‘Designing an Interactive Tool to Track Eating Behaviour in Children Ages 5-6’

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Abstract

This research aimed to forgo the shortcomings in current food tracking research by further exploring and developing an impactful method of quantifying children's eating habits. The tracking of eating behaviours is of crucial importance to unburden our healthcare system. Looking at existing research, it is evident that the field is in need of a consistent and standardized method that could be applied to both children and adults. This would allow researchers to gain a more detailed visual of the problem situation and then tailor interventions on a case-to-case basis. This is not only for tackling obesity but also other food-related health issues. This paper aimed to explore how effective current tracking methods are on children and contrast these to children's cognitive/reading abilities. Then user testing was carried out to determine if an interactive tool is usable by children and if so, what design elements contribute to its effectiveness. Based on this research, an interactive tool to effectively support the tracking of eating behaviours in children ages 5-6was designed and created. Results indicated that the accuracy and ability of tracking using the designed tool is remarkably high. The concept of tracking eating behaviours using a gesture-based tool was successful. However, certain elements, such as the force required to trigger/detect a response, could use fine-tuning to improve usability. The time it takes to complete one entire tracking cycle is, on average, around 3 minutes, which poses a very low entry barrier for the child. The design choices shaped the gesture-based tool in such a way that it enables children ages 5-6 to track their eating behaviour independently and accurately

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Chapter 1 - Problem statement and research questions

1.1 Introduction

Obesity can be defined as “excess of fat in relation to body weight” [1]. It is one of this century's most severe public health challenges due to its complex and multifactorial nature. This has proven (and will continue to prove) to be a major challenge to chronic disease prevention of human life around the world [1].

While adult obesity is already a prevalent problem across developed and transitional nations, child obesity seems to be on the rise [2]. Models based on the United States population predict that, given the current level of childhood obesity, 57.3% of today’s children will be obese at the age of 35 years [3]. Obesity greatly increases the risk of chronic disease morbidity, disability, depression, type 2 diabetes, cardiovascular disease, certain cancers, and increased mortality [1]. The effects of reduced well-being of a population have far-reaching and long-term consequences on the quality of life, socioeconomics, and the environment of those affected. Without proper measures, increasingly more children will become familiar with these conditions, emphasizing the urgency of introducing interventions early on.

There are many factors that can contribute to an individual becoming obese, but eating behaviour is the most influential factor. This is true for both adult and child obesity [4]. Eating behaviours seen in adults are often the result of learned eating behaviour when they were young [1].

Once obesity is diagnosed, most measures start with the tracking of eating behaviour in day-to-day life. Common research protocols include food frequency questionnaires (FFQs) and 24-hour recall methods. Both adults' and children’s eating behaviours are tracked using these research methods [4]. Although these protocols are effective for adult obesity patients, the same cannot be said about child obesity patients [5].

One of the most prevalent issues in current research is that protocols for eating behaviours are often modified according to the research topic and research subjects. These modifications have led to inconsistent results among studies [6]. This is particularly problematic in child eating behaviour research, where standardized methods are scarce. Researchers modify protocols aimed at adults to fit the needs of children. However, children’s cognitive abilities (reading and writing) vary significantly across the developmental stages. So, while these modifications are necessary, these changes often lead to inaccurate and ungeneralisable results.

The tracking of eating behaviours is of crucial importance to unburden our healthcare system. Looking at existing research, it is evident that the field is in need of a consistent and standardized method that could be applied to both children and adults. This would allow researchers to gain a more detailed visual of the situation to then tailor interventions on a case-to-case basis. This is not only for tackling obesity but also other food-related health issues.

1.2 Problem statement

This research topic 'Designing an Interactive Tool to Track Eating Behaviour in Children Ages 5-6' was provided by Wageningen University. Their main area of research focus on the domain of 'healthy food and living conditions". Zoë van der Heijden, a master student from the global nutrition department had carried out an explorative pilot study aimed to determine key criteria that a novel dietary behaviour assessment tool for children, ages 5-6, should meet.

Given the design and conceptualization of a physical protype lies outside of the domain of their research, they reached out to the University of Twente. Based on their findings they reached out to the University of Twente requesting for a tool to be designed; a tool capable of tracking the eating behaviours of children ages 5-6.

This research aims to forgo the shortcomings in current food tracking research by further exploring and developing an impactful method of quantifying children's eating habits. This thesis is divided into eight chapters, starting with a context analysis; this is done by doing a literature review, analysing the state-of-the-art technologies, and making user case scenarios to find the users' real needs. The ideation phase will be based on the gathered information from the background research. Finally, the concept generation chapter describes the ideation phase and what requirements were set to find the final set of concepts to be evaluated by the stakeholders.

1.3 Research questions

The main research question is as follows:

I. How can the design of an interactive tool effectively support the tracking of eating behaviours in children ages 5-6

The sub questions that will aid in answering the main research question is as follows:

II. How effective are the current technologies in tracking a child's eating behaviour?
III. How limited are the reading/writing abilities of children ages 5-6?
IV. To what extent are children able to use a tool to track their eating behaviour?

V. How do the design choices of the tool influence their ability

The sub-questions can be divided into two: questions II and III will be considered in the literature review. Questions IV and V will be considered during the evaluation/testing phase; a phase that involves designing and testing the interactive tool.

Several other questions were asked during the concept generation phase to ensure that the concepts stay true to their goal of tracking the eating behaviour of children. After doing a user evaluation of the generated concepts with the stakeholders, it can be further analysed if the questions asked during the concept generation phase could be turned into general requirements.

Chapter 2 - Background research

The context analysis aims to gather knowledge on how a tool can be created to properly track a child's daily food intake. This, to make research into children's eating behaviours easier. Often, an adult's eating habits stem from behaviours they were exposed to as a child [7], making it of utmost importance that an effective method be found to apply to children. The context analysis will discuss previous research on tracking eating behaviours and current technologies. This, to hopefully make predictions and assumptions on a future prototype that could fill in the voids in recent research.

2.1.1 Introduction to literature review

This review consists of two parts. First, it will provide insight into the current state-of-the-art methodologies used to track eating behaviours and their shortcomings. Secondly, conclusions are drawn to guide the shaping of novel methods to quantify children's eating habits.

2.1.2 Definitions of existing tracking methods

In table 1, you can find the definition of the methods discussed in the literature review.

Table 1 - Definitions of tracking methods

Method	Explanation
Self-reporting	A type of survey, questionnaire, or poll in which respondents read the question and select a response by themselves without any outside interference. [1]
24-hour recall	A dietary assessment tool consists of a structured interview in which participants are asked to recall all

	food and drink consumed in the previous 24 hours. It may be self-administered. [2]
Food frequency questionnaire	A dietary assessment tool is delivered as a questionnaire to estimate frequency and, in some cases, portion size information about food and beverage consumption over a specified period, typically the past month, three months, or year.[3]
Food records	A metho of collecting data on dietary intake by subjects' self-record over a specified period. [4]
Duplicate portions	A method of collecting a second identical edible portion of all foods and drinks consumed over a 24 h period[5]

2.1.2 Standardized methods of tracking eating behaviour

There are several ways to track an individual's eating behaviours, and these methods are applied in various research and healthcare fields. Although obesity is a multifaceted issue, the most significant contributing factor to a diagnosis is usually a person's eating behaviour. Tracking a patient's eating behaviour can thus lead to more insight, resulting in a better-suited intervention.

According to Brouwer-Brolsma et al. [6] and Naska et al. [7], self-reporting is the most common tracking approach. Both agree that the self-reporting approach can be divided into recall and real-time recording methods. The difference between the two is that real-time methods are, as the name suggests, done at the moment of consumption, whereas recall methods are used to look back and report what was consumed within a given time frame. Given this distinction, Brouwer-Brolsma et al. state that the most commonly used recall methods are 24-hour recall, dietary history method, and food frequency questionnaire[6]. Real-time monitoring methods, however, consist of food records and duplicate portions. Each method has its strengths and weaknesses and as such, are used in different scenarios. Of the methods mentioned earlier, Brouwer-Brolsma et al. claim that the '24-hour recall' and 'food frequency questionnaires' are the standardized methods used in research[6]. Naska et al. [7]and Foster et al. [8] agree with the notion that these methods are the standard methods used in research. At the same time, the dietary history method is the most commonly used in a healthcare setting. This is due to the nature of their intention and the level of accuracy required. Research usually

aims to find trends over extensive data sets, with a tolerance for inaccuracies, while more accurate and in-depth information is needed from an individual patient in health care.

2.1.3 Effectiveness of current interventions

Despite the staggering number of researched interventions to tackle obesity in children, their effectiveness is often questioned. In a systematic review of 96 citations researching the effectiveness of obesity interventions, Danielli et al. determined that of the four reporting a positive impact on tackling obesity in children, none were "simple single interventions"[9]. This also concurs with the research by Shorey et al. They point out that due to the heterogeneity in the included interventions analysed, the overall direct effectiveness of each intervention could not be measured. Moreover, Shorey et al. conclude that "more studies involving peers that are institution-based need to be conducted"[10]. Costas Diaz et al. support this claim as their research concluded that the programs based solely on individual interventions "have been effective in promoting positive changes in the eating habits of children and adolescents"[11]. To conclude, the complexity of multiple interventions used in research programs and the inability to measure individual effectiveness has emphasized the need for the development of a single intervention capable of successfully tackling obesity.

2.1.4 The effectiveness of personalized approaches

Given the limited success of tackling obesity by using complex interventions on broad research groups, some researchers have taken a more personalized approach. Kelly et al. argue that rather than trying to develop an intervention "based on long-range predictions about hoped-for behaviour change," which accurately describes how weight is tackled with regards to obesity, "working backwards using regressive inference is a much more profitable avenue for developing intervention"[12]. This suggests starting with analysing the behaviour and identifying who and where this behaviour is being carried out, would result in a more effective and personalized intervention.

Accordingly, in web-based nutrition interventions, Al-Awadhi et al. suggest that "personalized/enhanced web-based nutrition interventions may be successful at inducing short-term dietary change compared to non-personalized dietary interventions."[13]. The importance of creating an intervention based on behaviour has also been demonstrated by Kelly et al. [12]. The observation made by Lucassen et al., "targeted dietary behaviour interventions can be improved by integrating behaviour change techniques and tailoring to the individual, target

group, or situation" [14], can therefore be grounded by the research done by Al-Awadhi et al.[13].

These papers suggest that the shift towards more personalized approaches can significantly benefit individuals struggling with obesity in the long term because the approaches are catered to the individuals needs and surroundings. For children, this may be their cognitive/reading abilities or personal situation at home; all aspects that are not tackled by broader population-based interventions. This approach offers clear suggestions to increase the effectiveness of research, compared to that of current approaches.

2.1.5 Implementing adult methods to children

While Foster et al. agrees with the standards of recall methods, as previously mentioned, they recognize that children lack the cognitive skills to recall their food accurately[8]. Foster concluded that this might have to do with the lack of basic writing skills, limited knowledge of food names and types, and preparation methods. Craigie et al. [15] do not analyse the specific difficulties of applying the methods of tracking eating behaviours. Instead, their paper discusses how the variability and disparate approaches to assessing eating behaviour negatively affect the accuracy of research conclusions. Therefore, it is safe to assume that further research and testing are required to track eating behaviours in children accurately.

2.1.4 Conclusion

This literature review gives a broader view of the current tracking methodologies, which methods are most used in research and healthcare, and their effectiveness. Current interventions are poorly suited for research in younger ages. To overcome this, solutions such as personalized interventions are explored. These have been found to have a higher possibility of being effective.

2.2 Context analysis – state-of-the-art technologies

From fitness trackers to food diary apps, a plethora of applications are designed to make someone more aware of their "health" level. For some, these apps work wonderfully. However, these apps are daunting for others and could lead to obsessive behaviour. Many of these personal health apps are designed for the end user only; an expert is not involved in concluding whether a person's statistics are "healthy".

Experts that target patients eating behaviour often do so by making the patient answer paper-based food-related questionnaires or keep food-related diaries. Due to issues such as

concentration span, reading/writing abilities, and overall cognitive development, this method cannot be effectively applied to the degree required for research.

Having analysed the state-of-the-art technologies, two clear categories could be distinguished: the wearable tracker and the non-wearable tracker. Both types of technologies could be applied to tracking eating behaviours, but there are more of the non-wearable type than wearable ones. Furthermore, the wearable technologies were designed to be autonomous; they do not require human input to track whatever the human is eating. On the other hand, almost all non-wearable technologies required human input to function as an eating behaviour tracker.

Due to the lack of further literature and technologies, it can be concluded that an interactive eating behaviour tracker, aimed at children specifically, is simply not something that exists. Although elements have been added to mobile applications, none of the existing technologies seem to combine the elements needed to keep a child engaged or to keep tracking their intake accurately. This further emphasizes the need for such a tool to be designed, especially one centred around the child's needs first.

