, Theme and story, Rewards.**

But in order to get a better overview of what gamification elements are being used in educational applications for children, an analysis of existing applications was conducted in the table below. In this analysis, the following 3 games were chosen: **Recycle City**, **Ice Flows** and **Waterland Klimaatspel**. These were chosen because they fit the direct target demographic while containing varying sustainability topics. Besides analysing these games using the gamification hierarchy (*Figure* 1), the games were also analysed based on their input and output in order to explore how children interact with- and experience these games.

***Table 5** - Market analysis - Sustainable games for children*

	Recycle City	Ice Flows	Waterland Klimaatspel
Topics	• Various brief sustainable topics	• Climate change: in the context of glacial ice	• Water use and preservation • Nature conservation
Components	• Levels • Score • Questions • Leader board	• Levels • Score • Timer • Rules • Unlockable content • Star system	• Levels • Score • Questions • Timer • Rules
Mechanics	• Navigation • Quiz • Feedback	• Navigation • Challenges • Win-state • Feedback	• Navigation • Quiz • Challenges • Win-state • Feedback
Dynamics	• Education	• Education • Narrative • Progression	• Education
Aesthetics	• Hand-drawn • Old comic aesthetic • Highlights • Loop music • Feedback sounds	• Low-poly 3D • Vector Art • Colour harmony • Clear typography • highlights • Animations • Loop music • Feedback sounds	• Vector Art • Colour harmony • Hand-drawn • Clear typography • Feedback sounds
Input	• Mouse click	• Touchscreen: tapping • and sliding • Mouse: Clicking and dragging	• Mouse click
Output	• Audio feedback • Visual feedback: text, completed task	• Audio feedback • Visual feedback: environment change, completed task	• Audio feedback • Visual feedback: text, visuals, change of environment

In short, there are many approaches to creating educational applications for children using gamification elements. It is also important to note that just the gamification hierarchy is not enough to define which elements are best suited for the intended purpose. There are numerous other factors, both internally and externally, that affect those decisions. Input and output as used in the table above, are only 2 added items out of the surfeit of other factors that go into game development. As best described by Mullich (2015), it is up to game designers to test their products with their target audience and determine the points of interest to iterate on.

Still, it is notable that there seems to be an overarching pattern when designing educational games for children:

1. **Emphasis on aesthetics:** The use of appealing colors, graphics, a consistent style, and theme.
2. **Challenges:** Testing the player through puzzles, quizzes, or other learning experiences.
3. **Rewards:** Rewarding the player with points, score, or exchangeable tokens.
4. **User feedback:** Guiding the player experience and progression through visual and audio feedback.

While the content of these elements change depending on the context, each one of these can be found to some degree in almost any educational game aimed at children.

5.2. What are the most suitable techniques for data-visualizations aimed at young children in the Netherlands?

The human brain processes visuals significantly faster than it does text. With the majority of all the information processed by our brains being visuals (Dunn, 2023). Our brains are accustomed to interpreting and learning from visuals all day (Trafton, 2014). A 2016 study showed that visual learning proved to increase student's ability to comprehend information more effectively than traditional learning methods. This observation was particularly prominent for younger children in elementary school (Raiyn, 2016). Which is why when designing educative or data-driven products, the use of suitable visuals is important.

However, as previously discussed in the theoretical framework (Chapter 4.2), there are many approaches to visually present data. And when it comes to children, it is even more complicated to determine which visualizations are most suitable to meet their current level of data literacy. But that is where the education system is important. By taking a look at how schools incorporate data visualization in their curriculums, these techniques can be extracted and used when designing educational applications for children. Which then use visualizations that are already familiar to them.

In the Dutch educational system, children already start learning about tables and graphs in "groep 2" (school year 2). Throughout the years, they learn to read and analyse different visualizations such as pictographs, bar charts, pie charts, line charts and more (Squla, 2022). Next to the material they learn from books, teachers may also customize the way they teach the curriculum and the materials they use to better suit their students' learning trajectory and thus introducing other methods of visualizing data (Van Elk, 2021). But according to Twinkl (2021), the most commonly used data visualizations in elementary schools fall into three categories which suit any teaching style:

1. **Pictorial diagrams (pictographs):** Pictographs make use of pictures or illustrations to portray information. An example can be seen in *Figure* 4.
2. **Relationship diagrams:** There are many different types of relationship diagrams which are used to convey processes, connections, or concepts. The goal of these diagrams is often to illustrate how varying entities are related to one another. This is typically done through the use of lines and words. However, that is not to say that they are limited to only these constraints. An example of a relationship diagram can be seen in *Figure* 5.
3. **Mathematical diagrams:** Perhaps the most commonly used data-visualization in elementary schools are mathematical diagrams. Their purpose is to illustrate quantities and provide visual aid when teaching children how to process (mathematical) data. Example in *Figure* 6.

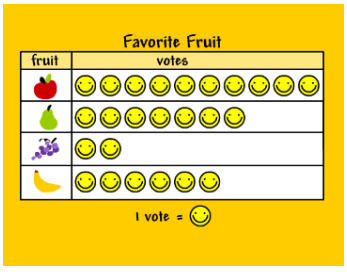

Figure 4 - Example pictograph [Diagram]. BrainPOP Jr. (2023)

Figure 5 - Example relationship diagram [Diagram]. Secretary Management Institute (2013)

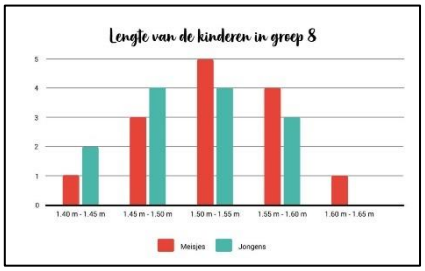

Figure 6 - Example mathematical diagram [Diagram]. R. Schaepkens (2021)

5.3. What topics of sustainability are currently communicated to young children in The Netherlands?

To understand what sustainability topics are currently being communicated to children in The Netherlands, the target demographics were approached and surveyed.

5.3.1. The children

Because children are the primary target demographic for this project, it was crucial to hear directly from them what they understand about the topic of sustainability. Therefore, a brainstorming workshop was conducted at Dr. Martin Luther Kingschool in Denekamp (*Figure* 7). During this workshop, 11 children from the "middenbouw" participated in 3 pre-established brainstorming activities (Appendix A.1)

Figure 7 - Groep 6 children at Kingschool during the test session of Morlay Souaré. [Photograph] E. Nijhuis (2023)

The children were divided into 2 groups: 5 children from year 5 and 6 children from year 4. Alongside the activities, the children were also encouraged to engage in conversation about sustainability and their understanding of it. For the younger children, activities that required writing, were fully replaced with discussions, and noted down by the organizer.

For the first activity of the brainstorm session, the children were asked to write down the first things that come to mind when they hear the word "milieuvriendelijk" (environmentally friendly). Alongside their own writing, the explanations they gave verbally were also noted down and later added to the list of keywords shown in the table below.

***Table 6** – Keywords list brainstorming session activity 1*

Year 4		Year 5	
Frequency	**Keywords**	**Frequency**	**Keywords**
5	Nature: animals, plants, and trees	4	Nature
5	Separating trash	3	Energy & water
3	Climate	3	Consumption
2	Energy & water conservation	2	Compost
2	Natural disasters	1	Green living
1	Windmills & solar panels	1	2nd hand shopping
1	Electric car	1	Humans
1	Compost		

For the second activity, the children were asked to draw *"the most environmentally friendly house or lifestyle that they can think of".* Once again, the children were encouraged to describe what they were drawing, and these discussions were noted down for later analysis.

The children of year 4 primarily focused on water conservation and the presence of nature. Notably, one frequently occurring theme was the emission of smoke into the air. However, one participant also drew the use of solar panels on their house (*Figure* 8).

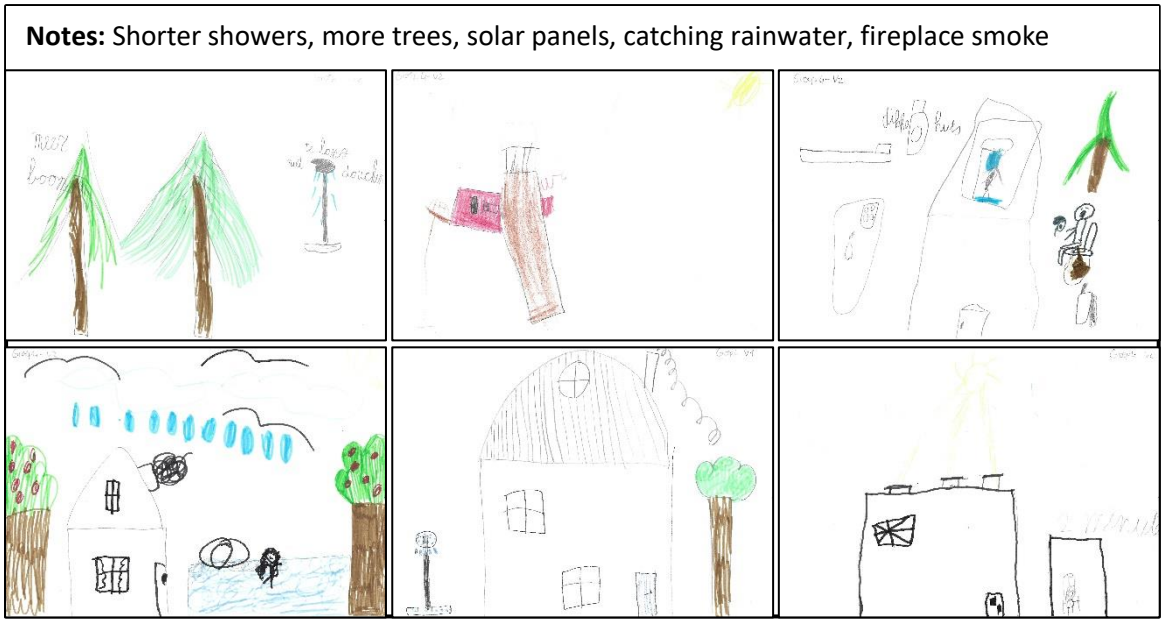

Figure 8 - Drawings year 4 – Kingschool Denekamp [Canvas]. N. Louiza (2023)

On the other hand, the children from year 5 focused primarily on green energy sources such as windmills and solar panels with one participant drawing an electrical car to their home. The second most frequently depicted topic was trash separation. Interestingly, some participants expressed feeling negatively towards smoke emissions in the air (*Figure* 9).

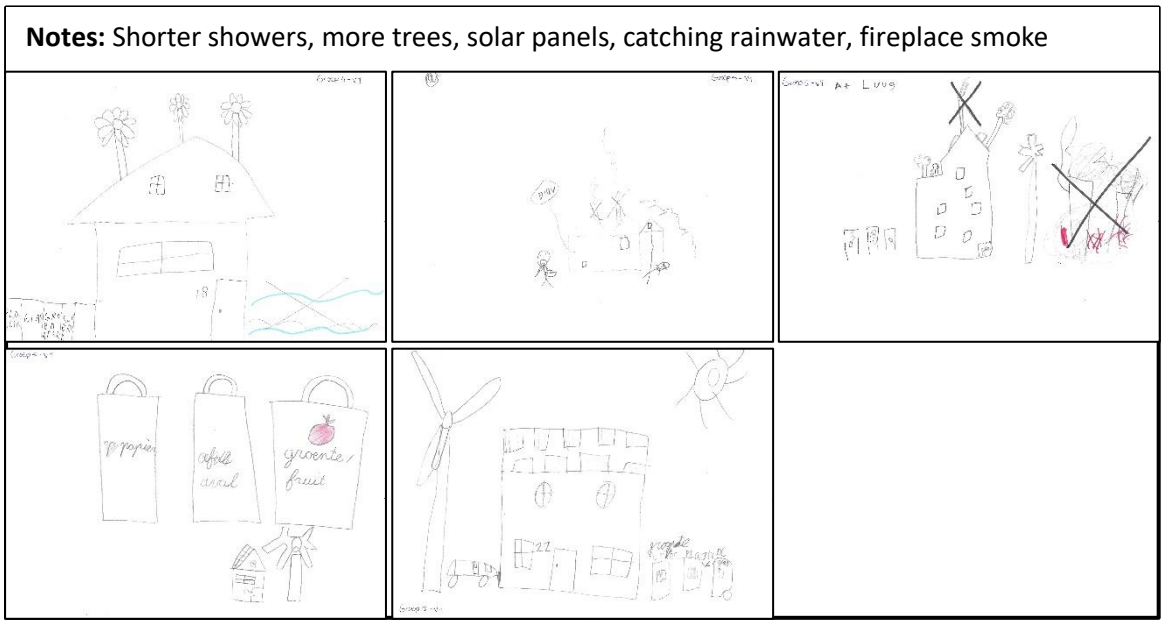

Figure 9 - Drawings year 5 – Kingschool Denekamp [Canvas]. N. Louiza (2023)

Lastly for activity 3, the children were presented with three scenarios and asked to share their opinions of each scenario which were then discussed within the group. An overview of their answers can be found in *Table* 7.

Table 7 - Brainstorming activity 3 - Scenarios results

Scenario 1: • If you saw that someone left the faucet running, what would you do? • What would you do if it happened again?				
Year 4	a	All the children mentioned they would turn the faucet off themselves.		
	b	All the children mentioned they would confront the person or call an authority figure.		
Year 5	a	All the children mentioned they would turn the faucet off themselves.		
	b	4 out of 5 said they would confront the person.	1 said they do not know.	
Scenario 2: 1. Your best friend threw some trash on the playground, what would you do? 2. What would you do if it happened again?				
Year 4	a	Some children would confront the friend.	Some would call an authority figure.	
	b	Most of them would threaten the person.	1 said they do not know.	
Year 5	a	2 said they would confront the person.	2 would pick it up.	1 does not care.
	b	2 would pick it up again.	2 would not care.	1 would get angry.
Scenario 3: One of your classmates wants to learn more about sustainability, how would you help them learn?				
Year 4	Some would try to explain.	1 said they would join them in activities.		
Year 5	3 would look for a book.	1 would look on the internet.	1 does not know.	

A full overview of the brainstorming results can be found in Appendix A.2.

5.3.2. Teachers

As stated previously, teachers are one of the primary sources of information for young minds. Therefore, it was important to understand what the current education system contains regarding sustainability. However, according to the official Dutch elementary schools' curriculum, there is no concrete learning trajectory regarding sustainability (Wettenbank, 2023). The law mentions that the topic of sustainability should be adopted by the schools but does not state to what extent nor does it specify the learning materials (Ennen, 2022).

Figure 10 - Survey for elementary teachers [Screenshot]. N. Louiza (2023)

To get a better understanding of how different schools are incorporating sustainability in their curriculum, a survey aimed at the teachers of children between 6 and 12 in The Netherlands was created (*Figure* 10). This survey was then sent out to different contacts, schools, and school associations (*Figure* 11). Unfortunately, due to their busyness and the laws around schools and participation in surveys, there were only 2 teachers who ended up participating in the survey.

Nevertheless, the teachers who participated in the survey presented some interesting insights (Appendix B). While both teachers were from the same type of elementary school, a private school, they had very differing curriculums regarding sustainability. While for one teacher their school did not present the topic at all, the other did. Aside from this, the teachers also expressed the importance of generating engagement when talking about sustainability with children. Not only engagement with the subject itself, but also in order to encourage children to take the lessons learned into their daily lives. It was mentioned that such lessons are better taught to children through practical activities rather than a theoretical approach.

School	Status	Notes
Prinseschool - Enschede	**Pending**	Email sent
St. Jan-Basisschool - Enschede	**Pending**	Form sent – With wrong school name
De Zeggelt - Enschede	**Pending**	Form sent – With wrong school name
Basisschool Pius X - Haaksbergen	**Pending**	Email sent – With wrong school name
St.-Bonifatius - Haaksbergen	**Finished**	Denied
Pieterskerkhof - Utrecht	**Pending**	Email sent
De Cirkel - Utrecht	**Pending**	Email sent
Vrije school Utrecht	**Pending**	Email sent
Panta Rhei - Deventer	**Pending**	Email sent – Speciaal school
Geert Groote (Skoba) - Dordrecht	**Pending**	Form sent
De regenboog - Dordrecht	**Pending**	Email sent
De stroming - middelburg	**Pending**	Email sent
Laurentiusschool - Delft	**Pending**	Email sent – speciaal school
Hermanbroeren - Delft	**Finished**	Denied
Stella Maris - Texel	**pending**	Email sent
Durpenhonk - Texel	**pending**	Form sent
Kingschool - Denekamp	**Finished**	Did not hear back from the principal (vacation)
Willemijn Zwart	**Pending**	Email sent. Awaiting a response
Ryan Hoekman	**Pending**	I sent a new email to Marcel Broekhaar
Director Geesteren	**Finished**	Could not help
Mark's sister-in-law	**Pending**	Inquiry sent
Stichting GameLab Oost	**Finished**	Could not help (Francis Grashuis)
Malor (Elementary teacher student)	**Finished**	She participated in the survey and sent it over to another teacher.
The Ramsey's (Voorgezet onderwijs teachers)	**Finished**	They are unable to help because their network is for higher-year students.