2.3 Description of target user group and domain

As mentioned earlier, the client has specifically requested that the tool be aimed at children ages 5-6. However, these children are not the only relevant users that must be considered in the design process of this tool. Children aged 5-6 do not usually operate their day-to-day lives alone. They are usually surrounded by their guardians, family members, teachers, and friends. Furthermore, an eating behaviour tracker is aimed to help researchers conduct studies into eating behaviours. This already identified several stakeholders:

1. Children aged 5-6
2. Parents or guardians of children ages 5-6
3. Experts and researchers aiming to study eating behaviours in children aged 5-6

These stakeholders are the most important ones to consider for this project. Therefore, it is necessary to consider their needs and how they will interact with the tool. As this research follows the grounded design method, it is crucial to circle back to the characteristics and habits of these stakeholders. Below, the different possible scenarios for each stakeholder group are described. The scenarios aim to identify the failure points and difficulties faced when applying the current methods of tracking children's eating behaviours. These scenarios are based on the understanding gathered from the research papers and the state-of-the-art technologies discussed

in the context analysis. Furthermore, as the tool designed within this thesis is aimed at research and medical applications, the scenarios have been adapted to fit that narrative.

2.4.1 Children aged 5-6

Using the knowledge gathered from the background research, three user scenarios have been developed. The scenarios are then used to analyse the shortcomings and how these lead to reduced effectiveness of methodologies. Furthermore, they provide a scene in which the tool developed in the thesis could be applied.

Scenario 1: A young child is given a paper-based food diary and tasked with writing down what they ate every hour. They find themselves struggling to remember to do the task, and not much of their daily intake is recorded. The experts analysing the food diary then get an inaccurate representation of what the child has eaten during their study. This could lead to wrongful conclusions in their research.

Scenario 2: A child struggling with obesity receives a task from their dietitian; they need to answer food questionnaires at the end of the day. Their guardians are tasked with asking the questions in the questionnaire and writing down the answers. However, the child struggles with remembering what they ate throughout the day, leading to frustration in both the guardians and the child. This leads to the answers being non-consistent, and the validity of the answers are questionable. In turn, this leads to the dietitian getting inaccurate information and could lead to misassigning a diet to the child.

Scenario 3: A child participates in a study and is given a paper-based food diary. The child has been able to keep up their daily intake for a few days. However, the study they are involved in requires them to journal their intake for at least three weeks. The child loses motivation to fill in the diary after a couple of days; the task is too dull and does not involve any fun engagement for the child. The child starts to fill in things randomly, as their guardians want them to "at least try" to keep up with the journaling. The diary is then filled with untruthful entries, and the study they are involved in receives false information, leading to misleading results.

Figure 1 - General depiction of children's confusion when asked to track eating behaviours throughout the day

2.3.2 Parents or guardians of children ages 5-6

Scenario 1: A young child struggles with dizziness during playtime. The general practitioner advises the child's parents to record what the child eats daily so that the general practitioner can exclude specific diagnoses. While the parents are well on track with recording what their child eats when they are home, they struggle with doing the same when the child is at school or their friends' houses. Even if the parents ask the attending adults to track what their child eats, keeping them up to that task is challenging. The child is at school 5 days a week, and at their friends on the weekends, so food entries are scarce. As the parents do not want to seem incapable of fulfilling a doctor's request, they make estimates of the foods their child might have eaten. This leads to inaccuracies in the recording of food intake, thus making the general practitioner misdiagnose their child.

2.3.3 Experts and researchers aiming to study eating behaviours in children aged 5-6

Scenario 1: The Health Council of the Netherlands has started a study to analyse if the average eating behaviours of Dutch children aged 5-6 are healthy. In the study, they ask the general Dutch public to track their young child's intake throughout the course of a month. Although the study is aimed to form conclusions about a toddler's eating behaviour, the parents/guardians are the ones who are supposed to fill in the daily questionnaire. As parents struggle to keep track of what their child eats, as stated in Scenario 1 of section 2.4.2, the researchers receive massive amounts of false data. Using this false data, the researchers draw (although accurate) misleading conclusions. The Health Council then advises the Dutch government not to take action, as their research shows that the average eating behaviour of a Dutch toddler is relatively healthy. However, the reality may be quite the opposite; thus, an entire generation of parents and children may be advised to keep up with what they are doing, leading to most children developing obesity as they grow older.

Scenario 2: A research body of the University of Twente has decided to create an interactive tool that can help children track their eating behaviour. The tool works independently of other mobile devices and can be remotely accessed by the researchers to check on the child's progress. The researchers are pleasantly surprised to see that the tool generates a lot of data and that the children involved actively engage with it quite often. However, during a user evaluation conducted after the first month of the tool's launch, it becomes clear that there was a massive misunderstanding between the researchers and the children. The children using the tool saw it as a toy, where they had to indicate what food they wanted to eat throughout the day rather than the foods they had eaten. Therefore, the

researchers' data have been rendered useless, and they need to rethink the tool's design to ensure that the child understands how to use it properly.

As seen in the scenarios above, the three main stakeholders are interconnected. The child cannot function without the parent, and the researchers need the parents' input to research children. Not surprisingly, this interconnection will form a part of the design process to ensure the needs of each stakeholder are met. Furthermore, by looking at 2.3.1 scenarios of children ages 5-6, we can identify how the combination of current tracking methodologies and the limited cognitive abilities of children reduce the effectiveness of these methods. In the next section, children's abilities will be identified and classified in further detail.

2.4 AVI levels

As mentioned throughout the previous chapter, the level of cognitive and physical development plays a strong role in tracking methods' success. Reading and writing are required for most, if not all, of these methods. Therefore, a baseline for their abilities is required. AVI levels offer just that. AVI is the abbreviation for "Analysis of Individualization Forms". It is a system that has been developed from the average reading development of children to measure the reading skills of children. A text's difficulty level can also be determined utilizing the AVI level. According to the AVI levels, children ages 5-6 fall under AVI-Start, M3 and E3. Table 2 below presents the baseline abilities of each of these levels.

Table 2 - Baseline language abilities for each age group according to AVI

AVI-Start	5 years old	- Immediately recognizes the articles de, het and a - Recognizes simple words, such as toe, tree, boat, car, etc.
AVI-M3	Ages 5-6	- Reads sentences with about six words without capital letters - Reads short sentences with one sentence per line - Does not read compound sentences - Easily names all graphemes - Reads monosyllabic words without reading difficulties - Reads fluently sound (M)K(M) (yes, om, teacher, I, pen, angry)
AVI-E3	Ages 6-7	- Reads sentences with about seven words - Reads one sentence per line with capital letters - Reads coordinating compound sentences fluently

		-Reads fluent simple two-syllable or compound words (rover, football) - Reads fluently monosyllabic words ending in dt, ng or nk - Reads smoothly two and three consonants in front and/or back - Reads diminutives fluently

The AVI levels offer a representative basis on which the tools' questions and answers can be formed. It indicates the abilities/ limitations of these age groups and answers the sub-research question, III. "How limited are the reading/writing abilities of children ages 5-6?". This, in turn, will form part of the limitations which should apply in the ideation of the tool.

2.5 Age determination guidelines for toys

The Consumer product safety commission CPSC age determination guidelines (**ADG**) provide designers and manufacturers information about children's toys, skills, play behaviour, and interests for different age groups and how they relate/apply to toy characteristics. As discussed earlier, children go through several stages of development where their physical and cognitive abilities vary greatly. Therefore, the guidelines applied to toy design and manufacturing can also guide the development of this thesis's tool.

The ADG consists of 8 play categories, each constituting several subcategories; these form the primary structure of the guidelines. For this thesis, we focus on category 8.1: *smart toys and educational software*. According to ADG, "*smart toys are toys that can respond to the user's play actions through sound, voice recognition, visual effect, or movement. This new line of toys has various levels of sophistication, but essentially a smart toy is computer chip based. Unlike simple battery-operated toys from past generations, smart toys and educational software/applications interact in more creative ways with the user. They also connect to computers through an Internet connection, or a cord right into the computer, for increased personalization and ability to respond to the user*". [16]

The ADG, much like the AVI levels, gives insight into the abilities and preference of each age group regarding product characteristics. The ADG groups are ages 4-5 and 6-8, respectively. In the below, the four most essential product characteristics for the smart toys and education software category are defined and the expected levels of acquired skills related to the category are described for the relevant age groups.

1. **Sensory Elements** - Those characteristics of toys that appeal to any of the five senses. These elements were considered based on light, sound, texture, smell, and taste. Stimulation of the five senses provides different responses from children at different ages. Colour/contrast is identified as a separate appeal characteristic, so it was not considered a visual sensory element.
    - Ages 4-5 & 6-8:
        - Interest held longer when software, application, or smart toy is energetic & rich with sensory elements like music, moving characters, blinking lights, & speech (cont'd)
        - Includes a great deal of music & visual engagement (cont'd)
2. **Motor Skills Required** - The specific levels of fine- and gross motor skills that are required on average for a child to interact with a toy successfully. Fine motor skills pertain to the ability to control the hands and fingers, including hand/eye coordination. Gross motor skills apply to the large muscle coordination necessary for using a toy. The amount of fine- and gross motor skills required by a toy can play a large role in determining the appropriate age range for a toy.
    - Ages 4-5 & 6-8
        - Fine motor skills are well developed, so small pieces with smart toys present relatively little challenge
        - Hand-eye coordination is well-developed, so mouse use is appropriate
3. **Level of Realism/Detail** - Toys' visual design and anticipated use. The level of realism is described in two ways: cartoonish versus real appearance and child versus adult qualities. Cartoonish/Real details pertain to the visual presentation of a toy. Level of maturity, cognitive ability, and motor skills are considered for the child/adult determination. The combination of these realism perspectives (cartoonish vs real and child vs adult) works together to affect the appeal and appropriateness of toys.
    - Ages 4 – 5
        - A child could use the camera on a touchscreen tablet to look at a toy and then 'play' with the toy on a touchscreen device through a process called augmented reality
    - Ages 6 – 8
        - Find realistic-looking toys appealing
        - Prefer real-world objects to plastic replicas

4. **Cause & Effect** - The attributes of toys that respond in some way to children's actions, either through lights, sounds, movement, or change in property. The cause and effect can range from very simple to highly complex and is directly related to a child's level of cognitive or motor skills.
    - Ages 4-5 & 6-8
        - Understanding the cause-and-effect relationship is fully developed, so programs utilizing this skill are engaging and provide contingent feedback to children's input (cont'd)

The ADG offer a clear and concise view of the abilities and requirements for smart toys and educational software. As such, they will be used to shape the ideas in the next phase, ideation, and offer a basis for evaluating the concepts.

2.6 Conclusion

The background research discussed above allows us to make predictions and assumptions for a future prototype that could fill in the voids in current research. Based on this research, we can now identify several requirements that must be considered in the ideation phase. These requirements are of utmost importance as they will not only shape the concepts in the ideation phase but also be a measure to reflect on the design's successfulness.

- A child ages 5-6 can carry the tool throughout their day-to-day life
- A child ages 5-6 should feel engaged and encouraged to continue using it over multiple days
- The tool should not have too many loose physical components
- The tool should be sturdy
- The tool is intuitive to use/understand
- The tool complies with the physical and cognitive abilities of children ages 5-6
- The tool complies with the age determination guidelines.
- The tool is independent of other technological devices used by children ages 5-6, i.e., mobile phones or tablet, etc.

Chapter 3 - Ideation

For the concept generation phase, information gathered in the context analysis was considered and put to use while selecting the concepts that could be used in this research. More specifically, a list of design specifications can be synthesized to meet the design requirements and effectively allow the tool to track children's eating behaviour. The first step was a brainstorming session, followed by a narrowing selection based on plausibility and context analysis. Finally, that selection was narrowed down even more to fit this project's scope.

3.1 From rapid ideation to final concepts

The first step in generating a concept was to conduct a brainstorm. The brainstorm session followed the rule of "nothing is too crazy", where every idea was written down without judgement. This phase generated 34 ideas about how to track eating behaviours in children. A mind map was made to organize the ideas, as shown below in Figure 2 - Unrestricted brainstorm outcome.

Figure 2 - Unrestricted brainstorm outcome

Following the unrestricted brainstorm session, a distinction was made between ideas similar to that used in the state-of-the-art section 2.3. Non-wearable and wearable ideas were sorted accordingly, as seen below in Figure 3 - Brainstorm ideas sorted into wearable and non-wearable.

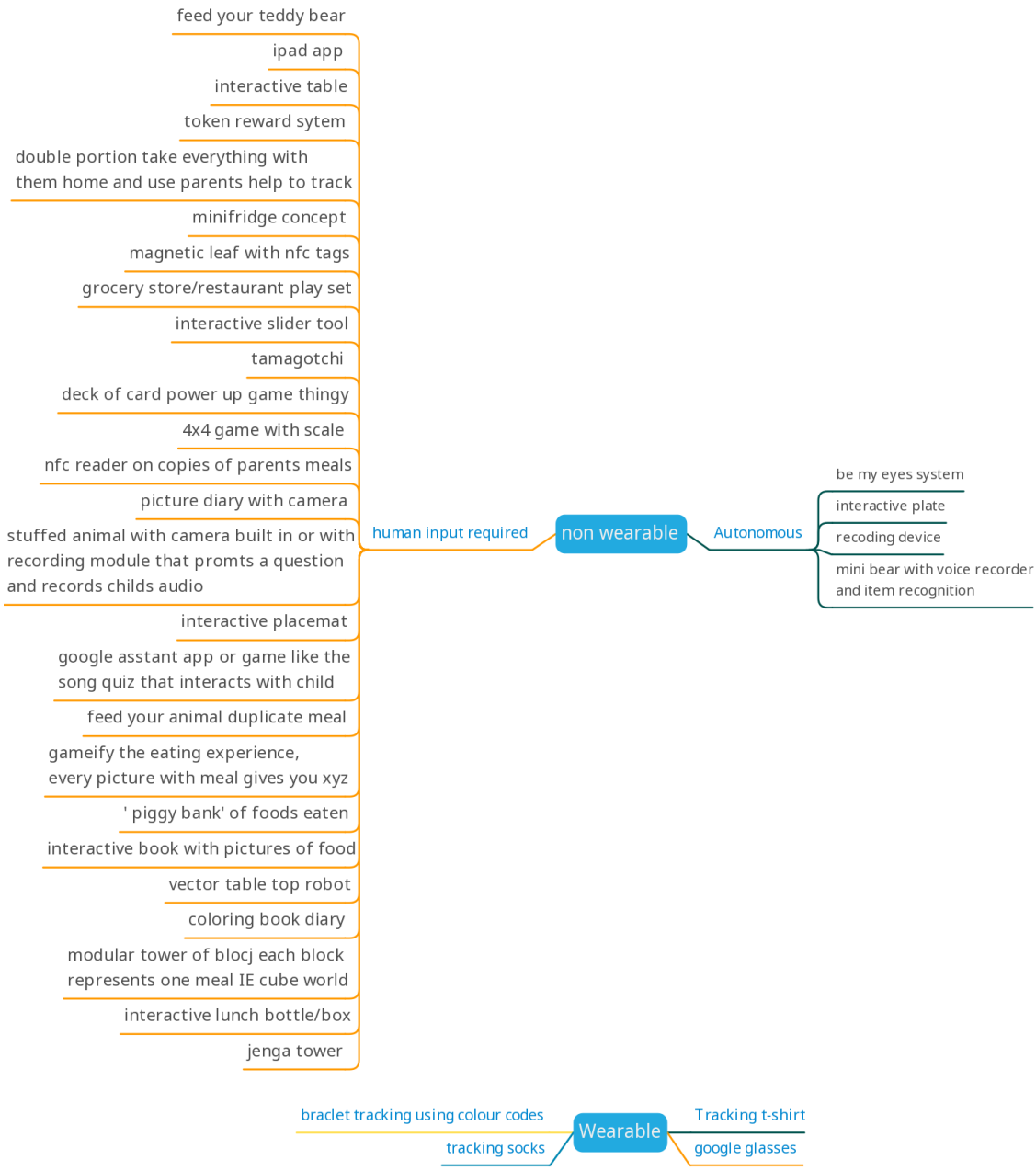


Figure 3 - Brainstorm ideas sorted into wearable and non-wearable

Then, following the general product requirements drawn in section 2.4, the sorted ideas were cut down into viable and practical concepts for a child to use. By doing so, the number of concepts was cut down to 18.

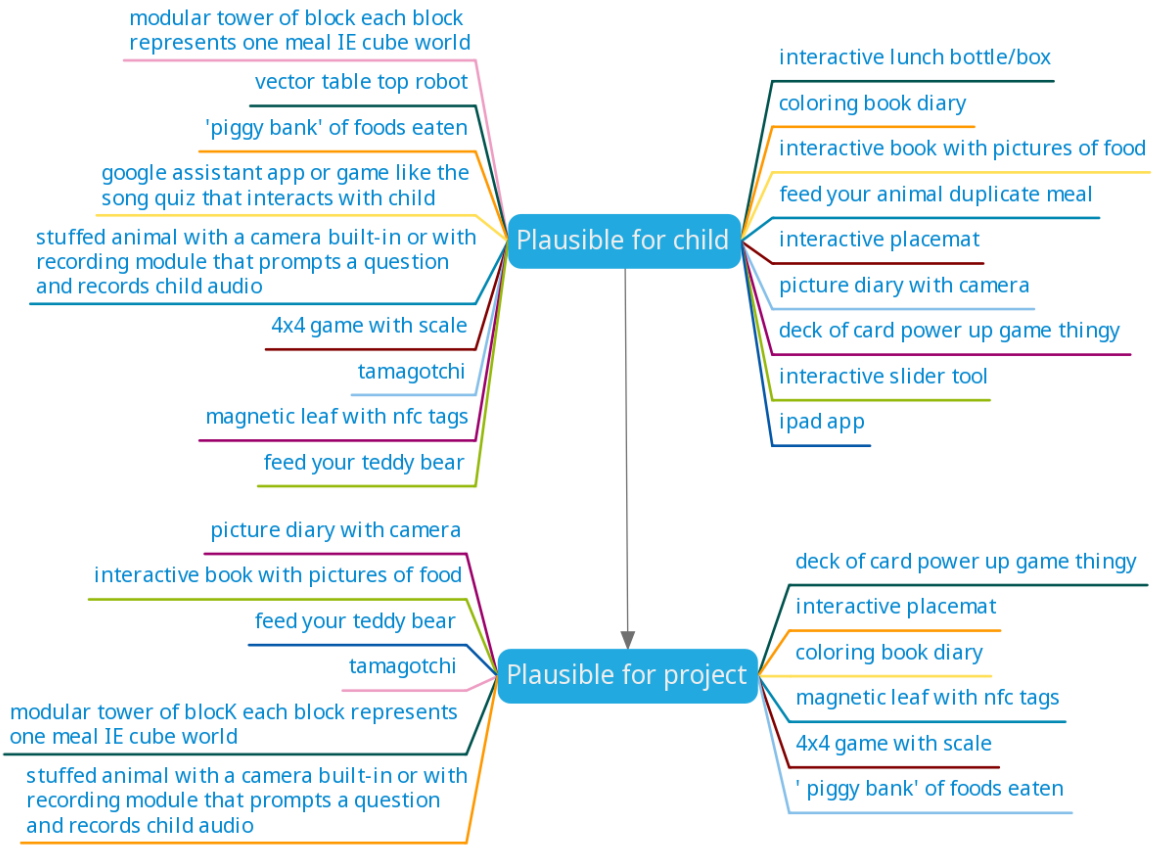
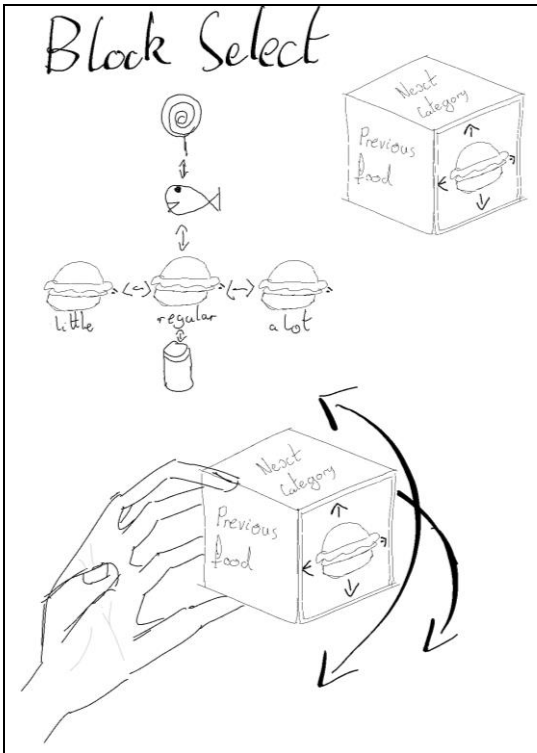


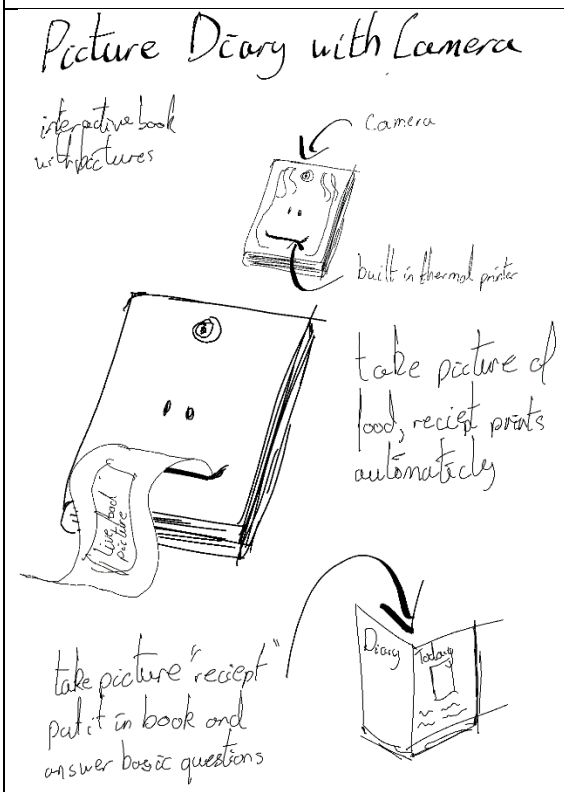
Figure 4 - Wearable brainstorm ideas categorized into plausible for the child and plausible for this project

In order to further narrow down the number of concepts, a question regarding feasibility had to be considered. As such, the question “Is this plausible to execute in the scope of this project?” was formulated and split into plausible for a child to use and plausible for this project. As seen in Figure 4 - Wearable brainstorm ideas categorized into plausible for the child and plausible for this project were considered, reducing the 18 concepts to 6 final concepts. These final six concepts were sketched and can be seen below in Table 3 - Description of the six plausible concepts for this project.

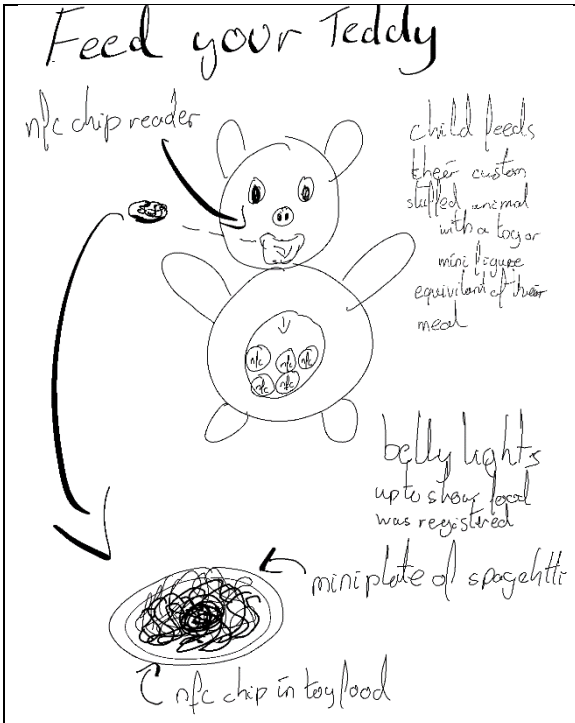
3.2 Concept descriptions

Table 3 - Description of the six plausible concepts for this project

<table>
<tr>
<td> 

Concept 1 - Block Select</td>
<td>Concept 1 - Block Select
It is a handheld cube with an LCD screen on its front-facing side and uses accelerometers to sense the user’s input. The user can interact with the interfacing using the flick of the wrist in a forward/backward motion to cycle through the categories of foods and a side-to-side motion to cycle through possible answers to the subsequent questions. Such as how much did you eat.</td>
</tr>
<tr>
<td> 

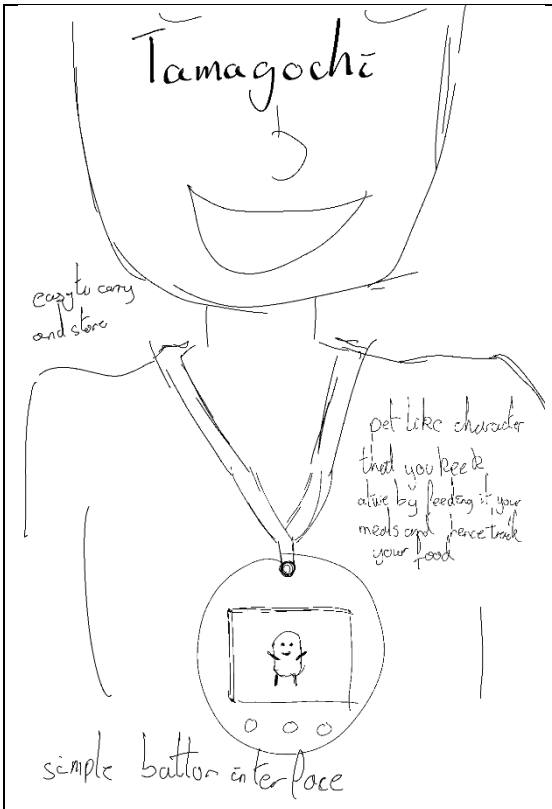
Concept 2 - Picture diary with camera</td>
<td>Concept 2 - Picture diary with camera
This tool functions as a questionnaire/ diary, however, with the added element of a camera and thermal printer (receipt printer). The user first uses the book with a built-in camera to capture an image of their meal. This is instantly printed on the receipt, which can then be stuck into the diary. The child can either answer the tracking questions immediately or, if necessary, look back at the picture at a later point and answer them appropriately without the hindrance of time between eating and recalling, as they have a visual representation in front of them.</td>
</tr>
</table>