Figure 11 - Contact list teacher survey [Table]. N. Louiza (2023)

5.3.3. Parents and guardians

A survey for parents and guardians of the direct target demographic was also created. To gather enough data, the survey was shared online through social media, in Facebook groups, forums and printed out to share at sport clubs, parks and other places where parents were present (Appendix C.2).

There were 115 participants who accounted for a total of 136 children in this survey. In the results of the survey (Appendix C.1), 72% of the participants expressed having a positive outlook towards sustainability and 43% regularly include their children in sustainable activities. On the other hand, 13% of the participants expressed that sustainability is unimportant in their household with 21% of the participants rarely or never including their children in sustainable activities.

In total, 79% of the surveyed parents expressed that they include their children to some extent in sustainable activities. Meanwhile, 44% expressed that they rarely or never initiate conversation about sustainability with their children and 64% of the children rarely or never initiate conversation. The survey results also showed that 44% of the participants are satisfied with what schools teach children about sustainability while 21% of the participants are dissatisfied.

5.3.4 Sustainability topics conclusion

Based on the results of these field research, a few observations were made Appendix D. Firstly, there seems to be a disconnect in communication between parents and children. This is especially noticeable when comparing how much the parents expressed including their children in sustainable activities in contrast to how much they talk about it. During the brainstorm sessions, the children also had a harder time expressing why they made certain decisions despite expressing that it was the right decision to make. Because of this, it is hypothesized that children understand the call for action on sustainable activities, but they do not understand why these actions are important. It was also noted that the lack of concrete materials for teachers further creates a disbalance among children's understanding of the topic of sustainability.

The surveys and workshops did however give a clear overview of which sustainability topics are currently communicated to children as shown in the keyword analysis below:

***Table 8** - Sustainable keywords ranking and frequency*

Rank	Activity	Frequency
1	Recycling	49
2	Sorting trash	44
3	Energy conservation	22
4	Gardening & sustainable consumption	19
5	Water conservation & environment clean-up	16
6	Sustainable transportation	11
7	Upcycling	9
8	2nd -hand shopping	8
9	Compositing	7
10	Donating	3

***Note:** The frequency was calculated using the feedback from parents and the results of the brainstorm sessions with the children. Rankings containing multiple activities were the result of a tie.*

6. Ideation

Creating a suitable concept based on the research findings.

6.1. Brainstorming

6.1.1. Group brainstorming

At the start of the ideation process, a group brain-writing session was organized with 4 participants. Each with varying degrees of understanding of this project.

1. **Artist:** Some insight into of the project.
2. **Technical Artist:** Limited insight into the project but working on something similar.
3. **Technical Designer:** Moderate insight into of the project.
4. **Designer (Author):** Full understanding of the project.

The brain-writing was divided using the same categories previously used for the market analysis of sub-question 1 (chapter 5.1). However, to simplify the process for all the participants, the game components, mechanics, and dynamics were grouped up into “gamification elements”. The participants were given 5 minutes to write down different elements that fall under these categories. The elements were later placed into respective sub-categories to be used as a starting point for generating ideas (*Figure* 12).

Figure 12 - Brainwriting session results [Canvas]. N. Louiza (2023) – See appendix E.

6.1.2. Idea generation

Using the results from the brain-writing and the research findings in chapter 5, two main ideas were generated.

6.1.2.1. Idea 1 – "Sustainable tasks tracker"

A gamified application which keeps track of children's daily "sustainable behaviour" through tasks which they can complete by taking a picture of or scanning the task when it is done. For example: the application will remind children to turn off electronics and appliances. The game inspiration came from Pokémon Smile which also uses the camera feature to motivate children to brush their teeth.

***Table 9** - SWOT analysis "Sustainable tasks tracker"*

Strengths	Weaknesses
• Focuses on **actionable activities*.** • They learn while actively contributing to their households' sustainability. • Mixes game with reality. • Parents can customize which tasks they want the game to include.	• Requires that the users have access to a mobile device with a camera. • Scanning the same things could become repetitive. • Doesn't directly incorporate the parents
Opportunities	**Threats**
• Could be merged with other activities for children to learn about.	• Privacy concerns with the use of camera. • Children might be too distracted by the application and lose quality time with parents.

***Actionable activities:** Activities through which they can contribute to their households and environment.*

While there were a lot of promising positives with this concept as shown in *Table* 9, the threats and concerns for the scope and feasibility, ultimately made it so that this concept was not further explored.

6.1.2.2. Idea 2 - "Project SK"

One of the main takeaways from the field research (Chapter 5.3.4), was the lack of readily available resources. When conducting the market analysis in chapter 5.1, it was also noted that although there are different resources on the internet about sustainability for parents, teachers and children, these resources were scattered or mixed in with other unrelated learning material. Because of this, the concept of "Project SK" was created:

A web application (or website) that will be used to aid parents when explaining complex sustainable topics. The app would serve as a "HUB" for educative games, visuals, videos, and other materials for children and categorized by their learning trajectory.

- For the scope of this project: The HUB will also contain **1 lo-fi prototype** for an interactive visualization about power conservation as proof of concept for the use of gamification in data visualization.

***Table 10** - SWOT analysis of "Project SK"*

Strengths	Weaknesses
• Primarily focuses on younger children. • The HUB focuses on **actionable content*** for children. • Contains different categories of content. • Divided by learning trajectory. • Contains information & guides for parents to teach their children and include them in sustainable activities.	• The amount of information could be overwhelming or too complicated for younger children. • If the focus is too much on gamification, it could defeat the purpose of delivering the messages.
Opportunities	**Threats**
• Could be one of the first HUBs for educative sustainability content for young children in The Netherlands. • Could be adopted into the education system to aid children in learning about these complex topics.	• Children may not be interested in interacting with this application on their own. • Parents and children may use other sources, such as Google, to get the answers to their questions.

***Actionable content:** Content that focuses on activities and topics that children can contribute to in their households, environment, and daily lives.*

Based on the results of the SWOT analysis (*Table* 10) and with the purpose of creating a place for parents to easily find resources about different sustainability topics for their children, this idea was chosen.

6.2. Concepting

With the idea already established, it was time to move on to concepting. In this phase, the focus was to ideate how both the website and the mini game within the website would look and function. With the results from the group brain-writing session and through looking at existing applications for children, visual inspiration was collected and turned into a mood board (*Figure* 13). Due to the topic of sustainability, a second iteration with a paper storybook style was also made (*Figure* 14).

Figure 13 - Vector inspiration [Mood board]. N. Louiza (2023)

Figure 14 - Paper inspiration [Mood board]. N. Louiza (2023)

From these mood boards, three concepts for the look of the website were sketched out and compared (*Figure* 15). It was during this process that the decision to merge the traditional vector art style with the storybook look was made. Thus, combining the two mood boards shown above. The idea was to create something that feels familiar while still exploring a different style that conveys sustainability.

Another suggestion from the group brain-writing was the inclusion of a mascot for the website. So, four mascot designs were made (*Figure* 17) and voted among the brain-writing participants. The design for a Tulip mascot was chosen to represent the Dutch origin of the website.

Lastly, with these concepts and the mood boards, a style sheet containing the colour palette and typography for the website was also made (*Figure* 16).

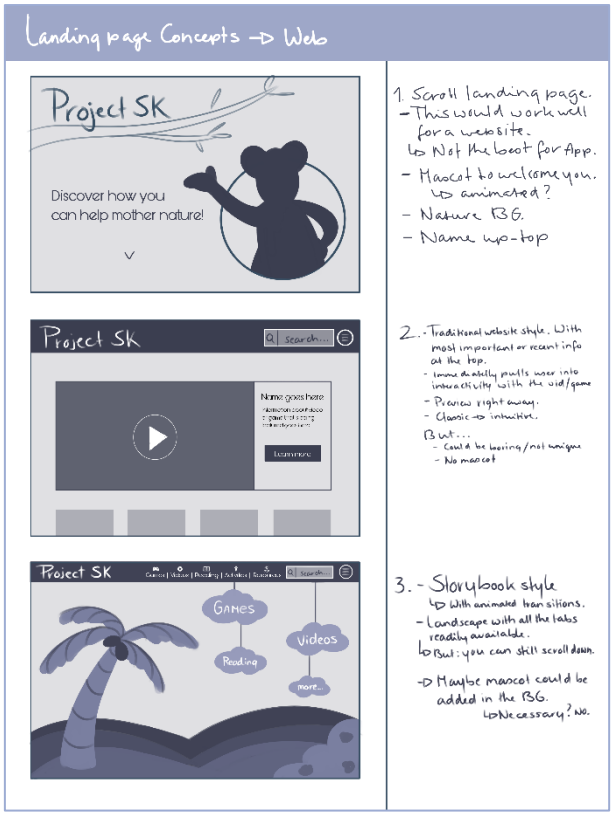

Figure 15 - Website concept sketches [Sketch]. N. Louiza (2023)

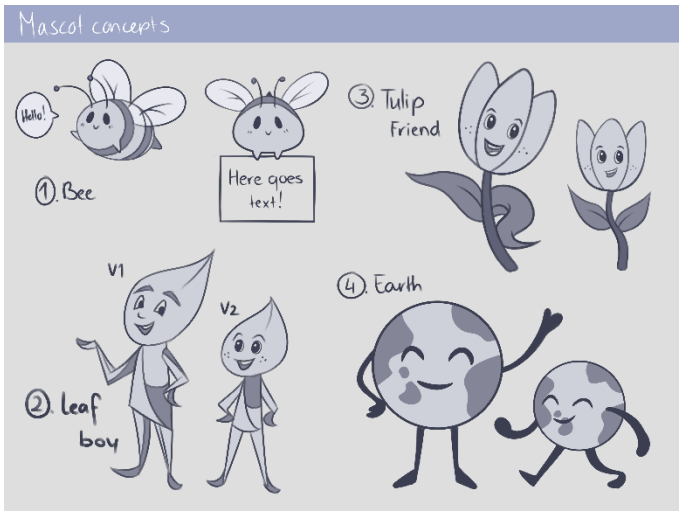

Figure 17 - Website mascots concepts [Sketch]. N. Louiza (2023)

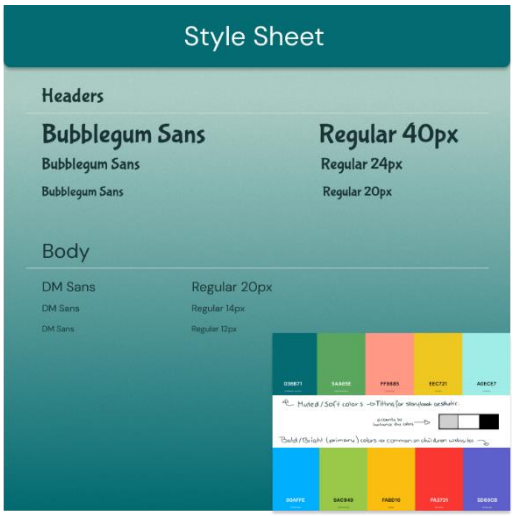

Figure 16 - Style sheet Project SK [Style Sheet]. N. Louiza (2023)

Once these concepts were made, the navigation for the website was sketched on paper to ideate how the user is meant to interact with the prototype (Appendix F.2). The next step was then to come up with an idea for the mini game (Appendix F.3). The concept for the mini game was a household energy manager game where the user has to tap on appliances that are wasting energy to turn them off as fast as possible. In *Table* 11, this concept is broken down using the 4 points derived from the research in chapter 5.1.

***Table 11** - Mini-game concept based on the research findings*

Mini game concept	
Emphasis on aesthetics	Use of vector art and consistency with the website style. Colour contrasts and highlights to make objects stand out. **Ideally**: Use of animations.
Challenges	Use of timer, time-based events and increasing difficulty. **Ideally**: A quiz to test knowledge gain.
Rewards	Rating system (How well did players do?). **Ideally:** Scoring from quiz.
User feedback	Visual feedback (animations, text, and images). **Ideally:** Audio feedback (UI sounds, game music, game sounds and voice overs).

6.3. MoSCoW list

Following the concepts, a MoSCoW list for both the website (*Table* 12) and the mini game (*Table* 13) was created to use as a priority list when designing the proof of concept. These lists were made with the scope of the project in mind. In which the different aspects of the proof of concept will remain conceptual but serve as a visualization of what the products could look like.

***Table 12** - MoSCoW list "Project SK" website*

Must have	Should have	Could have	Will not have*
• Landing page • Menu bar • Search bar • Games category • Reading category • Activities category • Videos category • Resources category	• School year subcategories • Transition animations • Mascot • (IRL) Events • Language selection	• Sprite animations • UI animations • Audio feedback • Music • Downloadable content section	• About section • Log-In feature • Material for teachers • Social media hyperlinks • Hyperlinks to educational pages

**The features in "will not have" were selected based on common website features obtained during the market analysis but due to the constraints and limitations of the project scope, they will be excluded. If this project is taken over by a future party, these features could be explored.*

***Table 13** - MoSCoW list "Project SK" mini game*

Must have	Should have	Could have	Will not have*
• **Introduction** • **Data visualizations** • **Timer** • **Progress bar** • **Text feedback** • **End screen** • **UI elements**	• Highlights • Visual feedback • Win/Lose state • 2 instances for objects • Transition animations	• Object animations • Text animations • UI animations • Quiz • Audio feedback • Music	• Responsive design • Scoring system • Leader board • Sharing results feature • Multiplayer functionalities

**The features in "will not have" were selected because based on the research results, they could enhance the concept, but due to the constraints and limitations of the project scope, they will be excluded. If this project is taken over by a future party, these features could be tested to see if they add value to the concept.*

7. Prototyping

With all the results from the ideation phase, the next step was to create the prototypes and to test both internally with peers and externally with the direct target demographic. Using the sketched ideas shown in Appendix F.1, the prototypes were made and iterated upon in Figma.

7.1. Prototype version 1

With the first website prototype shown in *Figure* 18, the groundwork for the proof of concept was set. The idea to merge the traditional children website style with the storybook style was tested by creating paper-styled assets for the backgrounds and combining geometrical UI shapes that contain free stock images and icons. This is also when the concept name was switched to “Tulip Buddies”.

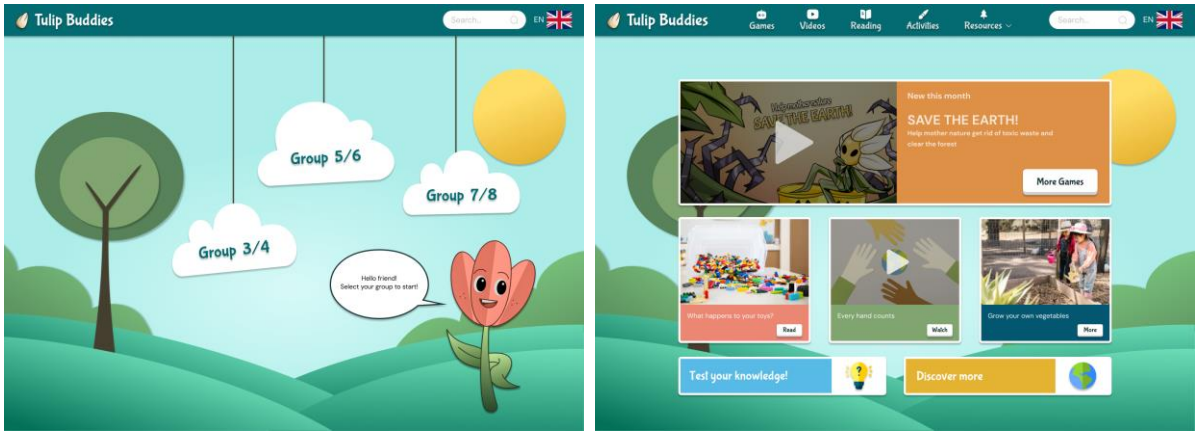

Figure 18 - Website prototype version 1 [Canvas]. N. Louiza (2023)

For the first mini game prototype, the premise of the game was to focus on household carbon footprints instead of just energy consumption. An informative introduction to quiz the user later, was also incorporated. In this prototype, placeholder images from the internet were used in the interior of the house to illustrate the gameplay concept (*Figure* 19).