Concept 3 - Feed your teddy

Concept 3 - Feed your teddy

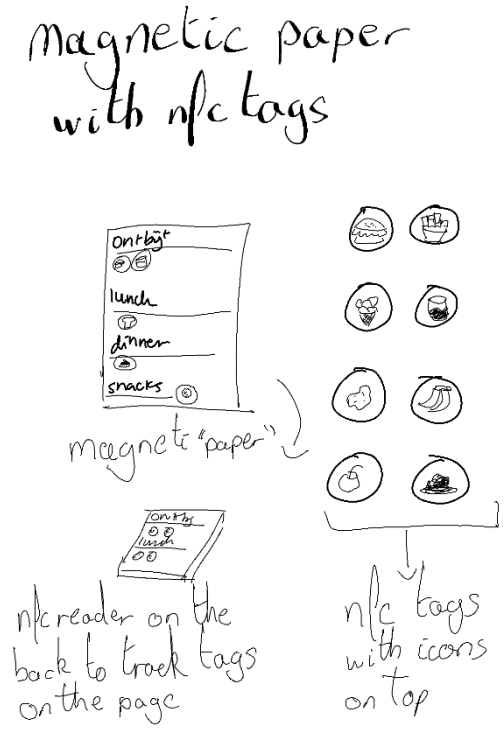
It is meant to act as a companion to the child. The child is supposed to feed their companion "teddy" a copy of their own meals. The meals will be figurine-like replicas supplied with the tool. The food figurines selections will cover a broad selection of foods consumed daily by children. The tool uses RFID to track the food figurines fed to the teddy. A reader will be placed in the mouth of the teddy, and corresponding chips will be inserted into the figurine meals. When the teddy is fed, the reader will recognize what food or category was eaten and logged on to the attached Arduino in a timestamped data logger. The food figurines can be taken out of the teddy bear and reused for the next day. The teddy bear may have elements of personalization, allowing the user to create a more personal attachment to their unique tool/teddy. i.e., Mr. potato head



Concept 4 - Tamagotchi

Concept 4 - Tamagotchi

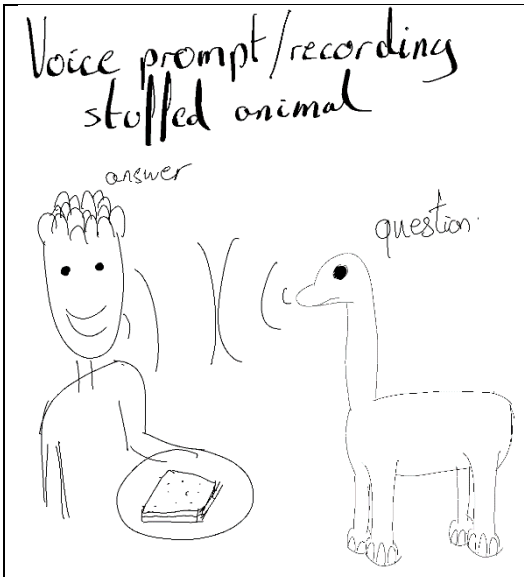
This tool aims to act as a digital pet the user should take care of. This will be done by requiring the user to track their own eating behaviour using a 3-button interface. The interface will allow the user to cycle through the category and quantity of food. An eating behaviour log is created by replicating their own eating behaviours to the digital pet.



Concept 5 - Magnetic paper with NFC tags

Concept 5 - Magnetic paper with NFC tags

This tool functions as a magnetic board; however, it has built-in NFC tags that allow the tool to track and timestamp each meal eaten. Several questions are permanently presented on the magnetic board with various possible answers (the magnets). Once a choice is made, the magnets are tapped on the board's reader and placed in the appropriate spot. Upon completing all questions, the board will save the recorded data which can be reset by moving the magnets back into their original place holders.

 *Concept 6 - Voice prompted toy pet*	Concept 6 - Voice prompted toy pet This tool works using a customizable stuffed animal. Using an integrated Arduino, the user can activate the recording function. A series of pre-recorded questions will be played on an internal speaker, prompting the user to track their eating behaviour by speaking to it. Th response is recorded and transcribed.

3.3 Evaluation of the concepts

In order to evaluate each concept, a concept evaluation matrix was created. This allowed for the success of each concept to be ranked based on the screening criteria.

3.3.1 Screening Criteria

The screening criteria were formulated using the general product requirements of section 2.5. These requirements were reiterated into three main requirements. Accordingly, each requirement comprises several sub-criteria that will be used to score and evaluate the concepts. Each criterion is given equal weighting in the evaluation.

1. The concept must grab and maintain the child's interest
    1.1. Does the concept offer contingent feedback?
    1.2. Is the concept independent of other devices, i.e., entertainment devices?
    1.3. Does the concept have elements of personalization?
2. The concept must comply with the physical and cognitive abilities of children ages 5-6
    2.1. Will a child be able to carry the tool throughout the day?
    2.2. Is the concept prone to losing elements? *
    2.3. Is the concept easy to understand/navigate?
    2.4. Are the visual elements large enough for children?

3. The product characteristics of each concept must fall in line with the Age Determination Guidelines

3.1. Does the concept align with the “Cause & Effect” characteristic?

3.2. Does the concept align with the “Sensory Elements” characteristic?

3.3. Does the concept align with the “Level of Realism/Detail” characteristic?

In order to successfully execute the evaluation without personal biases, each concept will be evaluated individually, and the summative scores, indicating the ranking of concepts, will be calculated after all concepts have been evaluated. This matrix will use a scoring scale ranging from 0 (Not applicable) to 5 (Very applicable). However, except for criteria 2.2*, 0 (very applicable) and 5 (Not applicable) will be used.

3.3.2 Concept evaluation

Table 4 - Concept evaluation matrix

	Concept 1	Concept 2	Concept 6	Concept 4	Concept 3	Concept 5
	Block select	Picture diary with camera	Voice prompted toy pet	Tamagotchi	Feed your teddy	Magnetic paper with nfc tags
1. The concept must grab and maintain the child interest	12	13				
1.1. Does the concept offer contingent feedback?	4	4	4	4	3	2
1.2. Is the concept independent of other devices i.e. entertainment devices?	5	5	5	5	5	5
1.3. Does the concept have elements of personalization?	3	4	0	0	2	0
2. The concept must comply with the physical and cognitive abilities of children ages 5-6						
2.1. Will a child be able to carry the tool throughout their day?	4	4	4	4	3	3
2.2. How unlikely is the concept prone to loosing elements?*	5	4	5	5	2	2
2.3. Is the concept easy to understand/navigate?	4	3	3	2	3	3
2.4. Are the visual material large enough for children?	3	4	5	2	3	4
3. The product characteristics of each concept must fall in line with the Age Determination Guidelines						
3.1. Does the concept fall in line with the characteristic “Cause & Effect”	4	3	4	3	2	2
3.2. Does the concept fall in line with the characteristic “Sensory Elements”	4	4	4	3	3	2
3.3. Does the concept fall in line with the characteristic “Level of Realism/Detail”	3	4	3	3	3	2
* Reversed scoring scale	39	39	37	31	29	25

In Table 4 - Concept evaluation matrix, the criteria can be seen on the y-axis and the concepts on the x-axis. Each concept is scored on the individual criteria, with the total score calculated at the bottom of their respective column. The concepts are sorted in descending order from best to worst rated.

3.3.3 Discussion and Conclusion

From Table 4 - Concept evaluation matrix, we can see the top 3 concepts scoring relatively close. Concept 1 - Block Select and Concept 2 - Picture diary with camera having a score of 39, and Concept 6 - Voice prompted toy pet a score of 37. First, concept 6 will be eliminated due to the concept not satisfying the sub-criteria of personalization. The ability for personalization has been determined to be a vital factor in forming a bond with the intervention,

and as discussed in 2.1.4 The effectiveness of personalized approaches can increase the efficacy. Furthermore, according to the ADG, in the category of technology play: smart toys and educational software, children from the age of 2 onwards can bond more with a smart toy that is personalized before even seeing the content it aims to display. From that, we can determine that visual perception of the intervention is important to children.

In order to make a selection between concepts 1 and 2, the client was brought into the evaluation process. The clients voiced their opinions and feedback on the two concepts and criteria. Furthermore, the meeting served as a brainstorming session on how applicable each concept is to this project's scope. By doing so, we determined this project's scope to lie in the ability to streamline the collection of data significant to research. As such, an additional question was formulated to identify the difference in strength between the two concepts. How important can the data collected be (structured data gathering, streamlined, closed answers)? How well does the concept track the answers?

From this, we could determine that the clients valued the ability to receive concise structure responses from concept 1 over the more open-ended answers recorded from concept 2. This lies in the fact that research requires standardized responses to draw conclusions from.

Using the concept evaluation matrix and the specified scope of this project, concept 1: Block select will be further developed in the next phase of specification.

Chapter 4 - Specification

The goal of this phase is twofold: First, the preliminary product requirements of the ideation phase will be refined and categorized into functional requirements (FR) and non-functional requirements (NFR). Then an overview will be given on how these FR/NFR will be defined and implemented in the concept chosen from the concept evaluation of chapter 4. In order to better understand how these requirements will apply to the tool on a day-to-day basis, the user scenario will be described.

4.1 User Scenario

Let us take Bob as an example user. Bob is five and a half years old and is a subject in a research program concerning children's eating behaviours. Bob is provided with the block select tool and is asked to track his meals throughout the day. Bob, like many children, is not bound to eat in one place like an infant. As such, three mealtimes will be covered in varying locations to cover the most possible scenarios.

4.1.1Breakfast

Bob wakes up and goes to eat breakfast; he brings the block select and places it on the table. While enjoying his breakfast, the block select triggers the initiation sequence. This sequence is time-driven and will be based on a predefined mealtime of the user. The screen flashes, the block rumbles, and plays a gentle tune to capture his attention. Bob picks up the blockselect and squeezes the tool to silence the “alarm”. He is then greeted with a prompt on the screen asking if he is ready to track his breakfast. Although Bob had just taken the first bite, he now agreed to track his meal. The tool begins the tracking process, and the different food options are presented on the screen. Bob's current meal is not the first option on the screen, so he flicks the block upwards/downwards to cycle through the meal options using his hands. Once he has found his meal, he squeezes the block select, confirming his choice. Next, the questions regarding his meal are presented, and each question is answered using a predetermined scale. Bob can change his answer along the scale by flicking the block left/right. Bob squeezes the block to confirm his selection. Each selection triggers a chime and a rumble, indicating it has recorded the action. Next, he answers the remaining question using the same method. Once completed, Bob is thanked and praised for completing the tracking process. The screen turns off, and bob returns to enjoying his breakfast.

4.1.2 Lunch

Bob is now at school and has taken his block select with him and kept it in his bag. As he is about to have lunch, he takes it out and puts it on his table. He’s about to have lunch but first needs to go the bathroom to wash his hands. Right before doing so, the initiation sequence starts and asks if he is ready; Bob does not have his food in front of him and therefore selects the response “no”. This puts the block select back to sleep for 10-12 minutes, after which the sequence will repeat itself until he is ready and respond “yes”. The tracking process then proceeds as normal.

4.1.3 Unanticipated snack

Bob is picked up from school by his grandparents, and on their way, home is given apple slices. This is not one of block selects predetermined mealtimes, so Bob proactively takes out the block select and interacts with it to wake it; he responds to the prompt and tracks his snack.

4.1.4 Dinner

Bobs is not back at home; he has left his block select in his school bag and starts to eat his dinner. This is not a problem because as the initiation sequence is triggered, he or his parents hear the chime. He grabs his block select and continues the tracking process as usual.

4.2 Requirements

The requirements, as mentioned earlier, will be categorised into functional and non-function requirements. Functional requirements describe the practical functions the concept is supposed to offer, while non-functional requirements describe how the concept should behave in practical use. Then the MoSCoW method will be used to prioritize these requirements. The MoSCoW method is a prioritization technique used to label each requirement's importance regarding the overall aims of the product design.

4.2.1 MoSCoW method - Functional requirements

These requirements were discussed and evaluated with the client before applying the Moscow method, narrowing down the requirements even further.

Table 5 - Functional requirements

Code		Requirement	MoSCoW priority
FR	1	The tool must have a display	Must have
FR	2	The tool must allow the user to track their eating behaviour	Must have
FR	3	The tool must store the answered information on an Arduino	Must have
FR	4	The tool must be able to sense a flicking gesture	Must have
FR	5	The tool should be able to play a tune	Should have
FR	6	The tool should be able to vibrate	Should have
FR	7	The tool should be able to sense a squeeze	Should have
FR	8	The tool could have a camera	Could have

4.2.2 MoSCoW method - Non-functional requirements

Table 6 - Non- functional requirements

Code		Requirement	
NFR	1	The tool must have a form of contingent feedback	Must have

NFR	2	The tool must have a prompt to confirm that the child is currently able to perform the tracking	Must have
NFR	3	The tool must have a useable UI	Must have
NFR	4	The interaction with the UI must be gesture-based	Must have
NFR	5	The tool should be durable	Should have
NFR	6	The tool should log the entry time	Should have
NFR	7	The tool should have an appealing UI	Should have
NFR	8	The tool should comply with the age-dependent requirements of children ages 5-6	Should have
NFR	9	The tool could offer a form of personalization	Could have

4.3 Conclusion

In this phase, the general requirements of chapter 3 were rephrased to be more specified, allowing them to be categorized into functional and non-functional requirements. These were then prioritized using the MoSCoW method. With these categorizations and prioritizations in mind, the realization phase can begin.

Chapter 5 - Realization

5.1 Introduction

The realisation was straightforward, with the requirements clearly defined in the previous phase. First, the acrylic case was designed, then each component was tested and codded to perform its dedicated task and finally combined into its final fully functional form.

5.2 Design Process

The design process can be broken into four parts: the acrylic case, electronics, graphics and software development. Below these three parts are explained in further detail.

5.2.1 Acrylic case

The tools housing consists of laser-cut 3mm acrylic and measures 10x10x10cm forming a perfect cube. The laser-cut file was created using a box-generating website, Maker case [17]. Here the required dimension could be set along with the option to add kerf compensation, allowing the cube to fit and hold its joints without the need for glue. The generated .dxf file was then edited in CorelDraw x7 [18]. During this process, the graphics of the front-facing side were added along with the engraved texture on the remaining sides. This was done to maximise

the usable space on the LCD screen and add grip to the otherwise smooth and glossy surface. The top side was cut using a different pattern, allowing it to bend when pressure was exerted on it. This turns it into a bendable surface allowing the flex meter to interpret the change in the surface as a push of a button. During the construction, however, the dimension of the Arduino mega became a limiting factor of the box, not allowing it to become any smaller. The schematic for the case can be found in Appendix 5 – Laser cut design of the tool

Figure 5 - Finalized prototype

Figure 6 - Texture of the final prototype

5.2.2 Electronics

The electronics operate using an Arduino Mega and a small 5000 mAh power bank. For the tool to function as intended, the following electronics parts will be required; Arduino Mega, Real-time clock module, 2.4” LCD screen, vibration dc module, gyroscope, speaker, flex meter, wires and resistors. More details and model names on the components can be found in Appendix 3 – Components list. The schematic of the electronics can be found in

Appendix 4 – Schematic, Tool circuitry

5.2.3 Software development

As mentioned in the electronics design process, an Arduino mega was used as the tool's operating system. The Arduino used the java language and was coded using a variety of libraries and self-written code for the individual components. The design process of the structure and its elements will be explained next.

The tool uses a state machine as its logic processing, meaning that at its core, it consists of 3 major components: A state, a transition requirement and a destination. This can be visualized as a decision tree shown in Figure 7 below.

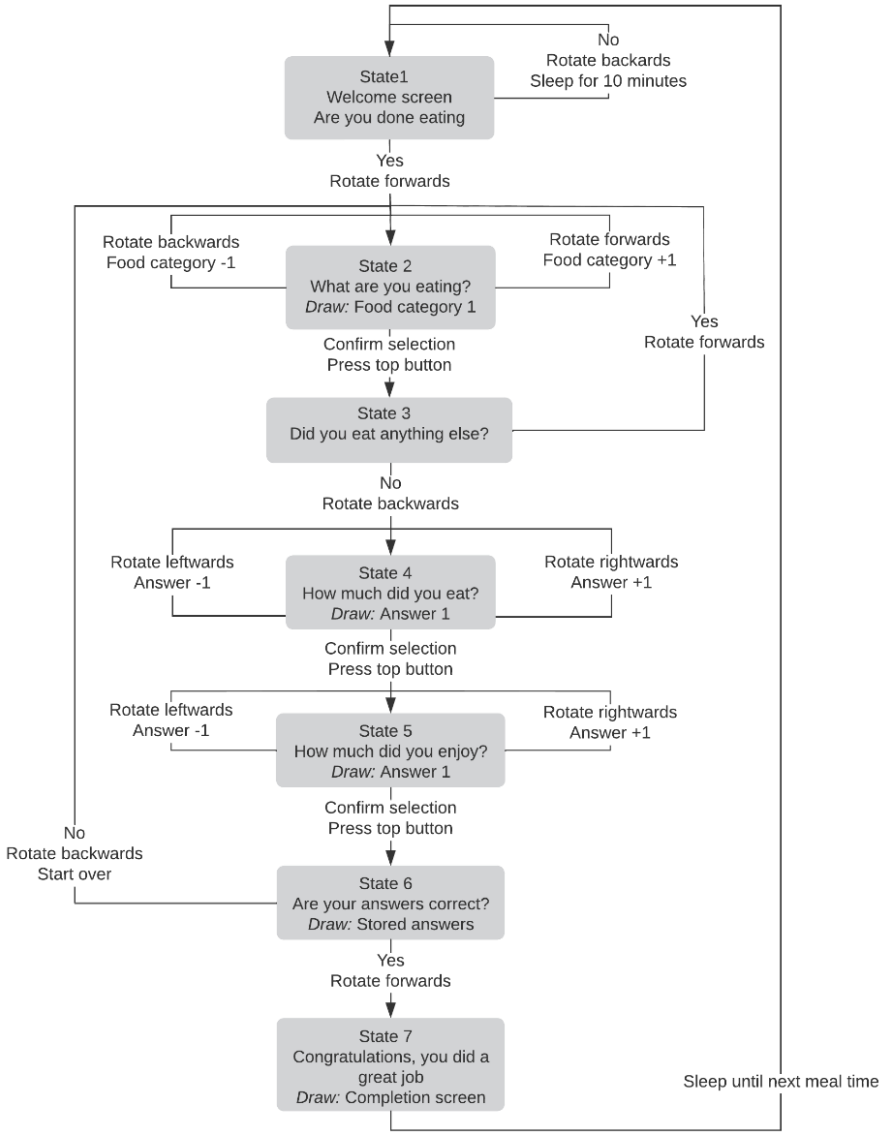


Figure 7 - Decision tree visualization

The image above only represents the backbone on which the tool operates; within each state, further processes and operations occur. Below is a list of the process taking place and the according libraries used:

- Analysing and processing the gyroscope's raw information into true/false Booleans
    - Wire.h
    - I2Cdev.h
    - MPU6050.h
- Using the real-time clock to timestamp the entries made
    - DS3231.h
- Logic processing of the state machine
    - Statemachine.h
- Constructing the tunes played on the speaker
    - Pitches.h
- Accessing the images stored on the SD card
    - SPI.h
    - SdFat.h
- Rendering the images used and drawing shapes on the screen
    - Adafruit_GFX.h
    - MCUFRIEND_kbv.h
- Vibration motor module
    - It does not require a library as it is analogue
- Sensing button pressed
    - It does not require a library as it is analogue

Upon assembling the case and wiring the electronics, the parts can be combined, and the code uploaded. With the code uploaded, the functionalities of each of the electronic components can be used.

5.2.4 Graphics

Once the tool was functional, graphics had to be designed and incorporated. Looking back at chapter 2, background information, cognitive abilities and age determination guidelines had to be considered carefully before deciding on a style of imagery. This stems from the fact that children ages 5-6 have a limited understanding of complex sentences and would greatly benefit from supporting imagery. Furthermore, the age determination guidelines suggest that

less realistic imagery is preferred and more beneficial to understanding the tool's user interface. As such, the graphics were designed in pixel art style. This satisfies the advice of less realism by the ADG and allows for a more ambiguous understanding of the category.

In order to create the images for the food categories, an asset was purchased on itch.io [19], which included a stylized pack of food, fruit, and vegetable icons. These were then resized and customized using Aseprite [20] to suit the application better. This software was also used to create other assets, such as the answer/rating scales. In Figure 8, you can see a sample of what these images looked like.

Figure 8 - Examples of what the tools display

5.3 User scenario

Below is an example user scenario giving a better insight into how each component is used in the tool.

The user holds the tool with two hands. The tool will chime and vibrate to grab the user's attention. Then the tools screen will prompt the user with the question: “Are you ready to track your meal?" with an upwards/downwards rotating motion, the gyroscope will sense whether the user is confirming or rejecting that they are ready. Then the user is presented with a list of different food categories; here too, they can cycle between options with the upwards/downwards rotation of the cube. In order to confirm their selection, the top of the cube is pressed as there is a flex meter built into the top surface acting as a button. Once their food selection has been made, the tool asks the user two questions, how much did you eat? Moreover, how much did you like it? These are answered with the cube's left/right rotation as it cycles through the presented scale. After selecting and confirming their responses, the tool will log their selected responses and use the real-time clock to timestamp their entry. Once the answers have been logged, the interaction of the tool is completed. In figure 9, you can see what the evaluation looked like.

Figure 9 - User testing participation

Chapter 6 - Evaluation

The user evaluation served two purposes: first, evaluate whether children ages 5-6 are willing/able to use a tool to track their eating behaviour, and second, evaluate the design choices made based on the background research of chapter 2. Thus, answering the sub-research question.

I. To what extent are children able to use a gesture-based tool to track their eating behaviour?
II. How do the design choices of the tool influence their ability

During the user testing, qualitative research was carried out. In order to do so, the user evaluation was only tested using the lunchtime scenario. This was done to better evaluate the tracking functionality rather than evaluating the ability to use it repetitively over the day. This means that the user evaluation consisted of re-enacting a lunchtime situation three times, each with a different meal. The evaluation sessions were conducted with the targeted age demographic for more accurate results.

The user evaluation consisted of 3 parts. The first part explains to the child how the tool is used, and the second part requires the child to track 3 test meals. The third part consists of a semi-structured interview regarding the experience using the tool.

6.1 Participants

In order to participate, the child must be between the ages of 5-6 and Dutch speaking as the tool's operating language is Dutch. Besides that, there was no preference for the number of male or female participants, ethnic backgrounds, or dietary restrictions.

For this evaluation, a total of 5 children participated; three were between the required ages of 5-6, and two were eight years old. The reason for including participants outside of the age range was due to the inherent similarities of the ages.

In the background research, it was found that the cognitive development of children is relatively rapid from one year to another. Therefore, the ability of children ages 7-8 should be similar if not better than that of 5–6-year-old. The opposite can be said for children younger than five years old. Given that 7–8-year-olds meet the same minimum requirements as 5-6, the increased number of participants was determined to benefit the user evaluation.

In table 7 below, more information can be found on each participant

Table 7 - User evaluation - participant information

Participant ID	Age	Gender	Testing location
1	6	Female	Home
2	8	Female	Home
3	8	Female	Home
4	5	Male	Lab room
5	6	Female	Lab room

6.2 Materials

In order to carry out the evaluation sessions consistently and effectively, the following materials were used

- Three exemplary meals were used during the tracking procedure
    - Meal 1: Sandwich with Chicken slices and grapes
    - Meal 2: Sandwich with hagelslag, a glass of milk and grapes
    - Meal 3: Sweat bread with raisins/currant, cherry tomatoes, and grapes
- Printed copies of the information brochure and the consent form along with a black pen.
- A guiding sheet for the researcher's introduction and semi structured interview questions to keep the information shared with the participants similar.
- If the parent consented, an audio recording device is used to record the entirety of the user evaluation.
- The tool itself. For further details about the tool, refer to chapter 5, Realization.

6.3 Procedure

Before the user evaluation, the child's parents were required to consent on their behalf. The parent was given an information brochure and consent form, see appendix 1 and 2. Upon consent, the user evaluation took place in the user's home and proceeded as follows.

6.3.1 User evaluation procedure

1. Introduce myself, the tool and three meals which will be part of the user testing; your child is not expected to consume these meals. These are simply a representation of what they may have eaten.
2. First, the researcher will show and explain how they would use the tool with meal no.1.
    a. The tool is an acrylic box (10cmx10cmx10cm). It has an LCD screen on one face and Arduino, which processes the graphics presented on the screen and the gesture-based interaction. The user holds the tool in their two hands. On the sools screen, the user is prompted with the question are you ready to track your meal" with an upwards/downwards rotating motion of the cube, the user can confirm /reject that they are ready. Then they are presented with a list of different food categories; here too they can cycle between options with the upwards/downwards rotation of the cube. In order to confirm their selection, the top of the cube is pressed as there is a button built into the top surface. Once their food selection has been made, the tool asks the user two questions, how much did you eat? And how much did you like it? These are answered with a left/right rotation of the cube. This cycles through the presented scale. Upon selecting their choice and confirming it, the interaction with the tool is completed.
3. Then your child will be asked if they would like to try it themselves. At this point, if the child is uncomfortable or unwilling to continue, the test will be stopped without any further explanation. If the child agrees to continue, the test will continue.
4. BREAK 10 MINUTES
5. The child will proceed to repeat the test 3 times. On the first attempt, your child will be asked to replicate what was demonstrated with meal no.1. During this exploratory attempt, your child can ask questions and help if they are confused or unable to proceed.
6. Then your child will be presented with meals no.2 and no.3, which they will have to track individually.
7. Once they have attempted to track each meal, the user testing will be over.