Figure 19 - Mini game prototype version 1 [Canvas]. N. Louiza (2023)

Feedback

This prototype was presented to the client and peers during which some feedback was gathered:

- Instead of the appliances going off on their own, there could be human figures who use the appliances and leave them on.
- To add another layer of information, showcase that some appliances expend more energy thus affecting the household eco footprint faster than others.

7.2. Prototype version 2

In the second iteration, the focus on the mini game. In this version of the prototype, the introduction was extended (*Figure* 20), the placeholder assets were all replaced with self-made assets and now the game also included appliances with a higher urgency as suggested by the previous feedback (*Figure* 21).

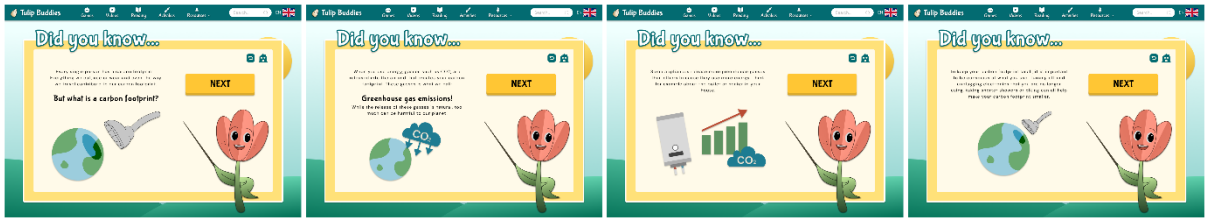

Figure 20 – Mini game prototype version 2 - Extended introduction [Image]. N. Louiza (2023)

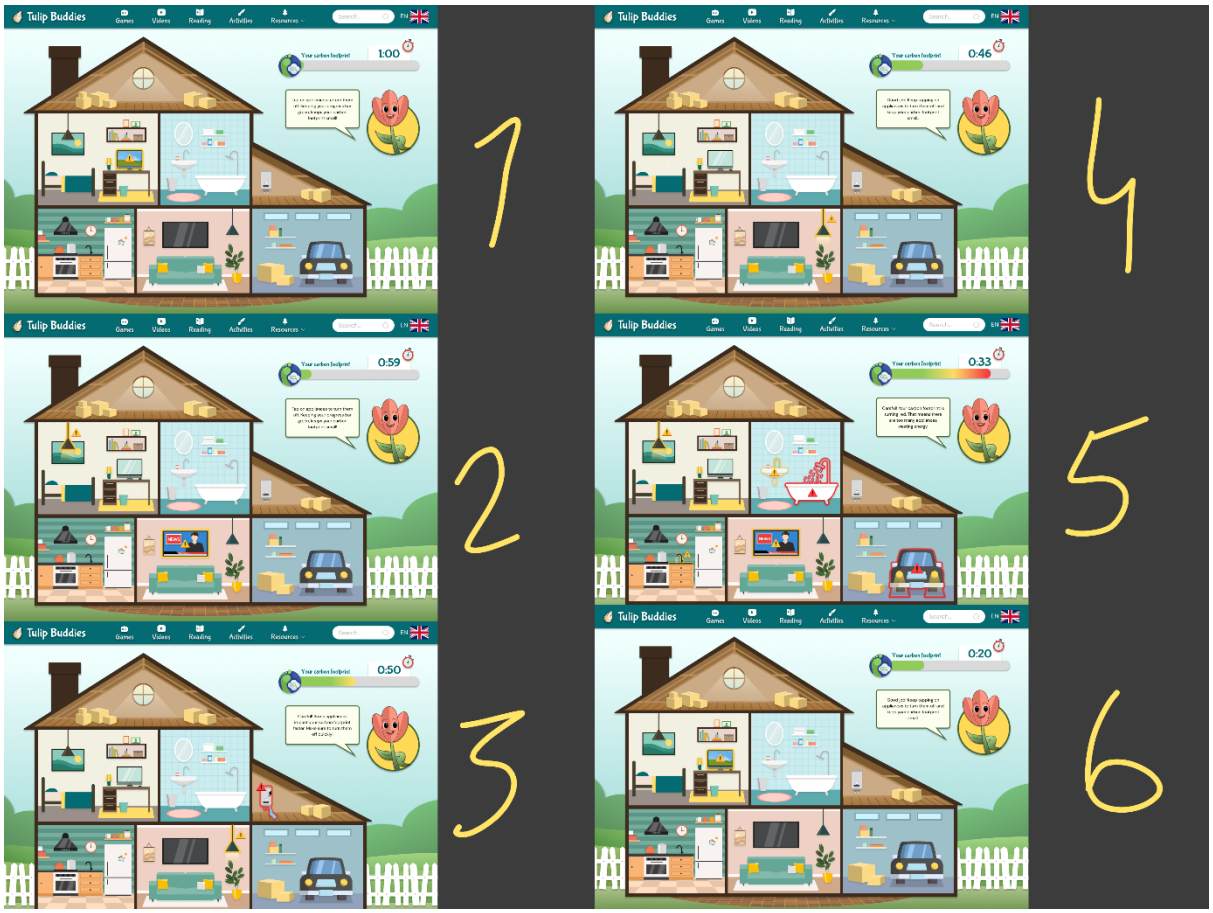

Figure 21 - Mini game prototype version 2 - priority emissions [Image]. N. Louiza (2023)

7.3. Final prototype

To test the prototype with the direct target demographic, the prototype was first translated to Dutch. Additionally, some highlights, transition and UI animations were added to enhance the look and feel of the prototype. To further showcase how the website pages could look, a game library page was created from which the mini game can also be accessed (*Figure* 22).

The final prototype can be accessed here. If the landing page is not loading properly, press the restart button on the bottom right of the page.

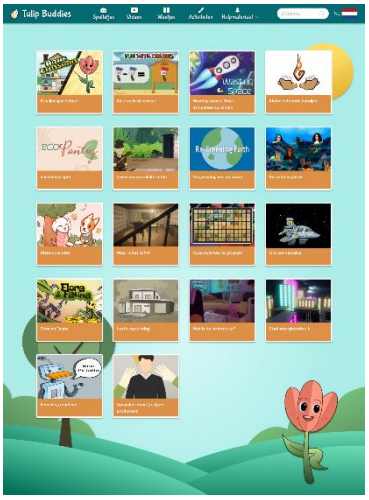

Figure 22 - Website game library screen [Image]. N. Louiza (2023)

8. Testing and results

The final prototype was tested using a qualitative usability test at Dr. Martin Luther Kingschool in Denekamp where 12 children from year 4, 5 and 6 participated (*Figure* 23). A plan for this test session was created with some suggestions from the client and peers (Appendix G.1) From the previous brainstorming session, it was noted that testing with young children is more effective if done through conversation. Therefore, this test session was conducted verbally while the organizers observed and took notes.

Figure 23 - Final test session at Kingschool with groep 5 [Photograph]. F.L. Welp (2023)

During the testing, the children were introduced to the prototype and asked to visualize it as a real website. They were then asked about their current understanding of carbon footprints after which they could explore the website with minimal to no guidance. Once finished, they were asked 7 follow-up questions. A full overview of the results can be found in Appendix G.2. But the findings from these results can be put into 3 categories:

1. The mini game in the prototype is missing a tutorial on how to play the game.
2. The text bubbles in the mini game were overlooked by all participants.
3. Participants in year 5 were the most drawn to the concept based on their positive feedback.

From these findings and what was observed during the test session, a few conclusions can be drawn. Firstly, the current mini game seems to be most suitable for children in year 5 because this is also the school year in which they are introduced to this topic. Therefore, aligning future concepts with the school curriculum as stated in chapter 5.2, can be beneficial. Another observation was that participants were often confused because of the lack of guidance on how to proceed. This aligned with the findings of chapter chapter 5.1 on the importance of user feedback and intuitive visuals.

9. Conclusion

A conclusion to the research findings and design process.

From both the research and development results, a conclusion can be drawn to answer the main question of this project: *"How can gamification elements be used in data visualizations that are aimed at children ages 6 – 12 in The Netherlands, to communicate the most current topics of sustainability within the household?"*

Firstly, the research results showed that there are countless gamification elements that can be incorporated into visualizations aimed at children. To find the most suitable result, the designers must first define what they want to teach their target audience and combine this with a gamified experience that balances risk and reward while using appealing visuals to guide the user.

By aligning the design to the education system's curriculum, the lessons that the children learn can be optimized by presenting them through different sources. Furthermore, it is important to include parents in this process to try balancing children's understanding of sustainability better. By doing this, parents may be encouraged to incorporate children in more sustainable activities while the children get to use their newly attained knowledge in their daily lives.

The prototype created for this project was also able to demonstrate that even with a limited prototype, if these above-mentioned points are considered, the general consensus of the direct target demographic is positive. And at the least, it served to generate some intrigue towards the concept among the participants.

10. Discussions and recommendations

Recommendations for future improvements to the research and final product.

If this project were to be developed further, there are definitely some areas that would need to be explored further or iterated. Starting with the research, one field that would need to be revisited is the education system. While some data was collected, there is still a lot to be extracted from what schools are currently teaching children on sustainability and how this project could align to that.

On a related note, the tests and workshops with the children were all conducted within small groups at the same school. To get more accurate insights on how this concept would perform in all of The Netherlands, the product must be tested with children in different regions of The Netherlands.

The prototype itself also has quite a few points of improvement. Starting with the feedback from the test session, it should be clearer how the users are meant to interact with the game. This can be done with a tutorial, visuals or through audio (voice overs). Audio and music is also something that should be explored on how that can be used to increase user engagement. The same can be said for animations.
Next to these, the MoSCoW list features that were excluded from the prototypes due to constraints could also be explored. Especially for the resources section of the prototyped website, a company or organization with an existing resources library, could be approached to collaborate on this project.

Most importantly however, the next step should be to take the prototype and develop it as a functional website or application to properly test the functionalities and gameplay. Using that, the concept can be further iterated and adjusted to fit the users' needs.

11. Reflection

A critical self-reflection on the project.

In this chapter, I want to focus on how I have experienced this project and the lessons learned. Looking back at the whole process, I have definitely learned so much about myself, about my work ethic and about topics I barely even knew about.

When I originally started at Smart Cities, I was quite nervous. It was my first time working completely independent on something so big and for a client. Still, it was a choice that I deliberately made because I wanted to prove to myself how much I am capable of doing. What I didn't take into account, however, is how much would be out of my control. When working with schools and children, it is very difficult to find willing participants or people who have the time out of their busy schedules. Networking had never been a strong suit of mine, but this project gave me exactly the push I needed to break out of my shell and reach out to others for help.

I was especially proud with the outcome of the parent survey and the brainstorming sessions. Despite my insecurity speaking Dutch, I pushed myself to go outside and reach out to dozens of participants. Through that experience, one realization I had was that I am my own biggest obstacle. During the surveys, I shared conversations with a handful of people who also expressed their insecurities and struggles. It reminded me that we are all humans with our own sets of problems.

On another note, working on a sustainability project for 5 months also made me become more aware of my own footprint and choices. I now find myself unplugging everything when they are not being used (something I admittedly did not do as much).

There are however some points of improvement that I want to work on next. The biggest one being balance. I spent so much time pushing myself to have "the perfectly researched concept" and a product with a plethora of functionalities that I, in hindsight, ended up making the scope bigger than I originally intended. I feel like this backfired as I ended falling behind on my original development plan, which created a very short window to receive and apply feedback from my supervisors, peers, and participants.
The pressure I imposed onto myself to perform at the same level as others with years of experience or comparing myself to groups of people made it paralyzing to perform sometimes. And even though I thoroughly enjoyed working completely independent, I realized that occasionally having peers to brainstorm with and having weekly meetings with my supervisors helped me stay on track and snap out of my own head.

Still, I was able to put everything I have learned through my time at Saxion to use during this project and come up with something I am very proud of. And for that, I am extremely happy.

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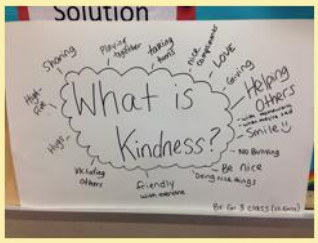
13. Appendix

Appendix A.1. Brainstorming workshop plan

Source: N. Louiza (2023)

Brainstorming workshop with children – round 1

Mind-mapping



Drawing prompts

Presenting scenarios

These methods were selected based on some preliminary research. Most notably, in a study by Desjardins and Wakkary (2011), they use these methods to extract children's understanding of sustainability.

About workshop

Place: Dr. Martin Luther Kingschool
Address: Clematisstraat 39, 7591XJ Denekamp
Date: Wednesday, April 5th 2023
Time: 9:00 – 12:00
Participants: 3 groups: 9 – 9 – 11 (29 participants)

Prepping:

1. Prepare a list of keywords (based on research and the surveys) that children of this age group would be familiar with → Key words can be found lower in this document.
2. Divide the group into smaller groups when necessary.
3. Use this list of keywords as prompts for the different tasks to the group of children.
4. Give them a certain amount of time. (E.g. 10 minutes)
5. Bring materials for the assignments: Paper, Pens, pencils, markers, erasers, sharpeners.

Activities:

Start by doing an introduction and reassuring the children that there are no right or wrong answers to anything. Explain what they are there to do and what we will be doing together:

“Hallo allemaal, mijn naam is Nicolle. Mijn Nederlands is niet perfect, dus als je ooit moeite hebt om iets te begrijpen, laat me het gewoon weten en ik zal het herhalen of duidelijker maken.

Vandaag gaan we een paar activiteiten samendoen, omdat ik graag van jullie zou willen weten wat jullie op dit moment begrijpen over de onderwerpen van duurzaamheid en milieuvriendelijkheid.

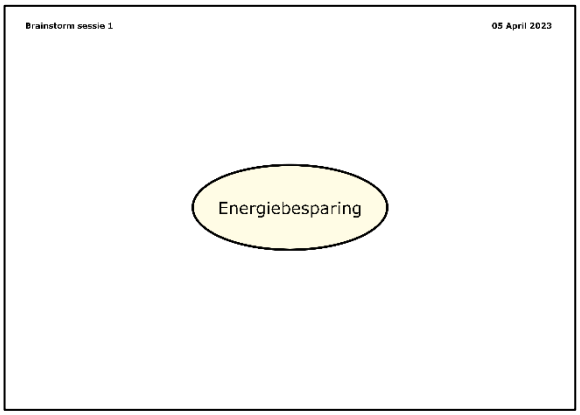
Er zijn geen goede of foute antwoorden of ideeën. Voel je niet onder druk en maak je geen zorgen dat je iets verkeerds krijgt. En als je ergens niet zeker van bent, vraag het me gerust en ik zal mijn best doen om je te helpen. ‘

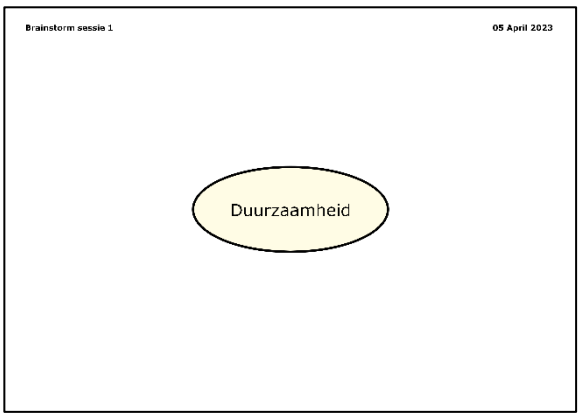
Assignment 1: Word spider

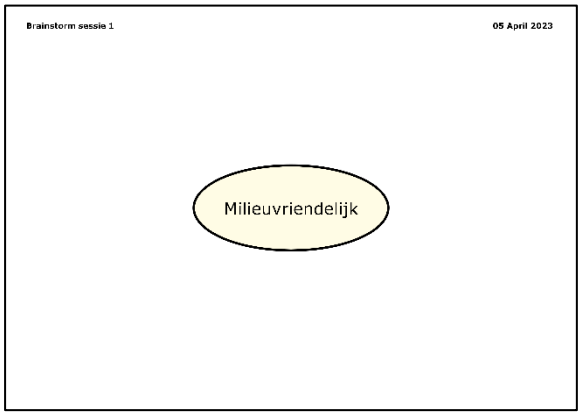
Om te beginnen, gaan wij eerst een woordspin maken. Jullie krijgen allemaal een vel met een woord erop en ik wil dat jullie zoveel bijbehorende woorden mogelijk opschrijven. (Dus wat jij denkt dat het betekent of wat allemaal daarbij past). Onthoud dat er geen goede of foute antwoorden zijn. Dus schrijf gewoon op wat jij denkt.