8. Your child will then be asked a few questions regarding their experience, such as did you have fun? Which part did you or did you not understand? Was the gesture-based interaction clear etc.?
9. Once the questions are completed, the test is over.

6.3.2 Interview procedure

As mentioned in step 8 of the user evaluation procedure, the child will be interviewed on the user testing they just performed. Since the user testing is performed with children, the interview will be semi-structured, using a list of questions to lead the discussion. Furthermore, to encourage the participant to respond honestly, they will be reassured that this is not a test and that there are no right or wrong answers.

The following questions were used to lead the conversation and cover the topics of look and feel and usage of the tool.

1. Was it fun to use?
2. Did you find anything boring?
3. Did you like the sounds the tool made?
4. Did you understand the images? Did it clearly depict the category?
5. What did you think of the screen?
6. Was the screen too big or too small?
7. Was the tool too big/small?
8. Was the tool too heavy?
9. Did you find it easy to use
10. Was there anything you found boring?
11. Did you enjoy personalizing the box?
12. Would you want to use it again?
13. What did you think of having to rotate the cube?
14. Was it clear when to use which movement?
15. Would you want your mum or dad to help you use it?
16. Would you take this tool with you to school to use it during lunch?
17. Is there anything else you want to tell me?

Given the semi-structured approach, questions may be worded differently or even left out according to how the participant responds. Common themes, observations and opinions will be touched upon in this chapter and further discussed in chapter 7 - Discussions and conclusions.

6.4 Data analysis

Upon completing the user evaluation sessions, 2 data sets were collected, the audio recordings made during the interviews and the data logged as a .csv file by the tool. Before being able to analyse the data, it had to be organized and scrubbed for any incomplete or otherwise erroneous data. Furthermore, the audio recording was transcribed, and any relevant comments or answers from the semi-structured interview were categorized. This formed a clear overview from which the results and conclusions could be drawn. The overview and results can be seen in Appendix 7 and 8.

6.5 Results

This section presents the results and observations drawn from the data analysis. First, the participant's responses to the semi-structured interview questions will be acknowledged, and any observations relevant but not covered by the questions will be highlighted. Finally, the tools logged data will be analysed.

6.5.1 Look and feel

By looking at the result from the user testing, we can see that all participants responded positively to the questions regarding the look and feel.

Fun to use? Anything boring about it?

All five participants answered yes when asked if the tool was fun to use. Furthermore, when asked if they found anything boring, all participants answered no. Participant 1,4,5 then further elaborated that the gesture-based interaction and sounds of the tool made it really fun.

Sounds of the tool

Given that “the sounds of the tool” were a popular reason for it being fun, the choice and frequency of sounds were further questioned. All participants had a strong positive reaction to the sounds. Four of the five participants enjoyed the sounds and indicated they would not change the choice or frequency of the sound. Participant 4 also agreed with enjoying the sounds however wanted more sounds, saying, “Yes, very fun, but I would want more sounds”.

Use and style of images

Next, the imagery used was questioned. Regarding the style, the choice of a more pixelated style of artwork, along with the label underneath, was very well reciprocated by the participants. Three of the five participants discussed this answer in greater detail.

- For participant 2, the label underneath the image was helpful when the image was a bit unclear to them.
- Participant 3 indicated they used the image as a cross-reference to see if their food was a fruit or a vegetable.
- Participant 4 comprehended what the images on the screen were showing however experienced difficulty associating similar items to the category at hand. For example, participant 4 had to categorize hagelslag, as a sweet spread. However, was unsure if that falls under a sweet spread or not. As per the user evaluation procedure, when a participant asks for help or is unsure of a similar category item, it was explained to them. In this case, the observer responded with, “honey, jam and peanut butter are also sweet spreads”. With this guiding comment, the participant could relate the two together and correctly select the sweet spread category.
- Participant 5 was the only participant to indicate difficulty with the images' clarity. Participant 5 responded, “sometimes yes, but other times not”. Upon asking for further details like “which images did you not understand”, they could not remember. Besides raising that they had this difficulty, all three tracked meals were correctly entered.

6.5.1.1 Observations during testing

Besides the results of the semi-structured interview, more insight can be drawn from the observation notes taken during the user testing. For example:

Sound

The start-up sound of the tool seemed to have a catchy tune as each participant was heard singing or humming the tune at least once during; the user testing, the interview questioning and even after the user testing. An attempt was made to gather more information on what they liked about the song. However, no participant was able to give a concrete answer

Personalization

During the first three participants, the tool's colouring in was unintentionally used to offer the participants a break from the user testing. This gave them a sense of ownership and was greatly appreciated as a fun tool element.

6.5.2 Usage

Here too, the participants agreed that the tool was fun and easy to use. While true, several drawbacks were observed and brought to light by the participants during further questioning.

Gesture-based interaction

It became apparent that the interactions could use some fine-tuning. For example, when discussing question 2.4, what did you think of having to rotate/pressing the tool? It was observed that all participants experienced at least one instance in which the tool registered the opposite motion to what was intended and one instance where the participants had to rotate the tool harder. Participants confirmed this error or difficulty 1,2, and 4 during this question.

While the gesture-based interaction could use some finetuning, the positive answers to question 2.6 indicate that it was clear when and how each interaction had to be carried out.

Physical attributes

Moving on to the physical attributes of the tool, screen size, tool size and weight, the answers remained positive. Everything presented on the tool was clear and legible. However, the ratio of screen to body size could use some change. It was observed during the user testing of participants 1,3, and 4 that the tool was placed back on the table to reset their grip. Participant 1 confirmed this when asked question 1.7 would you change the size of the tool? “Yes, the tool is too big for her hands.” Furthermore, participant 3 mentioned, “it was a bit heavy, especially when I have to move it around”.

Willingness and ability to use

Questions 2.4, 2.7 and 2.8 attempt to give insight into whether participants are willing and able to independently use the tool on a day-to-day basis. Based on their answers, it appears most, if not all, participants are able to use the tool without any help and would be willing to carry such a tool to places other than their homes. All the participants further strengthened this by indicating that they would want to use it again. Two participants even stated they wanted their own.

6.5.2.1 Observations during testing

Besides the semi-structured interview results, more insight can be drawn from the observation notes taken during the user testing. For example:

Learning effect

While the participants' answers indicated that they understood when to use each gesture, the observations made during the user testing indicated that the participants were learning from each testing round and that the need for help decreased with each round. For example, participants 1,2 and 4 had successfully categorized all their foods and claimed they were done during meals 1 and 2. After a few seconds of silence, the observer would read aloud the

remaining question on-screen, instantly prompting the participant to pick the tool back up and continue the tracking process themselves. Furthermore, the use of invalid gestures or asking what to do next also decreased between each round. This behaviour was also present in the logged data from the tool. The tool logs the start and finish time of each interact. This was used to calculate the completion time of each tracked meal. From this, we can see that, on average, the participant's completion time became faster with each round. By meal three each participant had a completion time of less than 3 minutes.

Finally, a comment made by participant 4, who was also the youngest participant and had the most difficulty in reading ability, stood out. Upon answering hesitantly that they found it easy to use, they commented, “I didn’t properly read the words”; to which the observer asked if this was due to the words being too difficult. He answered, “No, because I already understood what to do”.

Food items with multiple ingredients

In order to test the participant's categorizing abilities, meal 3 contained a food item made up of several ingredients. This food was Krentenbol, a sweet soft bread with raisins/currents in it. All participants raised the question of, “is this bread” to which the observer responded, “Yes, this is bread with raisins in it”. Three of the five participants actively logged fruit twice for the raisins. This was, however, not visible in the logged data as tool logs selection rather than the number of selected times.

Correcting the language of the question

Participant 3 brought up that the wording of one of the questions was incorrect and should be altered. The last question of the semi-structured interview was, “is there anything else you would like to discuss” to which they answered yes. They proceed to start a new entry to explain how the wording of “how much did you have left over” is wrong in Dutch. “Hehe het zegt hoe veel heb je over terwijl het zou moeten zeggen hoe veel heb je gegeten”

Active participation and thinking when answering the tools questions

During the user evaluation, the participants could not eat the meals in front of them. Therefore, when they were asked to fill in “how much they have left over” and “how much they enjoyed it”, they were allowed to pick which ever answer felt right. It was good to see that the questions were grasped correctly and genuinely answered. Almost all participants were observed actively discussing if they would like the food and if they could finish it. Participant 4 went through each option of smiles, re-enacting the smiley expression on his face and using

it to figure out which he related to the most. Participant 6 mentioned they would eat everything as they are intolerant to an ingredient. This shows how the question asked is properly understood by the participant.

6.5.3 Logged Data

Besides the semi-structured interview and the observations made, conclusions can also be made from the logged data of the tool. In table 8, shown below, the following information can be found.

- The participant ID
- Whether all individual food items of the meal were correctly categorized
    - Correct entry - all individual items were correctly categorized
    - Partial entry - not all items were correctly categorized/or categorized at all
    - Invalid entry - the tool misinterpreted the user's input and needed manual override to restart the interaction
- Which meal was being entered
- The completion time is calculated using the logged start and end times

Table 8 - Summary of processed logged data

Participant	Notes	Meal option	Interaction time
Observer	Correct entry	1	0:04:04
1	Invalid entry		##############
1	Correct entry	2	0:02:32
1	Partial entry	3.2	0:02:57
Observer	Correct entry	1	0:02:04
2	Invalid entry		##############
2	Correct entry	2	0:04:31
2	Invalid entry		##############
2	Correct entry	3.1	0:02:53
Observer	Correct entry	1	0:02:54
3	Correct entry	2	0:02:55
3	Correct entry	3.2	0:02:41
Observer	Correct entry	1	0:04:05

4	Correct entry	2	0:05:09
4	Correct entry	3	0:04:43
Observer	Correct entry	1	0:03:18
5	Correct entry	2	0:02:55
5	Correct entry	3.1	0:02:23

Looking at the data logged, we can determine that all meals were correctly tracked except for meal 3.2 by participant 1. This entry is shown in more detail in table 9 below.

Table 9 - Raw data of participant 1, meal 3.2

Date	Start time	End time	Answer 1	Answer 2	Selected categories			
26.10.2022	16:48:57	16:51:54	Alles	2	Brood	Yoghurt	Fruit	

The selected categories for meal 3.2 should have been brood, yoghurt, fruit groenten. However, participant 1 forgot to select the category “Groenten”. The order of selection, in this case, is irrelevant.

Chapter 7 - Discussion and Conclusion

7.1 project summary

The aim was to find out "How can the design of an interactive tool effectively support the tracking of eating behaviours in children ages 5-6". To do so, background research was performed on the following topics: The existing methods of tracking eating behaviours and the limitations faced when applied to younger age groups. How personalized interventions can offer greater effectiveness, and lastly how the cognitive abilities of children ages 5-6 can be applied when designing a toy/tool.

Based on the gathered background information the Creative Technology, five phases, design method was applied [21]. During the ideation phase, ideas were generated and validated by the client. In the specification phase, the functional and non-functional requirements of the selected prototype were determined. After that, the prototype was realized in the realization phase. Finally, an evaluation session was held to evaluate the design and usability of the tool.

7.2 Reflecting on the results

The first questions we attempted to answer were:

IV. To what extent are children able to use a gesture-based tool to track their eating behaviour?

V. How do the design choices of the tool contribute to their ability to track their eating behaviour

7.2.1 To what extent are children able to use a gesture-based tool to track their eating behaviour

To answer sub-research question IV, we must look at the following topics discussed in the result; accuracy and ability to use the tool, completion time, and willingness to complete. Looking at the evaluation results, we can conclude that the accuracy and ability of tracking is remarkably high, with only 1 of 15 entries being a partial entry.

From the observations and questions asked on usability, the concept of tracking eating behaviours using a gesture-based tool was successful. However, the result indicated that certain elements, such as the force required to trigger/detect a response, could use fine-tuning to improve usability. These adjustments can be made in the parameters of the tools code.

Furthermore, the time it takes to complete one entire tracking cycle is, on average, around 3 minutes, which poses a very low entry barrier for the child. When applying this to the user scenarios discussed in section 4.1, the child would be expected to track their meals about 3-4 times per day. This amounts to just under 15 minutes spent on tracking per day and constitutes a positive factor in increasing the child's willingness to track.

Finally, we can determine that the design choices based on the requirements determined in chapter 4.2 have shaped the tool in such a way that it enables children ages 5-6 to track their eating behaviour independently and accurately.