Key-words: Energiebesparing, duurzaamheid, milieuvriendelijk (pick one).

Templates:







Assignment 2: Drawing

Nu gaan jullie een nieuwe vel papier krijgen en ik wil dat jullie het meest milieuvriendelijke huis en levenstijl tekenen dat je je kunt voorstellen.

Je kunt je tekeningen ook schriftelijk toelichten of meerdere activiteiten tekenen.

Assignment 3: Scenario's

Vervolgens zal ik enkele situaties voorleggen en ik wil graag van jullie horen wat je in deze situaties zou doen. Steek je hand op als je een antwoord hebt en onderbreek anderen niet. Nog eens zijn er geen foute antwoorden.

1. **Als je zag dat iemand de kraan open liet staan nadat ze de badkamer hadden gebruikt, wat doe je?**
   Hoe voorkom je dat het nog een keer gebeurt?

2. **Je beste vriend gooide wat afval op de speelplaats, wat zou jij doen?**
   Hoe voorkom je dat het nog een keer gebeurt?

3. **Een ander kind in jouw groep wil meer leren over duurzaamheid en milieuvriendelijkheid, hoe zou je ze helpen leren?**

Wrapping up

Tot slot wil ik jullie allemaal vragen om maximaal je top 3 favoriete duurzaam activiteiten op te schrijven. Als er dingen zijn die je nog niet hebt geprobeerd maar wel zou willen proberen, schrijf die dan ook op.

Het kan samen met je familie, vrienden of op school zijn. Of iets dat je interessant vindt. Of zelfs iets wat je niet goed begrijpt maar wel wilt leren.

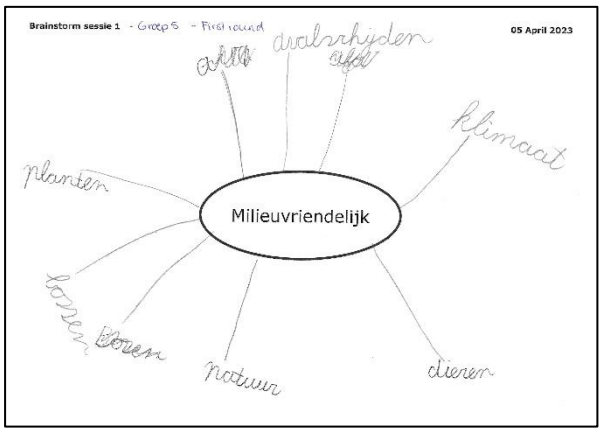
Had iemand nog andere vragen of wilde iemand iets anders over duurzaamheid delen dat je eerder niet kon delen?

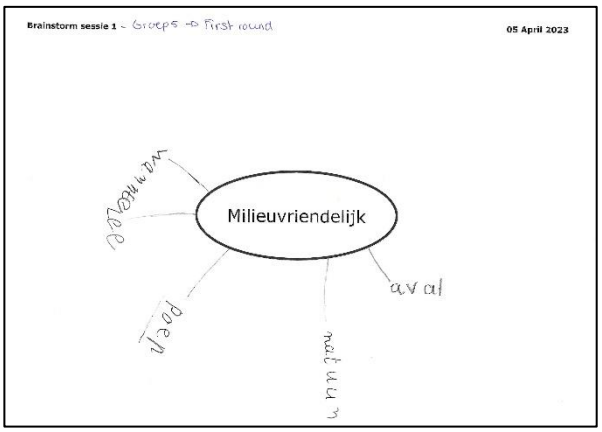
Appendix A.2. Brainstorming workshop results

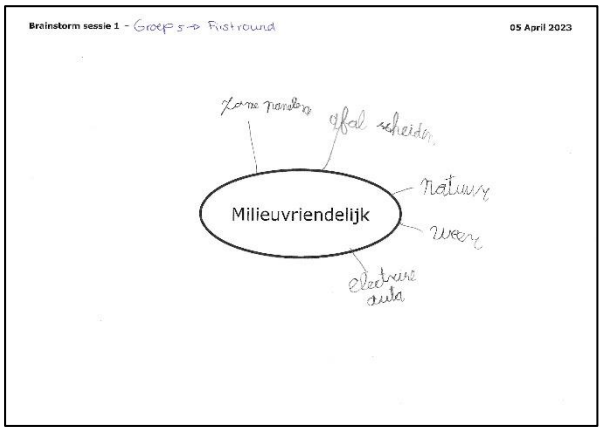
Source: N. Louiza (2023)

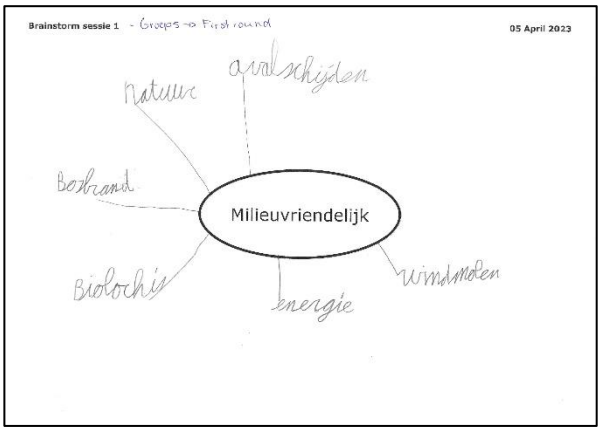
Round 1

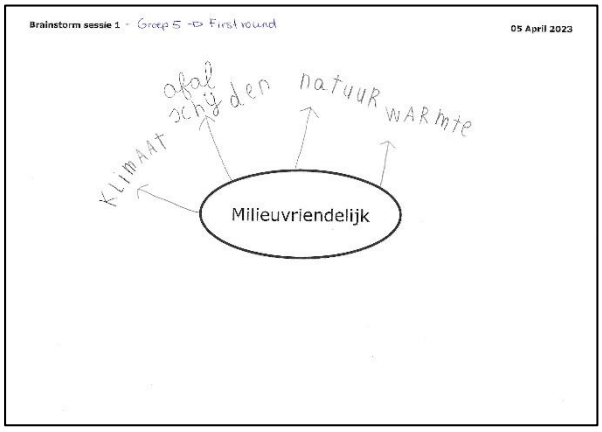
Activity 1 – Groep 5:



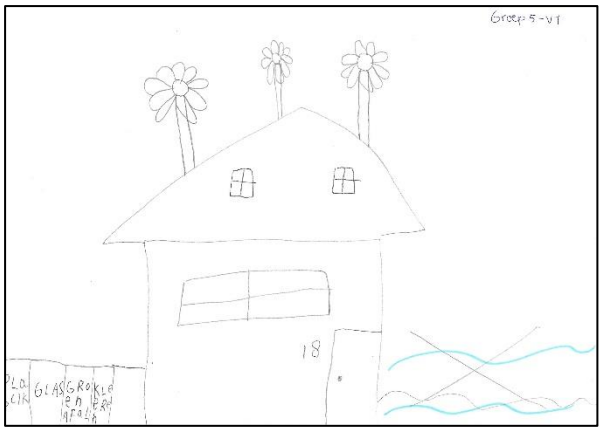


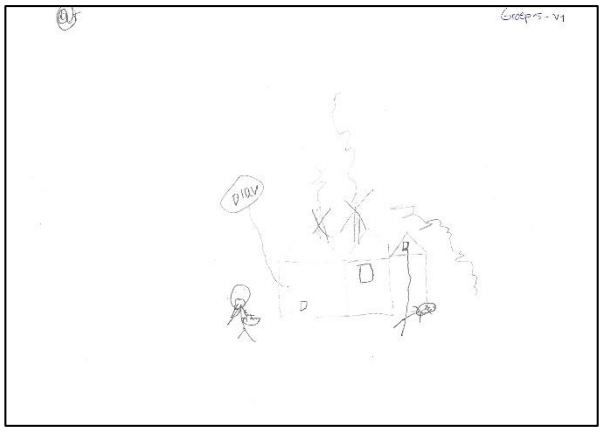


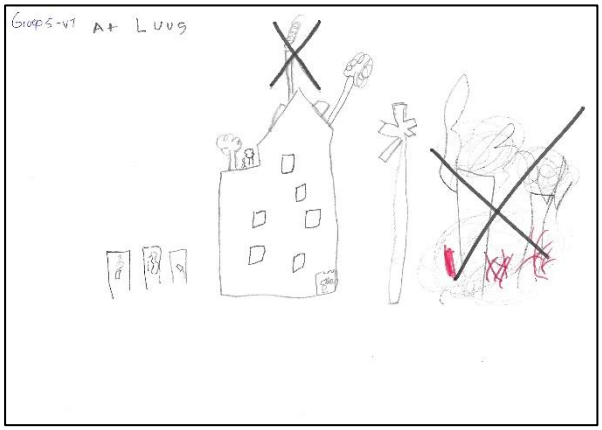


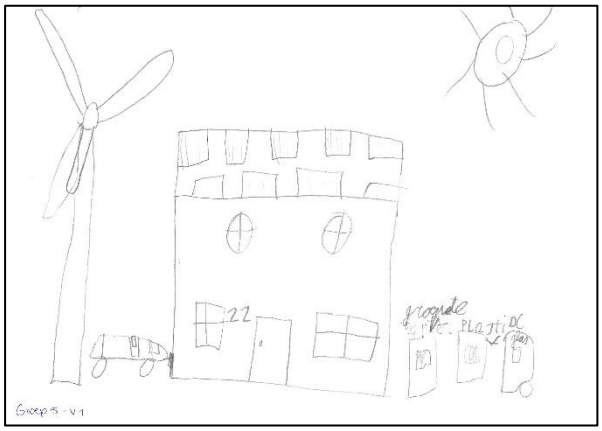


Activity 2 – Groep 5:

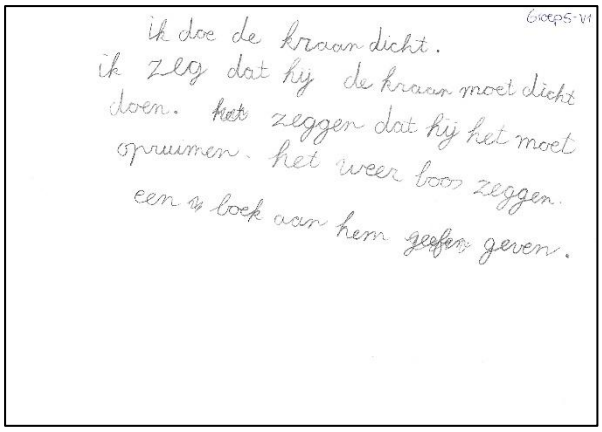


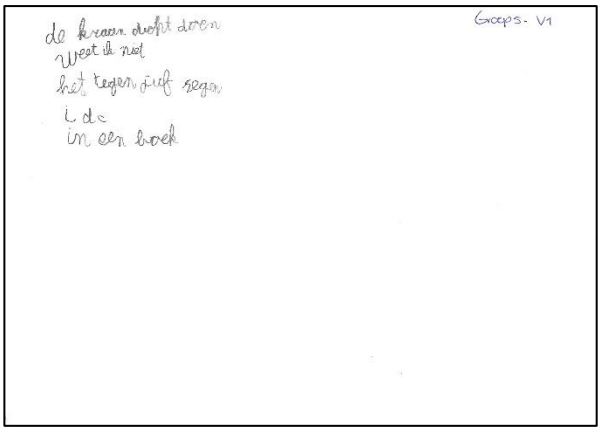


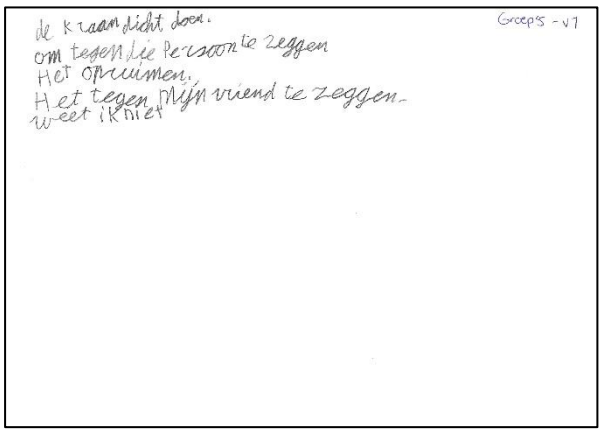


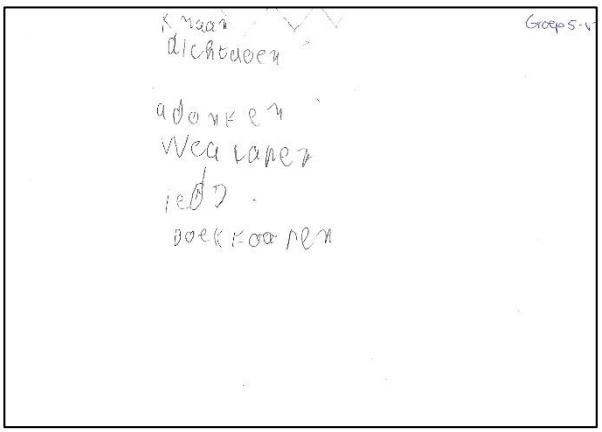


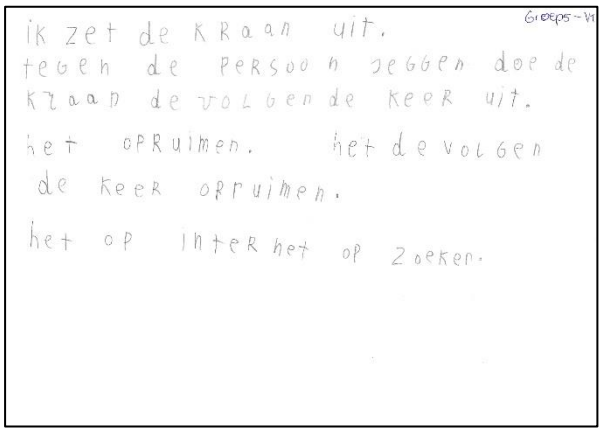
Activity 3 – Groep 5:





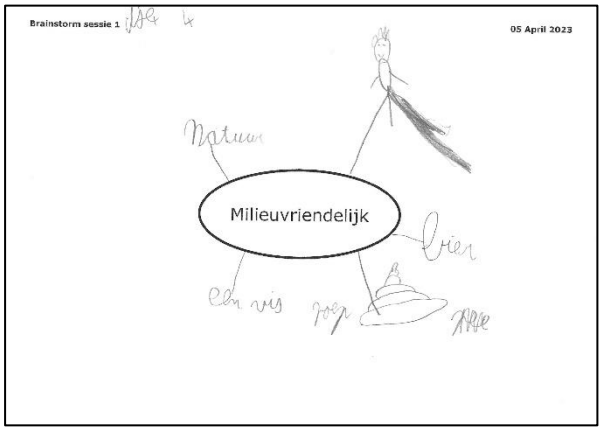


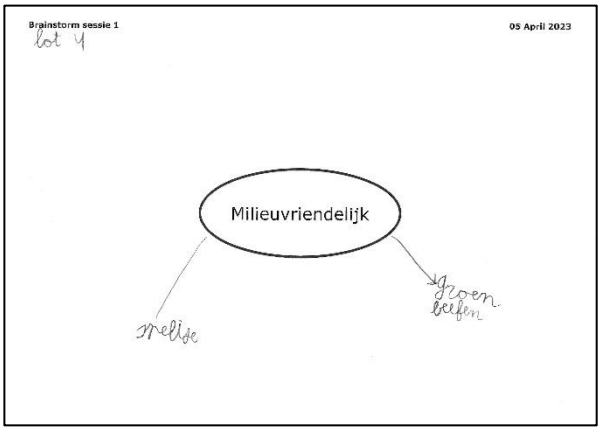


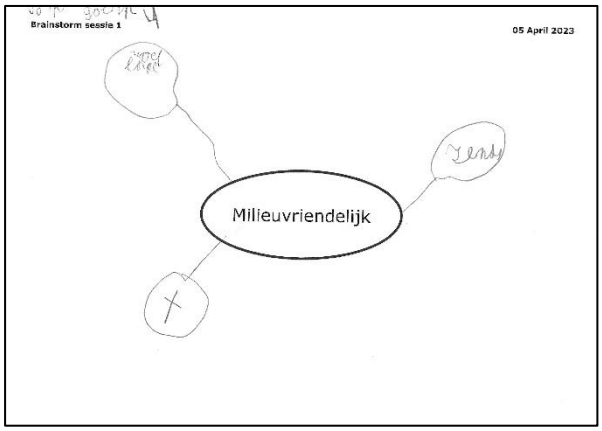


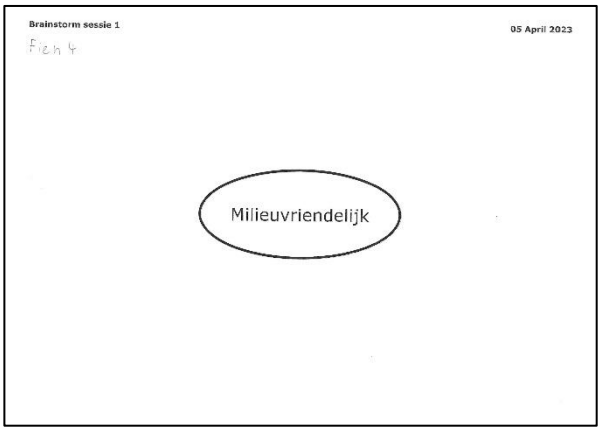
Round 2

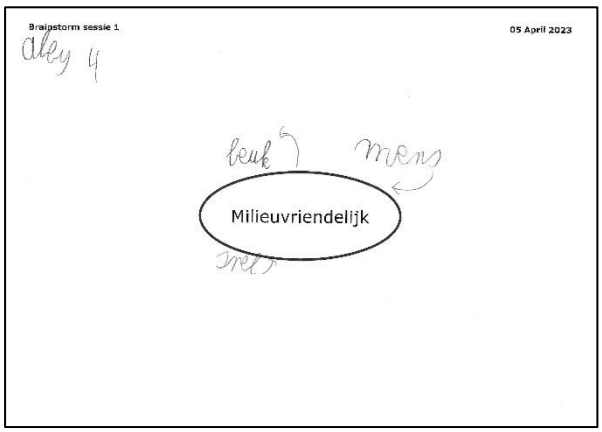
Activity 1 – Groep 4



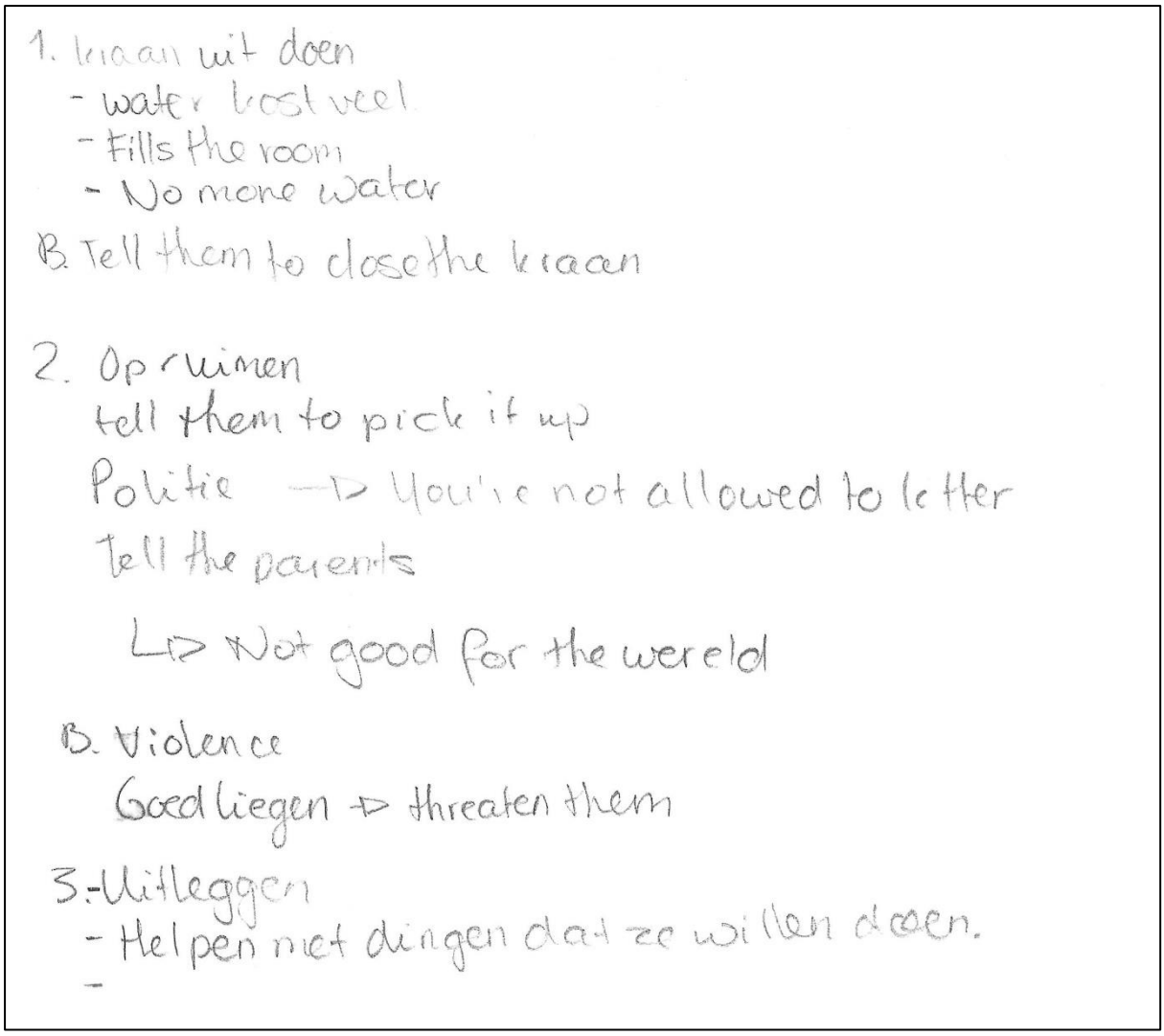








Activity 2 – Groep 4


1. kraan uit doen
- water kost veel
- Fills the room
- No more water
B. Tell them to close the kraan
2. Opruimen
tell them to pick it up
Politie → You're not allowed to letter
Tell the parents
↳ Not good for the wereld
B. Violence
Goed liegen → threaten them
3. Uitleggen
- Helpen met dingen dat ze willen doen.
-

Appendix B. Teachers survey results

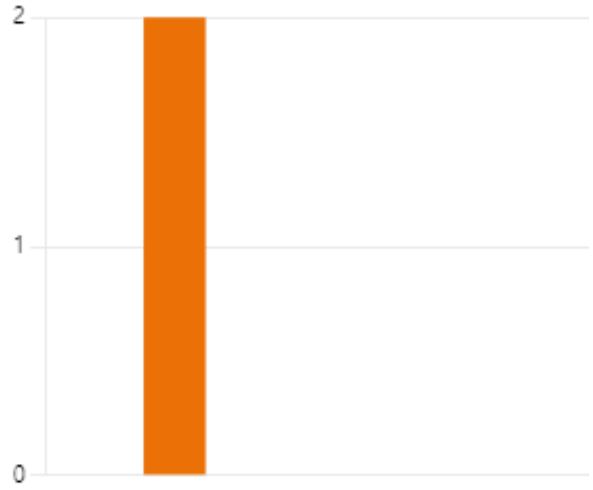
Source: N. Louiza (2023)

Sustainability for Children: What are children learning in the classroom?

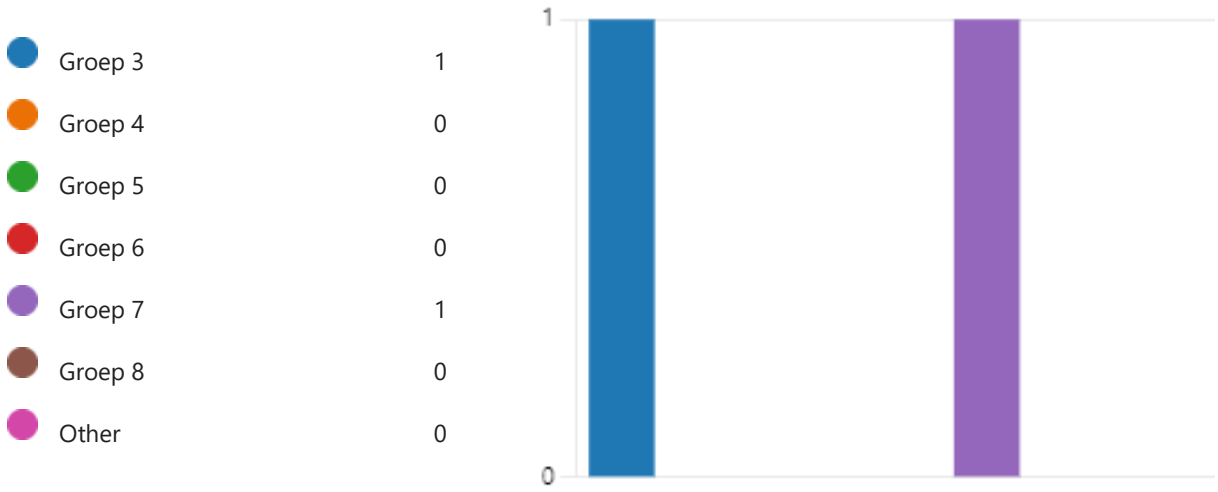
2	04:37	Closed
Responses	Average time to complete	Status

1. What type of elementary school do you teach at?

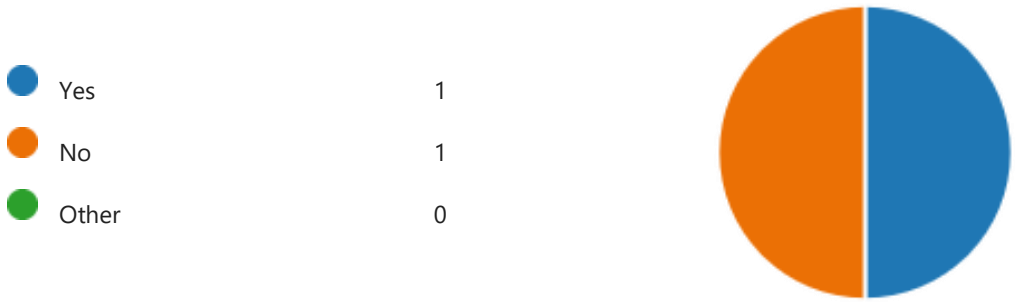
Public-authority school	0
Private school	2
Non-denominational private school	0
Community school	0
Special school for primary education	0
Internationally oriented primary	0
Other	0



2. Which school year group (Groep) do you teach?



3. Does the topic of sustainability appear in your school's curriculum?



4. Could you briefly describe what the curriculum entails regarding sustainability?

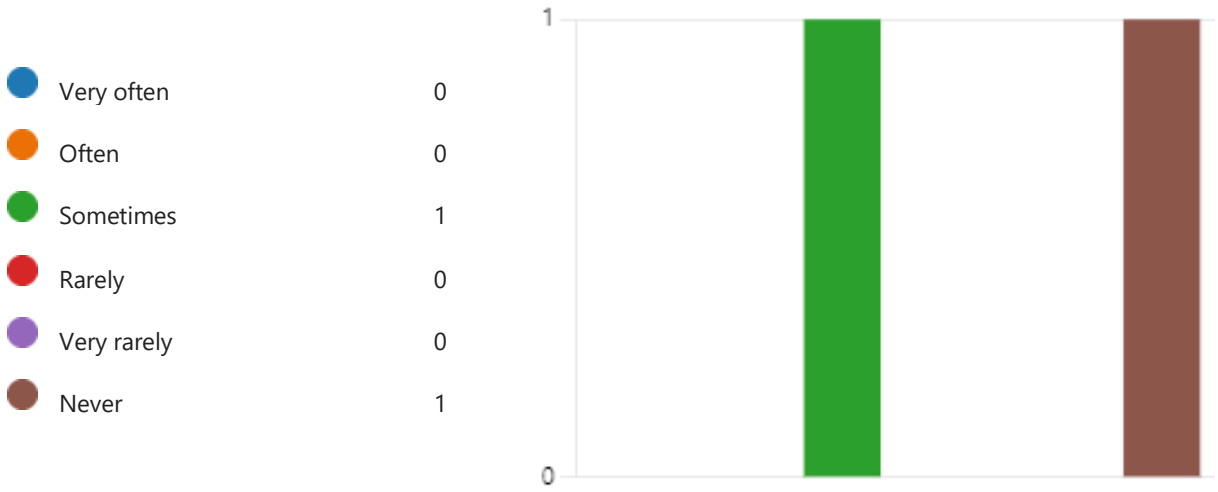
1

Responses

Latest Responses

"Met de Kinderboekenweek (2022) Gi-ga-groen hebben wij gewerkt aan het thema duurzaamheid. Momenteel werken we met het thema afval en dus recyclen, waarbij bijna elke les verwikkeld wordt met het thema."

5. How often does your classroom participate in sustainable activities?



6. What are some examples of sustainable activities your classroom has done?

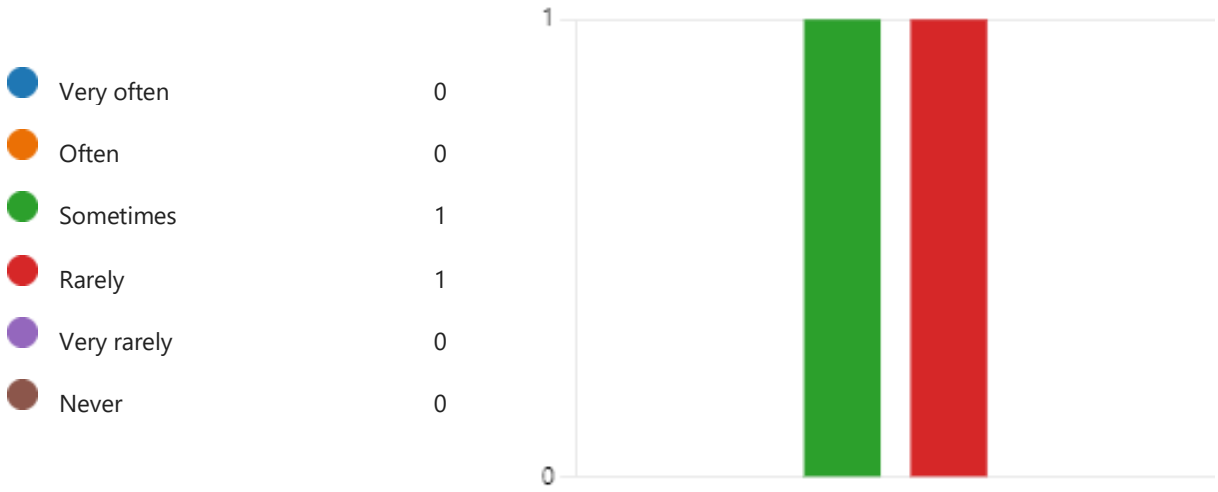
1

Responses

Latest Responses

"De kinderen werken minstens één keer per maand in de schooltuin."