Considering these three topics we can conclude that children are in fact able to track their eating behaviours using a gesture-based tool. Furthermore they can do so with a very high accuracy and independent from parental figures.

7.2.2 How do the design choices of the tool contribute to their ability to track their eating behaviour

Having concluded sub-research question V, we can now identify in greater detail how the individual design choices can contribute to the child's tracking ability.

The images and composition

Based on the Age determination guidelines discussed in chapter 2 background research, a more cartoon-like imagery was used along with a label of each category. This was very well reciprocated by the participants and proved to help the children with identifying the food categories.

Multiple participants discussed how the specific image used aided them in the selection process and when the image was a bit unclear, the label either confirmed or denied their interpretation of the image. However, in some instances, throughout the user testing, participants continued to show hesitation in their interpretation of the words labelled. This is why children's cognitive ability and reading skills were significant factors considered while designing the tool.

Reading ability

The 5 participants, ranging from 5-8 years old, had the expected cognitive ability and reading skills as suggested by the background research. However, as mentioned earlier, sometimes participants presented a sense of hesitation during certain stages of the tracking process. More specifically, when selecting the food categories, it requires them to think outside of what is visually presented in front of them and be certain of their reading skills. During the user testing, the participants could ask the observer if what they read and interpreted was correct. If this were to happen outside of the controlled evaluation session, the child could ask a parent or teacher for assistance. However, to maintain the current level of independence, further sounds could be developed and programmed to read the labels of categories out loud when cycling through the list.

Re-enacting emotions

This was not an issue in other instances, such as selecting how much they enjoyed the meal. Instead, the active participation and understanding of the images showed the strengths of having an interactive tool. In the result, participants actively re-enacted the emotion smileys representing the score of how much they liked it to relate and interpret what they were answering. Furthermore, it shows that they are aware of what is being asked of them, even in a user evaluation session where the child did not eat the meal; they were actively imagining they had and attempting to answer truthfully.

Physical attributes

Moving on to the physical attributes of the tool, here too, the tool's concept proved successful but would benefit from finetuning. For example, the size and weight of the tool were observed to cause some usability difficulties. With the participants being 5-8 years old, the cube seems a bit large and heavy from their hands and strength. This could have been prevented by implementing them during the design iteration however, due to limitations in time and availability was not carried out. Furthermore, this design was limited by the size and weight of the components used in the tool.

Gesture-based works

While this design limitation did alter the usability slightly, the gesture-based intervention concept proved successful in the hands of children ages 5-6.

Learning effect

It must be mentioned that the user testing occurred under favourable circumstances. The learning effect was heightened by the observer teaching how the tool is used and assisting when asked during the testing of each meal. However, this would also have to happen outside of a user testing scenario, each user would need to be taught how to use it. Therefore, a form of teaching on how to use the tool could be implemented in future versions of the tool.

All in all, the value of the background research and its implementation in the various design elements of the tool has proved to be very useful in improving the usability of a tool designed to track eating behaviours in children.

7.3. Relevance in the bigger picture

On a micro-level, the design of this tool offers a more effective method for tracking children's eating behaviour. The tool's design meets the children's cognitive and reading abilities. This allows children to become more autonomous in tracking their eating behaviour. This means that regardless of where or with whom they are eating, they can track the required information. Hence removing external factors to influence the collected data. This method offers a more standardized approach, unlike the methods of tracking eating behaviours discussed in chapter 2: Background research.

The collection of data made possible by such an interactive tool opens many research possibilities for the future. This possible increase in available data gives researchers and health professionals the upper hand in combating issues related to children's eating behaviour, e.g.,

obesity. And can further help in the diagnosis or identification of global patterns in children's eating behaviours.

While my thesis and tool were designed for children ages 5-6, the results on participants ages 7-8 show us that the tool could also be used for older age groups. Further research here could look into aspects such as: Until what age is this usable? How do the requirements differ for children older than 5-6? And at what age does the tool loos its effectiveness, and why.

By considering the needs of children first, the tool's design has enabled children to effectively track their eating behaviour with very high accuracy and without help from their parents. The semi-structured interview showed that children were willing to use the tool again and in places outside of their homes. This suggests the potential in using it over a longer period. Although further research could look into aspects of longevity of such an interactive tool.

On a macro scale, this tracking method offers researchers and doctors more significant insight into children's eating behaviours. In the medical field, doctors would be able to better interpret the actual eating behaviour of children. Therefore, improving the likely hood of diagnosing the issues at hand. Researcher could have more data to analyse and better determine trends in global eating behaviour for children.

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Appendices

Appendix 1 Information brochures

Appendix 1A - Information brochure, English version

To whom it may concern,

My name is Jasper-Sebastian, a bachelor's student of creative technology at the University of Twente. As part of my graduation project, I am researching and developing a new tool to enable children ages 5-6 to track their eating behaviours independently and more accurately.

What is the aim of this research?

This research aims to test the design of a new tool capable of tracking the eating behaviour of children ages 5-6. At this age, their cognitive, reading and writing skills are relatively limited and are a limiting factor when applying current methods of tracking. Therefore, the tool has been designed from the ground up to meet their needs while simultaneously recording the required information for research. This is achieved by creating a toy-like cube consisting of a screen and a gesture-based interface. To test the effectiveness of this tool I need to conduct user testing. For this, I am looking for children ages 5-6 who, together with your permission, would like to try out the tool and help in evaluating its effectiveness.

Details on how the testing will take place

First, a preparatory discussion will take place between the parent and the researcher. During this moment, the researcher will ask if your child has any dietary restrictions to consider. This is important as your child will be asked to track 3 predetermined meals using the tool (your child is not expected to eat or taste these meals). Furthermore, besides preventing any allergies this discussion will give the researcher insight into whether the child would be familiar with the meals presented.

The testing itself should preferably take place at the table where the child usually has their dinner. Furthermore, assuming the parent would like to be present during the testing we would kindly ask that they be seated out of the child's direct line of sight i.e., behind or to the side of them. This is to attempt the conversation to be held between the child and the researcher rather than via the parent. If this is not possible or you would prefer otherwise the testing will continue as normal with the parent seated next to or across from the child. The entire testing process is covered in more detail in the following section and should take no longer than 45 minutes.

Activities

1. Introduce myself, the tool and 3 meals which will be part of the user testing, your child is not expected to consume these meals. These are simply a representation of what they may have eaten. Before the testing, you will be asked about any dietary restrictions to take into consideration. This is to prevent allergic reactions and to ensure your child can identify what the meal in front of them may be.
2. First, the researcher will show and explain how they would use the tool with meal no.1.
3. Then your child will be asked if they would like to try it themselves. At this point, if for whatever reason the child is uncomfortable or not willing to continue the test will be stopped without any further explanation. If the child agrees to continue the test will continue.
4. The child will proceed to repeat the test 3 times. On the first attempt your child will be asked to replicate what was demonstrated with meal no.1. During this exploratory attempt, your child can ask questions and help if they are confused or unable to proceed.
5. Then your child will then be presented with meals no.2 and no.3 which they will have to track individually.
6. Once they have attempted to track each meal, the user testing will be over. Your child will then be asked a few questions about their experience, such as did you have fun, which part did you or did you not understand? Was the gesture-based interaction clear etc.?
7. Once the questions are completed the test is over.

Stop protocol

As mentioned earlier if for whatever reason the child is uncomfortable or not willing to continue the test will be stopped without any further explanation. Additionally, if the researcher sees your child in distress or presents any extensive frustration the testing will be stopped.

Burdens and risks

Your child is not at any immediate risk or burden. The only foreseeable points of concern include the child not wanting or being uncomfortable with continuing the test. After they have been explained and shown what to do, or if they are unable to complete the task given. In this case, the child will still be praised and treated equally as though they have completed the task to prevent any last feelings of failure or disappointment.

Data Collection

Data collection will occur throughout this research, this includes the child's age, gender and data logged using the tool (time and the answers selected by your child, no other data is recorded by the tool). Additionally, if given consent, an audio recording will take place during the testing and later be transcribed. This allows the researcher to focus solely on the interaction with your child without having to simultaneously take notes of observations or your children's responses. The audio recording will be transcribed after the fact and may be used to quote remarks or answers in the research document. In order to protect your and your child's privacy during the research, no personally identifiable remarks or information will be used. This will be achieved by assigning participants with a number which will be used throughout the data analysis and conclusions.

Withdrawal from the study.

Withdrawal from this research is possible at any point before or during the testing. In this case, all user information collected will be deleted within 48 hours of your request.

This research project has been reviewed by the Ethics Committee Information and Computer Science. If you have questions about your rights as a research participant or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science.

If you have any questions or concerns with regards to this research, please contact me via email at j.haesler@student.utwente.nl 0655928264 or my supervisors Juliet Haarman j.a.m.haarman@utwente.nl and Randy Klaassen r.klaassen@utwente.nl .

I look forward to your participation.

Kind regards,

Jasper-Sebastian Häsler

Appendix 1B - Information brochure, Dutch version

Beste deelnemer,

Mijn naam is Jasper-Sebastian en ik ben een derdejaars Creative Technology student aan de Universiteit Twente. Voor mijn thesis ben ik onderzoek aan het voeren naar een tool dat de eetgewoontes van jongere kinderen (ongeveer 5-6 jaar oud) kan bijhouden.

Wat is het doel van deze studie?

Het doel van deze studie is om het ontwerp van een tool te testen die de eetgewoontes van jonge kinderen kan bijhouden. Op deze jonge leeftijd is de leesvaardigheid van een kind niet volledig ontwikkeld, wat erg limiterend kan zijn voor de standaard manieren van eetpatronen bijhouden. De tool is daarom specifiek ontworpen voor deze doelgroep, en tegelijkertijd wordt er informatie verzameld voor de onderzoekers. Dit wordt behaald door een kubus te maken dat op een stuk speelgoed lijkt. De kubus bevat een scherm, en wordt bestuurd door bewegingen te maken met de hele kubus. Om de effectiviteit van de tool te testen, moet ik de tool door echte gebruikers laten testen. Ik vraag daarom aan u, of u met uw kind toestemt om mij in mijn onderzoek te helpen.

Testwijze
Allereerst zal er een gesprek plaatsvinden tussen de ouder en de onderzoeker. Tijdens dit gesprek zal de onderzoeker vragen of uw kind aan bepaalde eetgewoontes moet houden. Het antwoord op deze vraag is belangrijk; uw kind zal namelijk de tool moeten gebruiken om bepaalde gerechten te registreren in de tool. Uw kind hoeft deze gerechten niet te eten, of te proeven. Verder zal het antwoord ook bepalen of bepaalde gerechten uit de keuzemenu moet worden gehaald omdat uw kind allergiën heeft.

Onderzoeksplanning

1. Ik zal mezelf voorstellen en uitleg geven over hoe de tool werkt. Verder zal ik ook een uitleg geven over de drie gerechten die in de studie geserveerd zullen worden. Uw kind hoeft deze gerechten niet te eten, ze hebben een representatieve rol over wat uw kind mogelijk op een dag kan eten. Voor het testen zal ik u vragen stellen over de eetgewoontes van uw kind, en of die nog allergiën heeft.
2. Eerst zal de onderzoeker laten zien hoe de tool gebruikt kan worden nadat ze een maaltijd hebben gegeten. Dit wordt gedaan met gerecht nummer 1.
3. Uw kind zal dan gevraagd worden of zij ook willen proberen om met de tool te werken. Als uw kind, voor wat voor reden dan ook, niet comfortabel is met het testen, zal de test worden gestopt zonder dat u daar een reden voor hoeft te geven. Als uw kind instemt om door te gaan, zal de test doorgaan.
4. Uw kind zal drie keer gevraagd worden om dingen met de tool te bereiken. De eerste keer zullen zij gevraagd worden om na te bootsen wat de onderzoeker heeft gedaan. Daarna worden zij

gevraagd om verschillende keuzes in het menu te selecteren. Uw kind kan tijdens deze stap vragen stellen.

5. Bij gerechten nummer 2 en 3 zal uw kind gevraagd worden om deze zelf in de tool bij te houden.
6. Nadat uw kind alledrie gerechten heeft ingevoerd, zal de gebruikerstesten klaar zijn. Uw kind zal dan een paar vragen gesteld krijgen over hun ervaring. Voorbeeldvragen zijn: “Was het leuk om met de tool te werken?”, “Wat vond je moeilijk om te begrijpen?”, en “Was het duidelijk dat je met bewegingen de keuzemenu kon selecteren?”
7. Het einde van de gehele test is het moment waarop uw kind alle vragen heeft beantwoord.

Stop protocol

Als uw kind, voor wat voor reden dan ook, zich niet comfortabel voelt om met de testen door te gaan, zal deze meteen worden gestopt. Verder zal de onderzoeker ook bijhouden of uw kind gefrustreerd raakt, en als dit langer duurt dan verwacht, zal de onderzoeker de testen stoppen.