7. How often do you start conversations about sustainability with your classroom?



8. What are some examples of conversations about sustainability that you have had with your classroom?

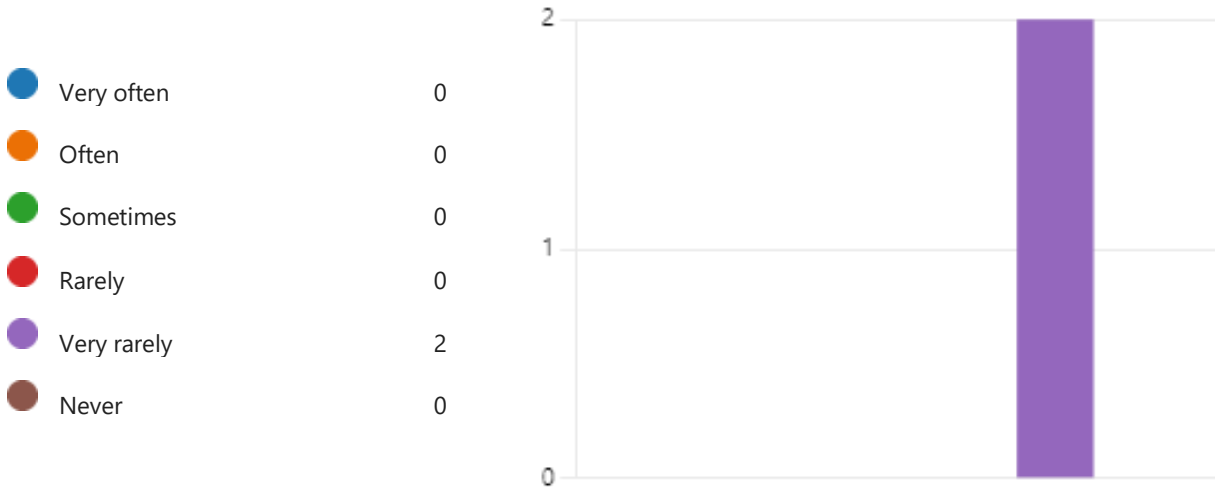
1

Responses

Latest Responses

"Tijdens natuurlessen komen wel eens dingen aanbod over duurzaamheid."

9. How often do your students start conversations about sustainability in the classroom?



10. What are some examples of questions your students have asked about sustainability?

1

Responses

Latest Responses

"Vragen over het scheiden van afval."

11. Did you have difficulty answering the questions of your students?

Yes	0
No	2
Sometimes	0

12. Why was it difficult to answer their questions?

0

Responses

Latest Responses

13. What would encourage you to talk more about sustainability in the classroom?

2

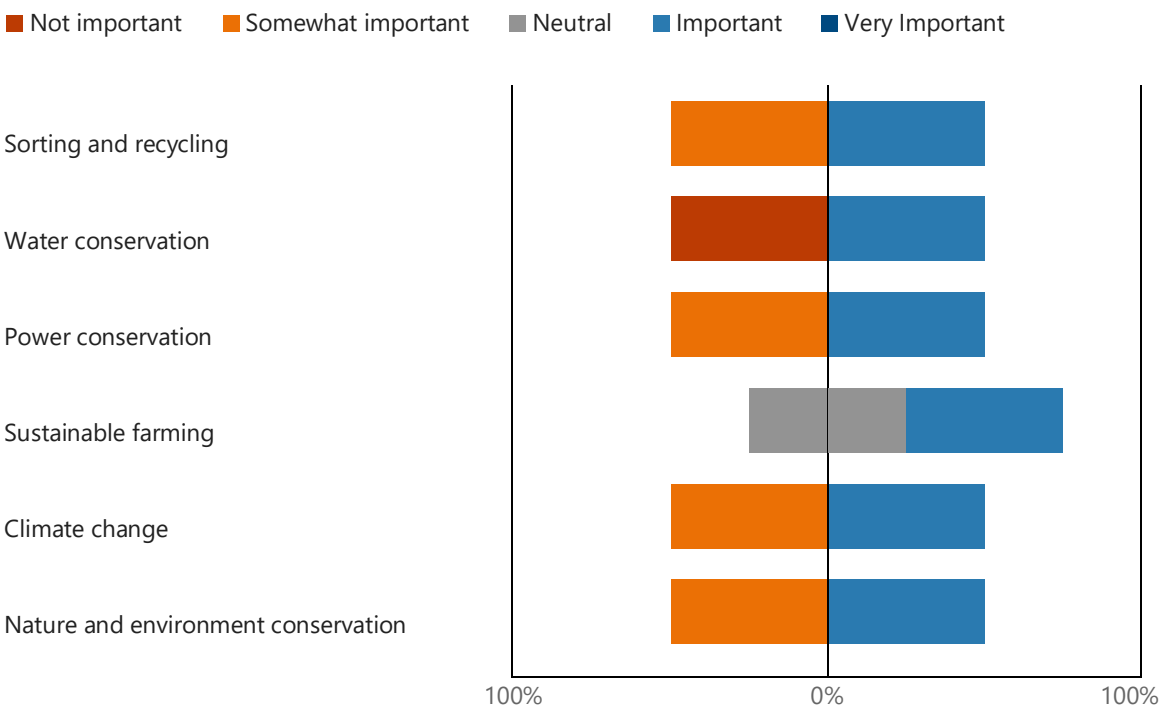
Responses

Latest Responses

"Mogelijkheden die methoden aanbieden om een duurzaamheid bij een les te betrekken. Het kost vrij veel tijd om zelf een les op te zetten."

"Lessen die echt interesse opwekken bij de leerlingen"

14. How would you rate the following topics on their importance for children?



15. Are there any other sustainability topics that you think are important for children to learn about?

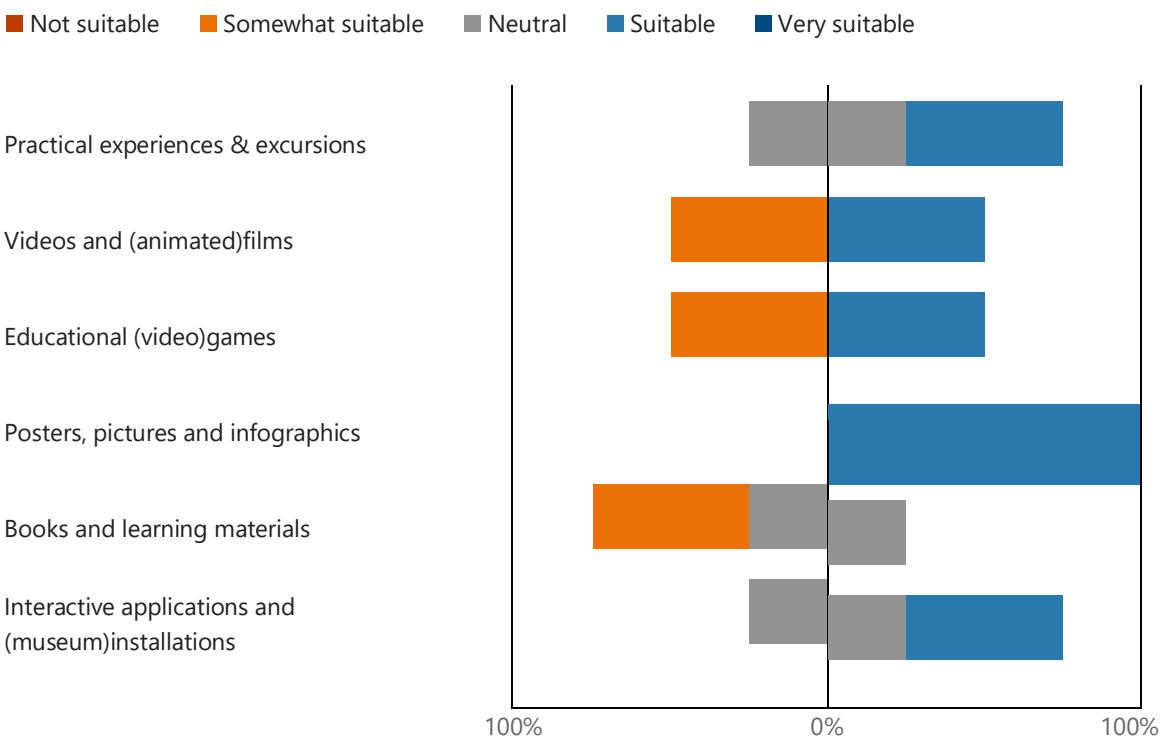
1

Responses

Latest Responses

"Vooral het stukje bewustwording welk soort en hoeveel afval je zelf produceert en hoe je dit kunt verminderen."

16. How would you rate the following techniques on their suitability to educate children on sustainability?



17. Are there any other techniques that you think are suitable for educating children about sustainability?

Latest Responses

1
Responses

"Vooral excursies en rijke leeromgevingen kan het kind stimuleren in de bewustwording van duurzaamheid"

18. What requirements should an educational product, such as a game or data visualization, meet in order to educate children about sustainability?

1

Responses

Latest Responses

"Het moet rijk zijn, dit wil zeggen dat het de kinderen prikkelt en uitdaagt om iets te proberen of te doen. Het moet praktisch en zelfstandig uit te voeren zijn."

19. Are there any other comments or remarks you would like to add?

0

Responses

Latest Responses

Appendix C.1. Parents and Guardians survey results

Source: N. Louiza (2023)

Sustainability for Children: What are children taught at home?

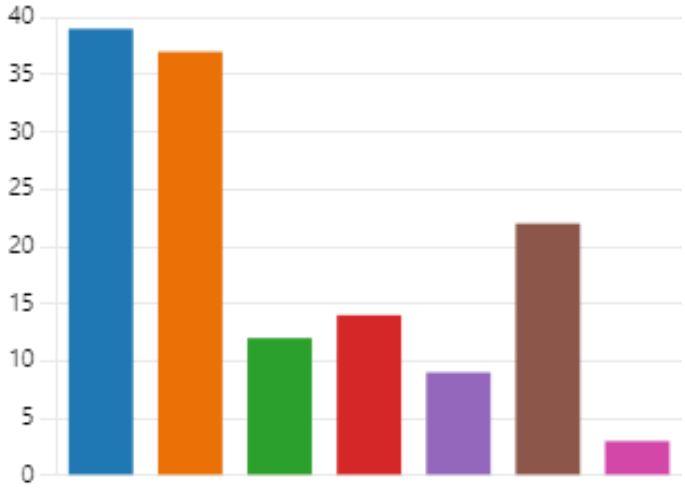
115	04:56	Closed
Responses	Average time to complete	Status

1. In which age group is your child(ren)? (Multiple answers possible)

6 - 7	70
8 - 10	34
11 - 12	28

2. In which school year group (Groep) is your child(ren)? (Multiple answers possible)

Groep 3	39
Groep 4	37
Groep 5	12
Groep 6	14
Groep 7	9
Groep 8	22
Other	3

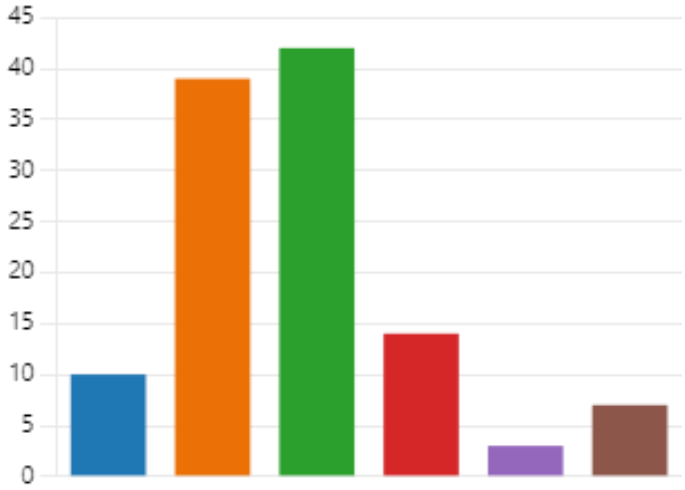


3. How important is sustainability in your household?

Very important	17
Somewhat important	66
Neutral	19
Somewhat not important	11
Not important	2

4. How often does your household engage in sustainable activities that include your child(ren)?

Very often	10
Often	39
Sometimes	42
Rarely	14
Very rarely	3
Never	7



5. What are some examples of sustainable activities your household does that include your child(ren)?

96

Responses

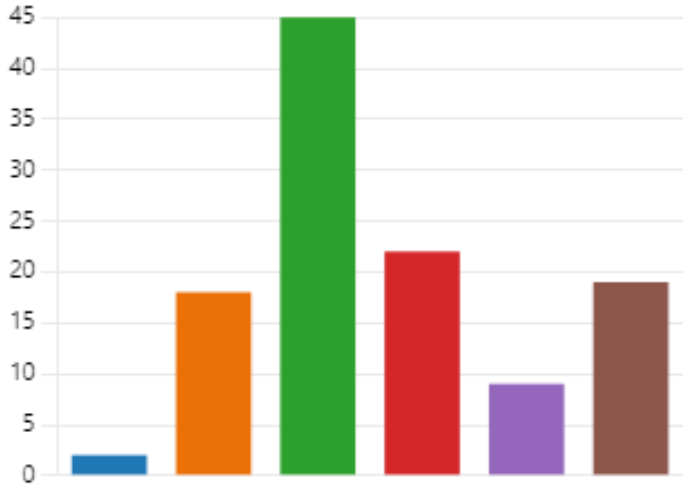
Latest Responses

"Wij proberen onze kindere van vroegs af aan te leren recycle...

"Limit shower time, recycling, using the bike"

6. How often do you start conversation on sustainability with your child(ren)?

Very often	2
Often	18
Sometimes	45
Rarely	22
Very rarely	9
Never	19



7. What are some examples of conversations on sustainability that you have had with your child(ren)?

65

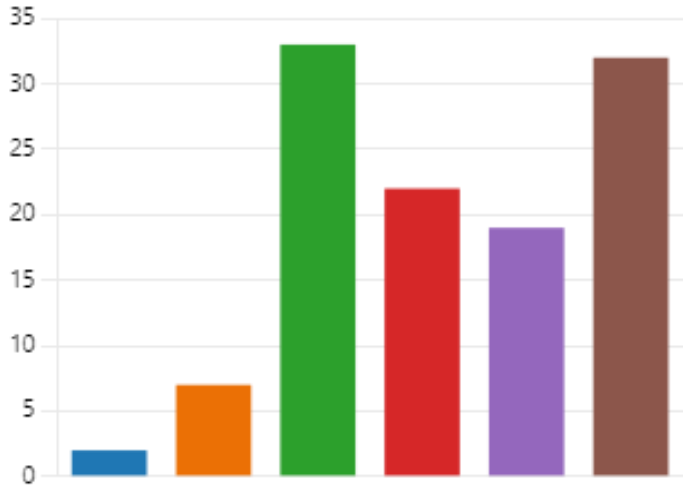
Responses

Latest Responses

"*Take care of the planet, water, recycling*"

8. How often does your child(ren) start conversation on sustainability?

Very often	2
Often	7
Sometimes	33
Rarely	22
Very rarely	19
Never	32



9. What are some examples of questions or remarks about sustainability that your child(ren) have asked?

51

Responses

Latest Responses

"*Vragen zoals waarom moeten wij water besparen*"

"*why we need to limit shower time*"

10. Did you have difficulty answering the questions of your child(ren)?

Yes	4
No	63
Sometimes	16

11. Why was it difficult to answer?

20

Responses

Latest Responses

"*Het uitleggen in een manier waarop zij het begrijpen kan la...*

12. What would encourage you to talk about sustainability with your child(ren) more often?

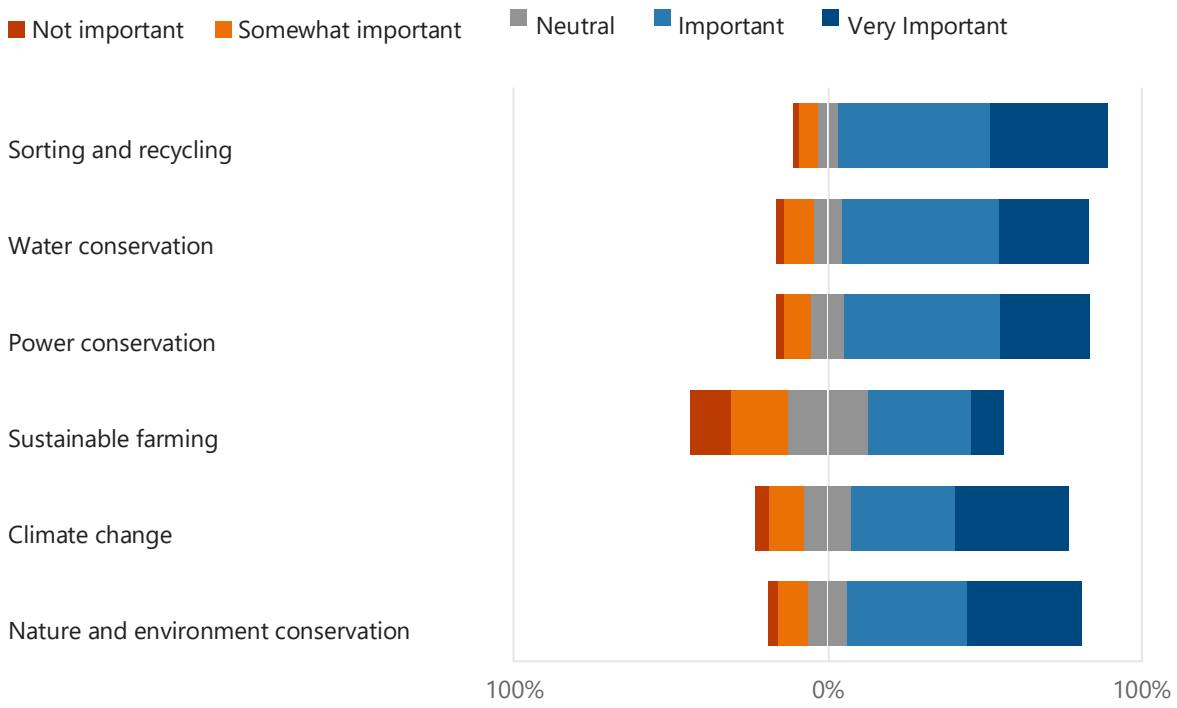
115

Responses

Latest Responses

"*Als er een manier zou zijn dat het gemakkelijk en leerzaam maar ook leuk is...*

13. How would you rate the following topics on their importance for children?



14. Are there any other sustainability topics you think are of importance to children?

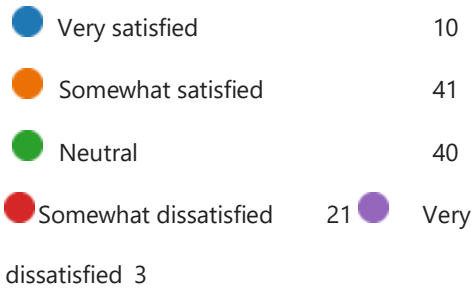
58

Responses

Latest Responses

"*Using sustainable transport means, supporting sustainable b...*

15. How satisfied are you with how much your child(ren) is learning about sustainability from educators?



16. What do you think educators could improve on when educating children about sustainability?

115
Responses

Latest Responses

"*Ik weet dat de school verschillende programmas probeert te ...*

"*De gevolgen tonen van wat er allemaal kan gebeuren als w...*

"*Taking more about the actions they can do* "

17. Are there any other comments or remarks you would like to add?

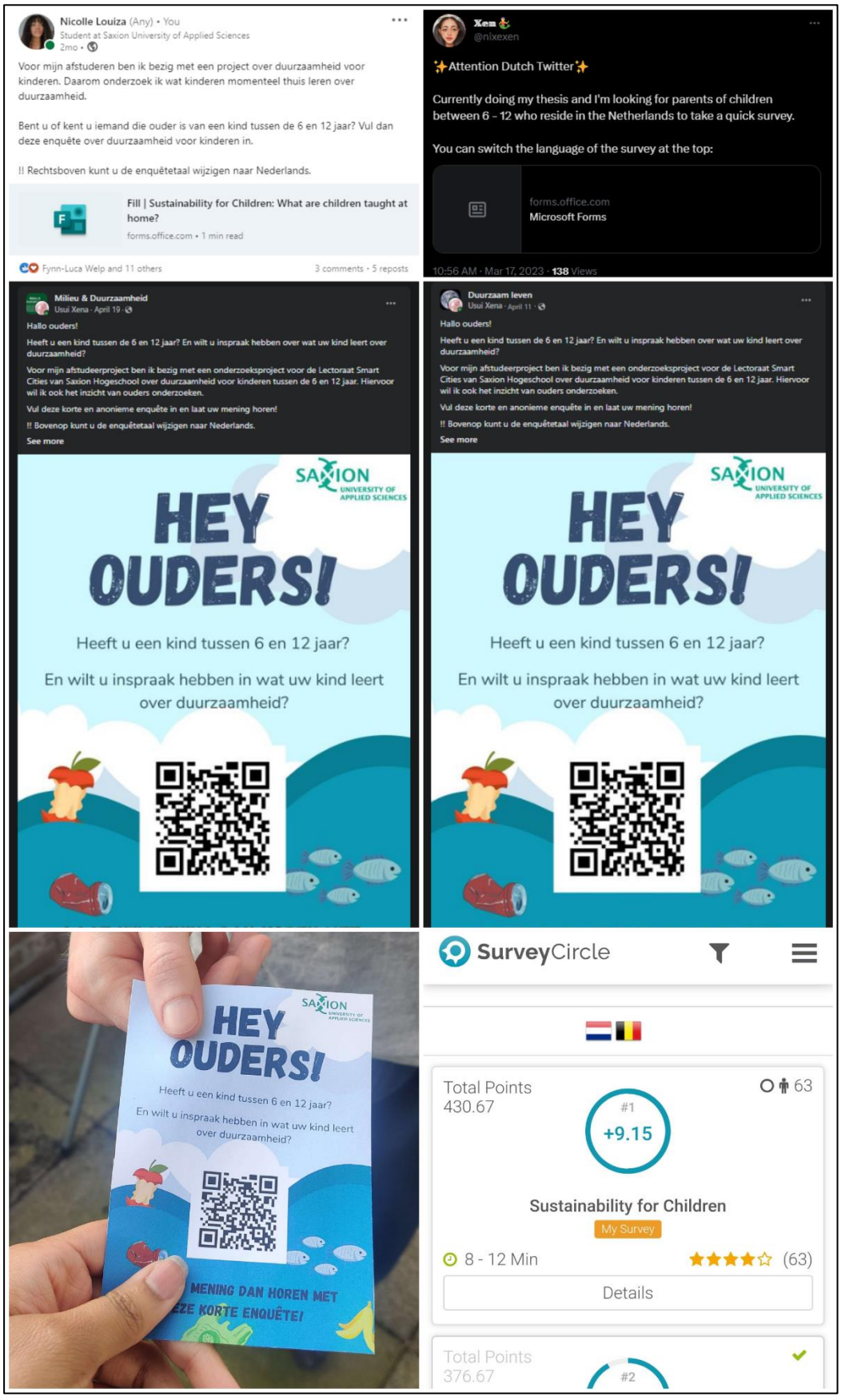
41
Responses

Latest Responses

"*No*"

Appendix C.2. Survey sharing overview

Source: N. Louiza (2023)

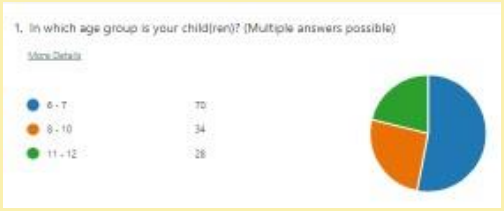


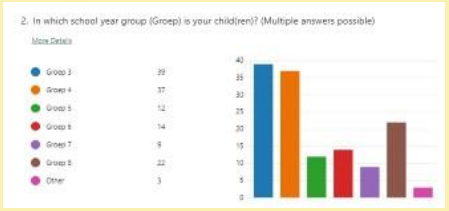
Appendix D. Field research analysis – Defining the problem

Source: N. Louiza (2023)

The parents survey: Participants

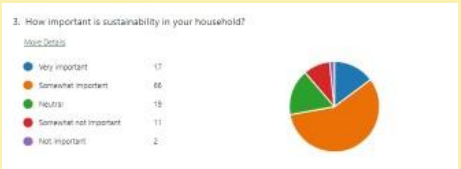
- There were a total of 115 participants in the survey.
- In total, they encompassed for136 children.
- 88 of the children are in the "middenbouw" (**65%**)
- And 45 are in the "bovenbouw" (**33%**)

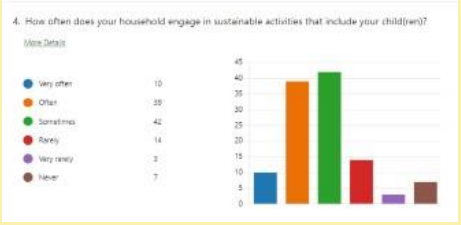




The parents survey: Interest

- **72%** of the participants expressed a positive outlook on sustainability.
- **43%** expressed including their children in sustainable activities **often** or **very often.**
- **13%** of participants expressed that sustainability is **unimportant** in their household yet **21%** of participants **rarely** or **never** include their children in sustainable activities.





The parents survey: Topics

- The most common sustainable activity was **recycling/sorting trash**.
- In the category of recycling: **upcycling*** was also brought up numerous times
- **Saving energy and water** came in 2nd place.
- **Gardening** and **sustainable (food) consumption** were tied in 3rd place.
- Other frequent topics were:
  Sustainable transportation, **2nd-hand shopping, compositing** and **donating.**

** Upcycling refers to the use of existing materials to create new ones to avoid waste.*

The parents survey: Topics

While there was an overwhelming amount of participation and interest in sustainability from the parents, the topic of sustainability was not as often a discussion in the households.

- **44%** of the participants **rarely** or **never** initiated conversation on the topic.
- **64%** of the children **rarely** or **never** initiated conversation on the topic.

The parents survey: Takeaways

- Due to the contrast in participation and conversation in the households and the children's understanding of the topic, it can be hypothesized that children understand the importance of sustainable activities but do not understand *why* they are important.
- The conversations that do start, often do when the children hear something from school or other outside sources *or* when engaging in sustainable activities with parents.
- There is a lack of available material to facilitate comprehensive explanations of the topic of sustainability to young children.

Teachers: Takeaways

- There is currently no concrete "core goals" regarding sustainability for primary schools in The Netherlands (Wettenbank, 2023).
- Due to the vagueness of this, every school tackles this topic drastically different.
- The information provided to the children on sustainability should be something that they can relate to in their lives. Because this will motivate them to take action and be more interested in the topic.

Workshop with children: Takeaways

- The children are intrigued by the topic of sustainability but do not fully understand *why* it is important.
- The interest to learn about it and take action is already present but they do not have the right/enough material to understand the complexity of it.
- The younger children are more interested in learning and ask more questions on the topic. Their interest to learn about it is higher.
- It is *my observation based on the talks with the children* that there is a disconnect between what the adults believe the children are interested in and what they actually want to learn about.

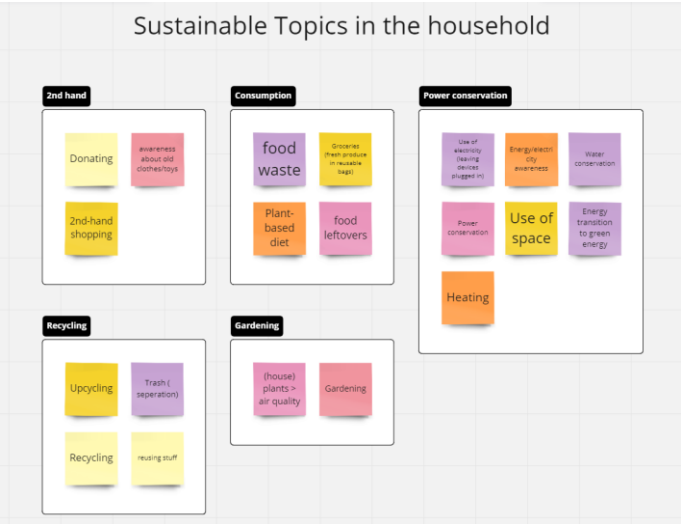
Important Notes

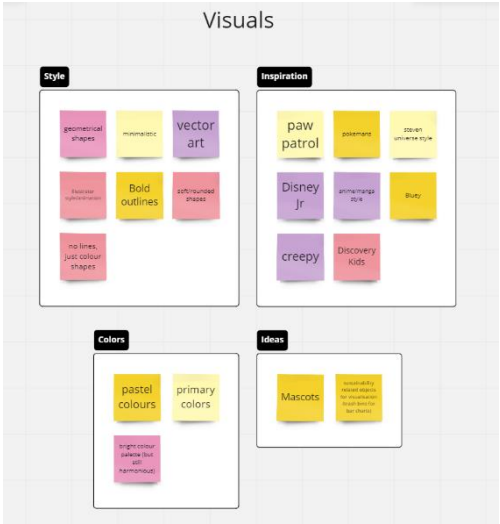
- **Because of the lack of access to teachers, the focus on sustainability in the household and time constraints, the insight of teachers on the topic was limited.**
- **The insight gathered from the direct target audience (children) from the workshop is as of now only focused on "middenbouw".**
- **However, the insight of "bovenbouw" will still be gathered during testing & iteration of the product to gather future recommendations and points of improvement.**

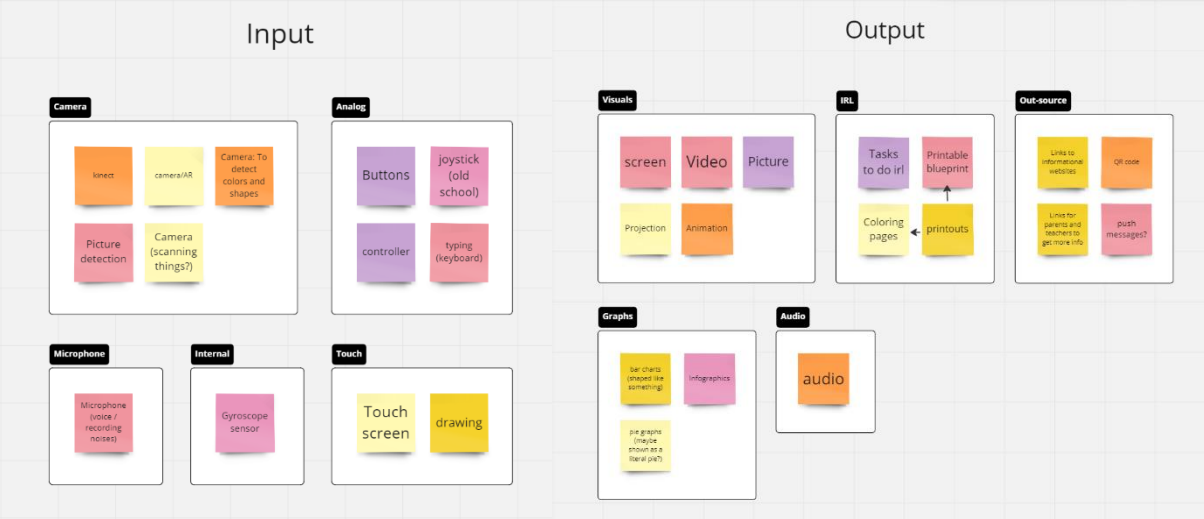
Appendix E. Brainwriting results

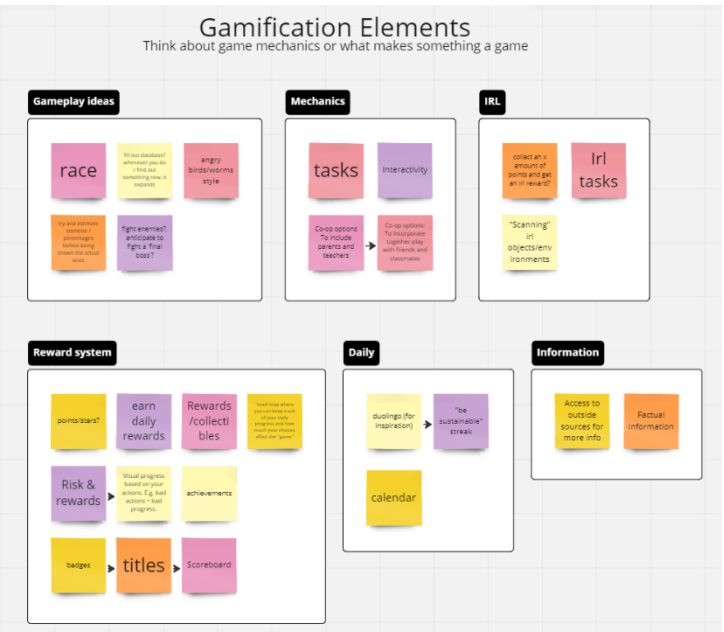
Source: N. Louiza (2023)

Link: https://miro.com/app/board/uXjVMSM2E0c=/?share_link_id=879231224388



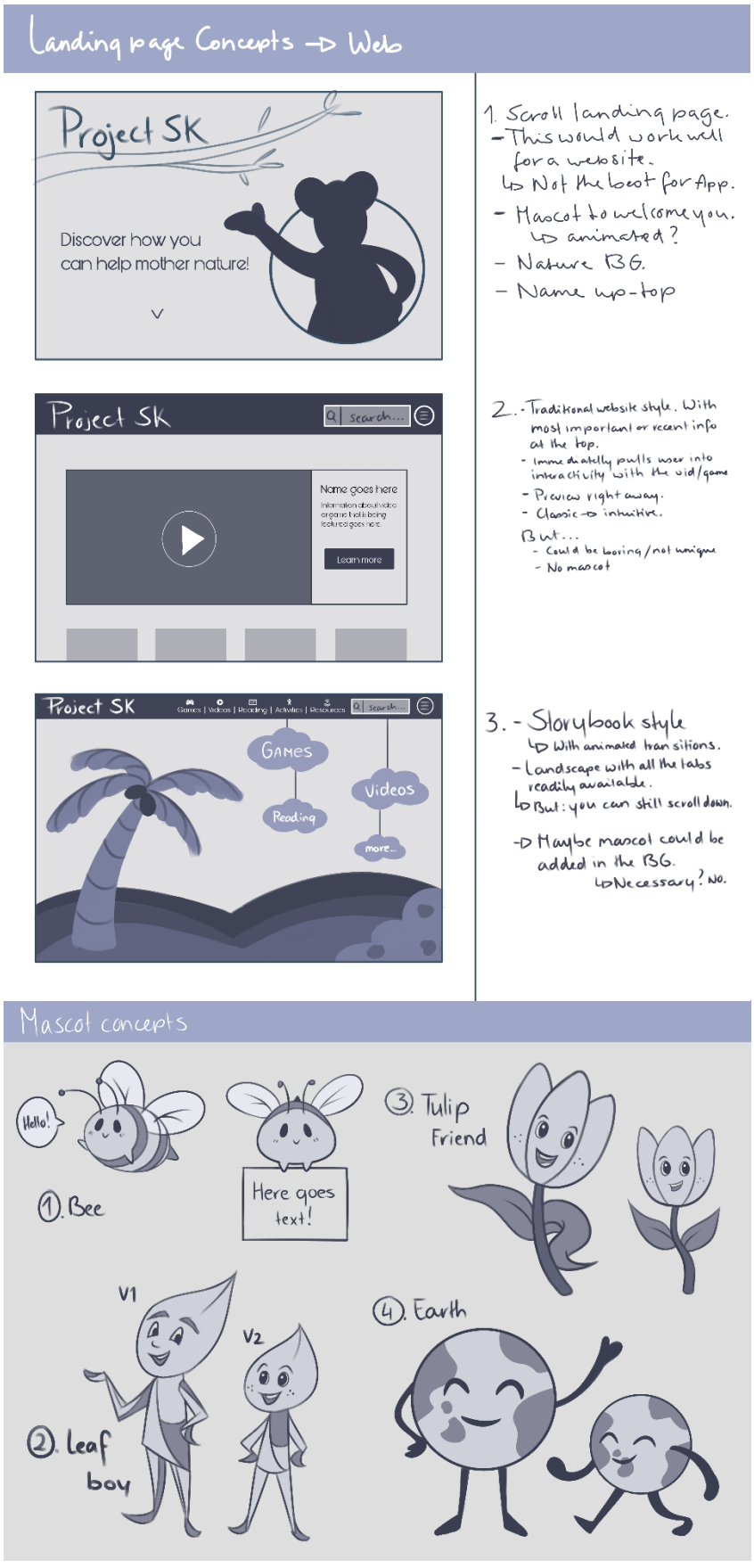






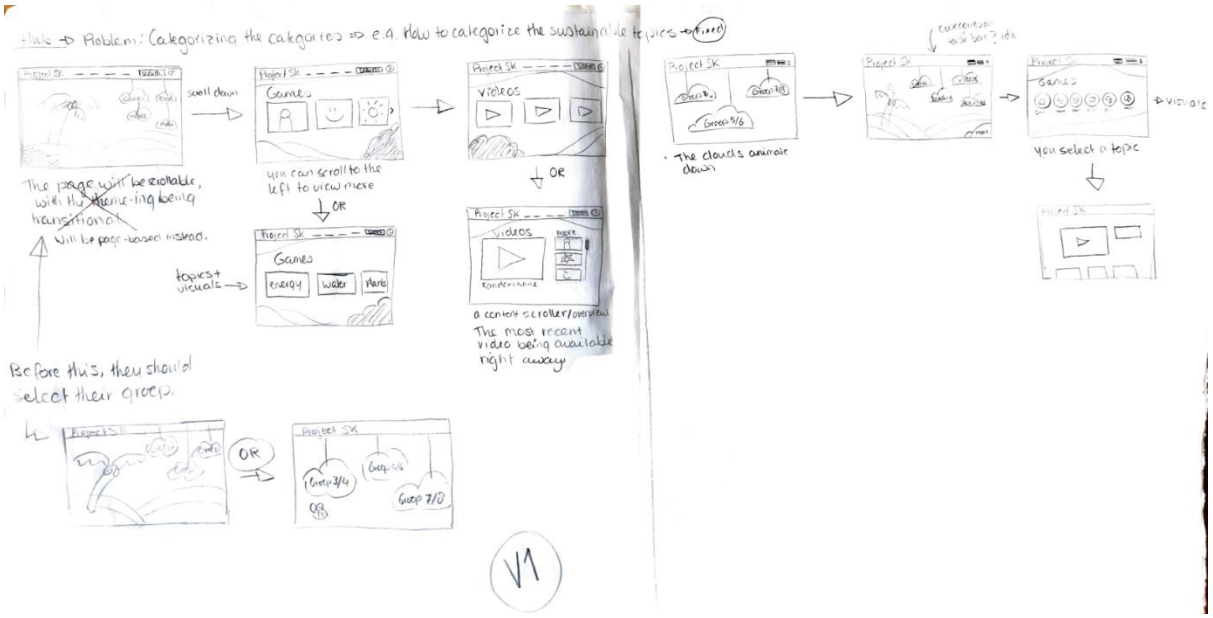
Appendix F.1. Visual concepts

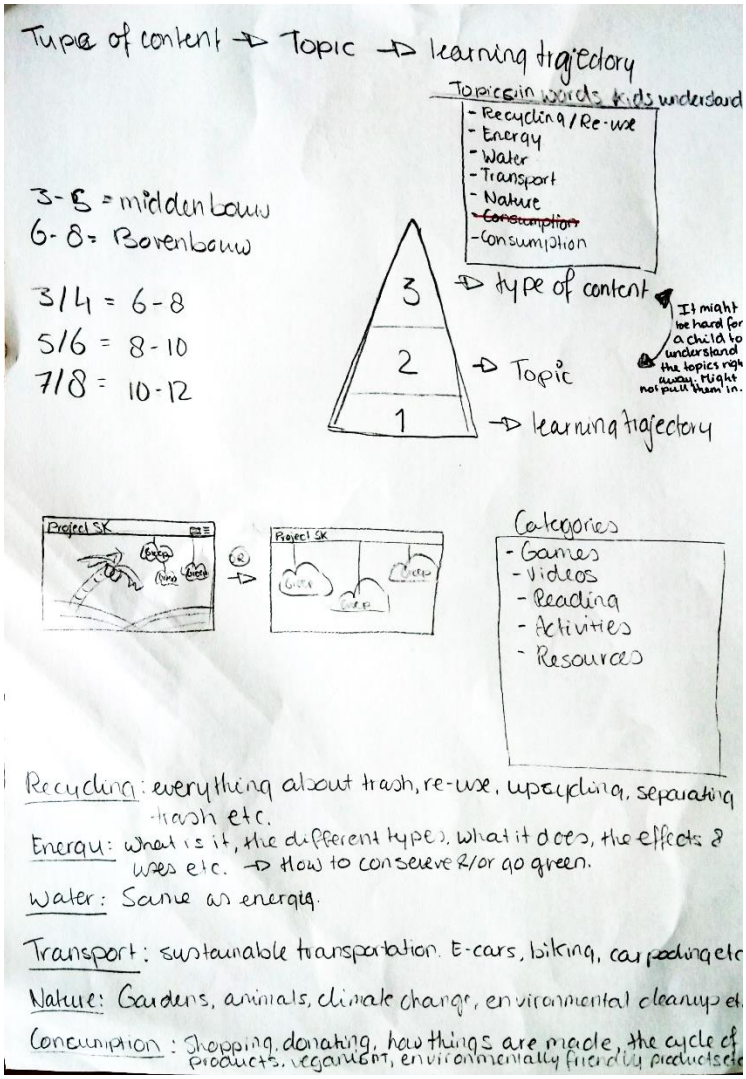
Source: N. Louiza (2023)



Appendix F.2. Website navigation concept

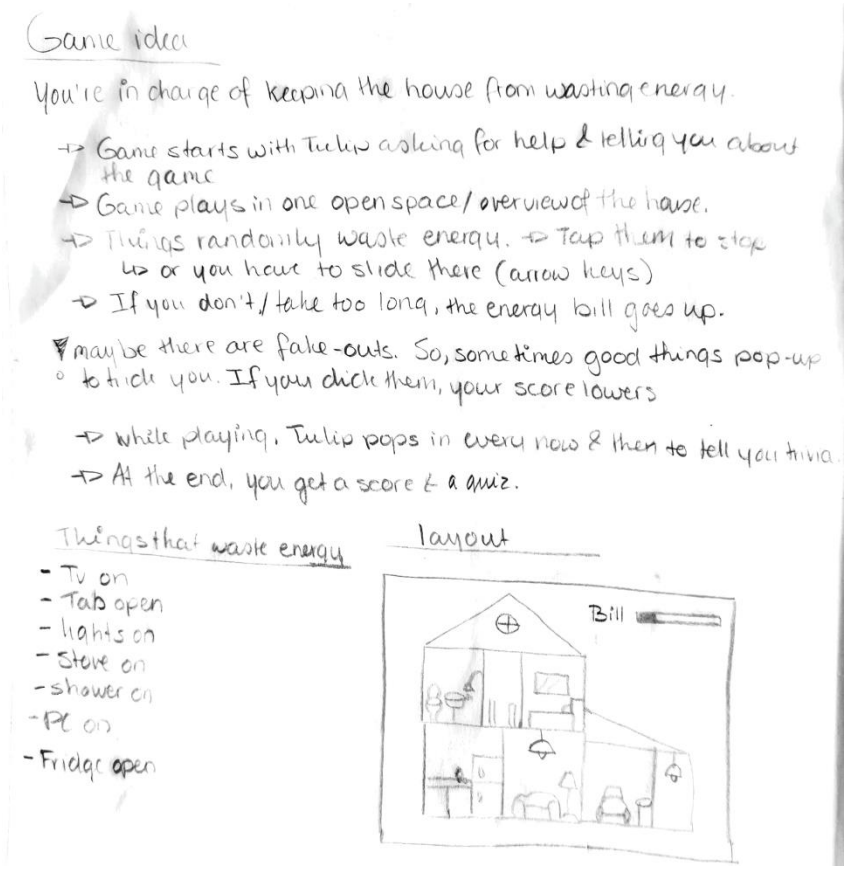
Source: N. Louiza (2023)

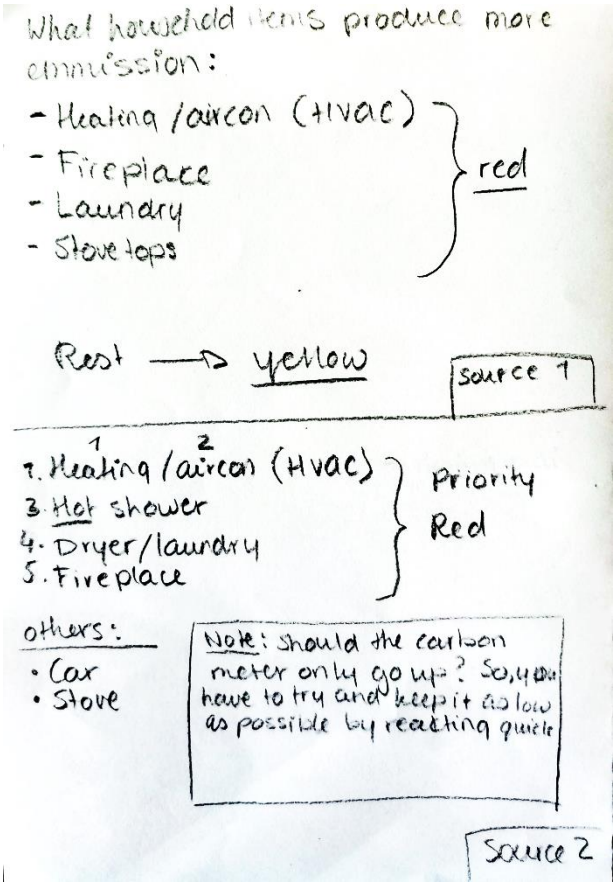




Appendix F.3. Mini game concept

Source: N. Louiza (2023)





Appendix G.1. Final testing plan

Source: N. Louiza (2023)

About the test

Type of test: Qualitative concept usability test
Place: Dr. Martin Luther Kingschool
Address: Clematisstraat 39, 7591XJ Denekamp
Date: Thursday June 15th 2023
Time: 10:30 – 14:00
Participants: 10 – 14 children from year 4 to 6

Setup

- The game will be tested with 2 participants at a time due to time constraints.
- An equal number of children from each school year will be selected for testing.
- The children can bring their own school laptops or use the one provided.
- The test will take place in an area with minimum distractions.

Process

- There will be a short introduction where the children will learn about the product, the test and what is expected of them. In this introduction, the children will be told that the idea is to imagine that the prototype is a real functioning game and to critically assess it as such.
- As part of the introduction, the children will be asked the following 2 questions:
    1. Have you ever heard of a carbon footprint? If yes, can you briefly describe what it is?
    2. Have you ever heard about greenhouse emissions? If yes, can you briefly describe what it is?
- The children can then interact with the website with minimal to no guidance while observed by the organizers.
- Points of interest will be noted down and questions may be asked regarding certain choices they made.
- After the interaction, the children will be asked 7 follow-up questions:
    1. Was there something that was unclear or difficult?
    2. What do you think could be improved on the website or game?
    3. What did you find the most fun?
    4. Did you learn something new? If yes, could you briefly explain it?
    5. After playing this, do you want to learn more about sustainability?
    6. Would you use a website like this if it was real?
    7. Do you have any more questions?

Appendix G.2. Final testing results

Source: N. Louiza (2023)

Each test round had 2 participants and the results were based on the responses of both participants.

Year 6	Round 1	Round 2
Intro	Both participants were familiar with eco footprints and greenhouse emissions.	Both participants were familiar with eco footprints and greenhouse emissions.
Q1	How to interact with the mini game.	No.
Q2	Add an explanation on how to play the game. Increase the brightness of the lamps in the house.	Tulip the mascot looks creepy.
Q3	The way that the text was presented.	Clicking around in the prototype.
Q4	No.	No.
Q5	No. They are not that interested in it.	Maybe. But it depends on the topic.
Q6	No, they would rather do something else.	Maybe.
Q7	They asked about the process of making a website like this.	No.
Notes	They were skipping through most of the text and not reading. The information was below their level and therefore they were mildly bored. However, they were engaged when interacting with the prototype and clicking through everything.	It was unclear to them what they were supposed to interact with during the mini game. They were also very interested in the other functionalities of the website that they couldn't access.

Year 4	Round 1	Round 2
Intro	They were not familiar with either term.	They were not familiar with either term.
Q1	How to start and play the mini game.	No.
Q2	Add a tutorial for the mini game.	Nothing.
Q3	Playing the game.	Clicking around in the prototype.
Q4	It was their first time learning about this topic.	No, because it was boring.
Q5	Yes, if there are more games.	No.
Q6	Yes.	No.
Q7	No.	No.
Notes	They took their time to explore the whole website and read all of the text at the beginning of the mini game but did not notice the text during the mini game. Some of the text was also too small for them to read.	At first, they were interested in clicking everything on the website. Once they couldn't interact with what they wanted, their interest lowered. They also skipped through all the text in the mini game.

Year 5	Round 1	Round 2
Intro	They were familiar with both terms, but it was very new to them.	Had heard about them before but have forgotten.
Q1	Did not find anything unclear.	Did not know where to click sometimes.
Q2	More options to click through.	The game should be longer.
Q3	They enjoyed everything.	Clicking around in the prototype.
Q4	Even though it was not new information, they were able to remember what they had learned about it earlier in the school year.	A little bit.
Q5	Yes.	Maybe.
Q6	Yes, especially if it has things to read.	Yes, if it has games.
Q7	They asked if the website was going to be developed further.	No.
Notes	They explored the website the most and discussed what they were seeing and reading. They also took time to read everything and were very excited about the concept.	They were engaged in interacting with the prototype and tried to click and ask about features that were not implemented yet. Even though they could not access them, their engagement did not lower.