Risico’s en zorgen

Uw kind neemt geen risico’s door in te stemmen met de testen. De grootste zorgen zijn wanneer uw kind zich niet comfortabel voelt en de test wilt stoppen, of wanneer zij de gegeven taak niet (volledig) kunnen uitvoeren. In dat geval zal uw kind nog steeds positieve feedback krijgen om ervoor te zorgen dat er geen (blijvende) gevoel van teleurstelling opgewekt kan worden.

Het verzamelen van informatie

Het verzamelen van informatie zal gedurende de hele studie plaatsvinden. De leeftijd, gender, en de ingevoerde informatie op de tool zijn een voorbeeld de informatie dat verzameld kan worden. Als u ermee instemt, zal er ook een audio opname plaatsvinden van de gebruikerstest, waarvan een transcriptie wordt gemaakt. De audio opname kan de onderzoeker helpen om te focussen op de interacties met uw kind, in plaats van het tegelijkertijd nemen van notities en aandacht teg even aan uw kind. Citaten van de transcriptie kunnen op het rapport worden gebruikt. Om uw en de privacy van uw kind vast te stellen, zullen er geen identificirende citaten en/of informatie worden gebruikt. Dit wordt gedaan door u en uw kind een gebruikerstestnummer teg even, waarnaar terug zal worden gerefereerd in het rapport.

Terugtrekken uit de studie

U en uw kind kunnen ten alle tijden besluiten om terug te trekken uit de studie. In dat geval zullen alle verzamelde data binnen 48 uur worden verwijderd.

Deze studie heeft goedkeuring gekregen van de Ethics Committee Information and Computer Science. Als u vragen heeft over uw rechten al seen deelnemer aan de studie, of als u meer informatie wilt krijgen, kunt u contact opnemen met de Secretary van de Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

Als u vragen heeft over mijn thesis, of over de tool, kunt u mij bereiken op j.haesler@student.utwente.nl of 0655928264, of kunt u mijn supervisors Juliet Haarman en Randy Klaassen bereiken op j.a.m.haarman@utwente.nl of r.klaassen@utwente.nl

Ik kijk uit naar uw deelname.

Met vriendelijke groet,

Jasper-Sebastian Häsler

Appendix 2 – Informed consent forms

Appendix 2A – Informed consent form, English version

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated 19/09/2022, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	□	□
I consent voluntarily that my child be a participant in this study and understand that I can refuse to answer questions and can withdraw my child from the study at any time, without having to give a reason.	□	□
I understand that taking part in the study involves the user testing of a tool to track eating behaviour, data is logged on the tool, and if given consent an audio recording	□	□
I understand that a transcription of the audio recording will be created before the recording is deleted.	□	□
Use of the information in the study		
I understand that information provided will be used for data analysis in the written research report.	□	□
I understand that personal information collected about my child that can identify them, such as [e.g., age, and gender], will not be shared beyond the study team.	□	□
I agree that quotes, remarks, or other information can be quoted in research outputs	□	□
Consent to Audio Recorded		
Optional: I consent to the audio recording of the interview and the user testing of my child.	□	□

Signatures

_____ _____

_____

Name of participant and legal representative [printed] Signature

_____

Date

Appendix 2B – Informed consent form, Dutch version

Kruis de juiste cirkels aan	**Ja**	**Nee**
Deelname in de studie		
Ik heb de mogelijkheid gehad om vragen te stellen over de studie en mijn vragen zijn voldoende beantwoord.	□	□
Ik stem vrijwillig in om deel te nemen aan deze studie. Ik begrijp dat ik vragen niet hoef te antwoorden en mijn kinds deelname in kan trekken wanneer ik wil, zonder hiervoor een reden te hoeven geven.	□	□
Ik begrijp dat ik tijdens de studie een gebruikerstest zal moeten uitvoeren om informatie over eetgedrag te verzamelen. Ik begrijp dat de informatie op de tool wordt opgeslagen, en dat behalve de ingevoerde data. Als ik daar toestemming voor geef, begrijp ik ook dat de gebruikerstest ook kan worden opgenomen in audioformaat.	□	□
Ik begrijp dat er een transcriptie van de opgenomen audio opname wordt gemaakt voordat de opname verwijderd kan worden.	□	□
Het gebruik van verzamelde informatie		
Ik begrijp dat alle informatie dat ik geef in de studie wordt gebruikt, en dat het in het rapport wordt benoemd.	□	□
Ik begrijp dat er persoonlijk informatie wordt verzameld dat mijn kind kan identificeren, en dat deze niet buiten het studieteam wordt verspreid. Denk aan leeftijd, geslacht, leesvaardigheid, en mogelijk anderen.	□	□
Ik stem ermee in dat citaten, opmerkingen, of andere informatie dat ik in de studie geef, gebruikt en geciteerd kan worden in de studie en het bijbehorende rapport.	□	□
Toestemming audio opname		
Optioneel: Ik stem ermee in dat het interview en gebruikerstest mag worden opgenomen in audioformaat.	□	□

Handtekeningen

_____ _____ _____

Naam deelnemer en voogd Handtekening

_____ Datum

Appendix 3 – Components list

- Arduino Mega
- RTC DS3231 with AT24C32 EEPROM
- 2.4-Inch Touch Screen TFT LCD Shield for Arduino
- Vibration DC Motor Module - 3.7-5.3V
- MPU-6050 Accelerometer and Gyroscope 3-Axis Module 3.3V-5V
- Speaker 8Ω 2W
- 2.2-inch resistive flex sensor
- 1K ohm variable resistor potentiometer
- 47K ohm resistor
- 5000mAh power bank
- Micro USB cable
- 3mm acrylic plate
- A computer or laptop with Arduino IDE

Appendix 4 – Schematic, Tool circuitry

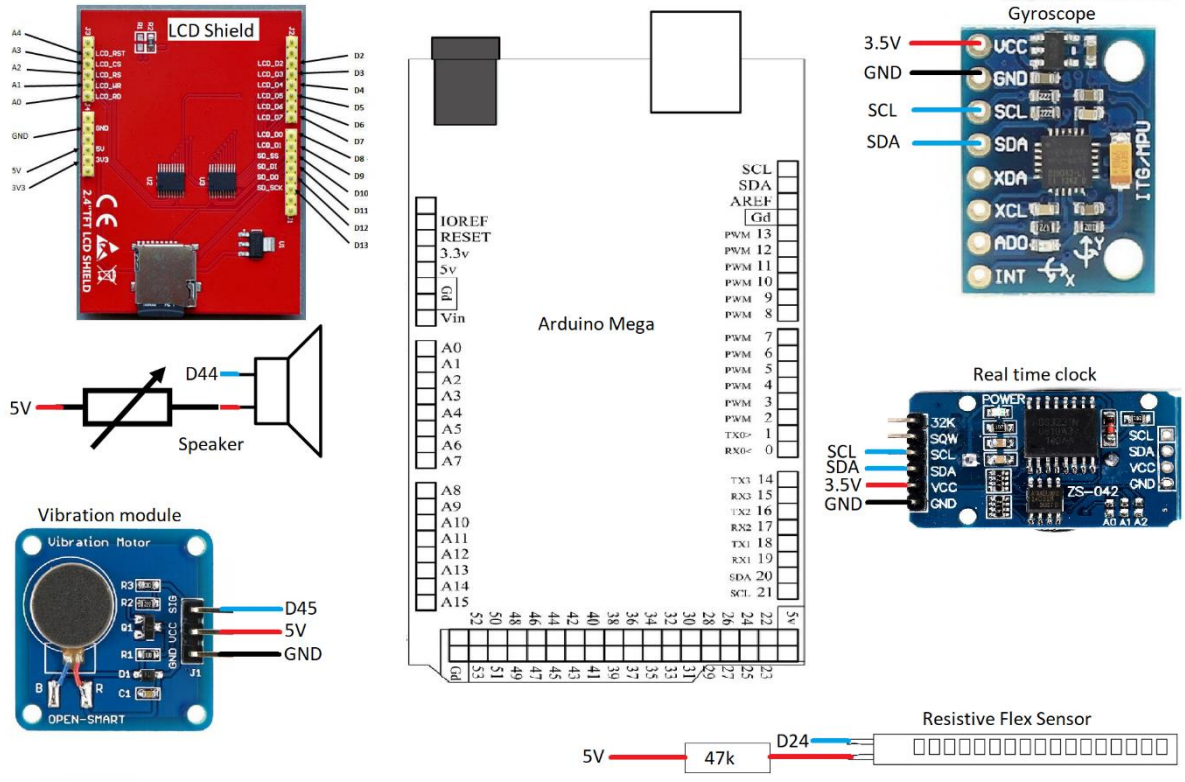

Figure 10 - Circuitry schematic

Appendix 5 – Laser cut design of the tool

Refer to the followign link:

https://drive.google.com/drive/folders/1kUuiebPpaDSNjq8XV80tndeCsNiC32Mi?usp=sharing

Appendix 6 – Arduino code

Refer to the followign link:

https://drive.google.com/drive/folders/1kUuiebPpaDSNjq8XV80tndeCsNiC32Mi?usp=sharing

Appendix 7 – Overview of tool logged data

Table 10 - Raw logged data

Raw logged data								
Date	Start time	End time	Answer 1	Answer 2	Selected categories			
26.10.2022	16:33:17	16:37:21	De helft	5	Brood	Worst beleg of vlees	Fruit	
26.10.2022	16:38:18							
26.10.2022	16:44:10	16:46:42	Alles	4	Brood	Melk	Fruit	Zoet beleg
26.10.2022	16:48:57	16:51:54	Alles	2	Brood	Yoghurt	Fruit	
26.10.2022	17:03:49	17:05:53	De helft	5	Brood	Worst beleg of vlees	Fruit	
26.10.2022	17:07:06							
26.10.2022	17:09:03	17:13:34	Niets	1	Brood	Melk	Fruit	Zoet beleg
26.10.2022	17:15:17							
26.10.2022	17:16:38	17:19:31	Niets	3	Brood	Groenten	Thee, water of sap	
26.10.2022	17:36:59	17:39:53	Niets	5	Brood	Worst beleg of vlees	Fruit	
26.10.2022	17:40:35	17:43:30	Alles	5	Brood	Melk	Fruit	Zoet beleg
26.10.2022	17:46:35	17:49:16	De helft	4	Brood	Yoghurt	Fruit	Groenten
31.10.2022	15:06:45	15:10:50	Alles	5	Brood	Worst beleg of vlees	Fruit	
31.10.2022	15:11:38	15:16:47	Niets	5	Brood	Melk	Fruit	Zoet beleg
31.10.2022	15:29:27	15:34:10	Alles	5	Brood	Yoghurt	Fruit	Thee, water of sap
31.10.2022	15:40:11	15:43:29	De helft	4	Brood	Worst beleg of vlees	Fruit	
31.10.2022	15:43:58	15:46:53	De helft	4	Brood	Melk	Fruit	Zoet beleg
31.10.2022	15:47:43	15:50:06	De helft	3	Brood	Fruit	Thee, water of sap	Groenten

Table 11 - General overview of logged data

Logged data - overview				
Participant	Notes	Meal option	Interaction time	
Observer	Correct entry	1	0:04:04	
1	Invalid entry		##############	
1	Correct entry	2	0:02:32	
1	Partial entry	3.2	0:02:57	
Observer	Correct entry	1	0:02:04	
2	Invalid entry		##############	
2	Correct entry	2	0:04:31	
2	Invalid entry		##############	
2	Correct entry	3.1	0:02:53	
Observer	Correct entry	1	0:02:54	
3	Correct entry	2	0:02:55	
3	Correct entry	3.2	0:02:41	
Observer	Correct entry	1	0:04:05	
4	Correct entry	2	0:05:09	
4	Correct entry	3	0:04:43	
Observer	Correct entry	1	0:03:18	
5	Correct entry	2	0:02:55	
5	Correct entry	3.1	0:02:23	

Meal options	Item 1	Item 2	Item 3	Item 4
1	Brood	Worst beleg of vlees	Fruit	
2	Brood	Melk	Fruit	Zoet beleg
3.1	Brood	Groenten	Fruit	Thee, water of sap
3.2	Brood	Groenten	Fruit	Yoghurt

Appendix 8 – Overview of responses to semi structured interview

Refer to the followign link:

https://drive.google.com/drive/folders/1kUuiebPpaDSNjq8XV80tndeCsNiC32Mi?usp=sharing

Results.xlsx - Sheet 1

Appendix 8.1 - Participant 1

Column1	1
Was it fun to use?	Yes especially the sounds the tool made
Did you find anything boring?	No
Did you like the sounds the tool made?	Yes
Did you understand the images, did it clearly show what it was	Yes
What did you think of the screen	I could see everything clearly
Was the screen too big or too small	
Would you want to change the size of the box	Yes, it was a bit big for my hands
Was the tool too heavy	It was fine
Did you find it easy to use	Yes very
Was there anything that you found difficult	No
Did you enjoy personalizing the box	Yes I really liked colouring it
Would you want to use it again	Yes
What did you think of having to rotate the cube?	It was good but a bit difficult to turn it (required more force)
Was it clear when to use which movement	Yes
Would you need your mum or dad to help you use it	*they laugh* No
Would you take this tool with you to school to use it during lunch	Yes I could
Is there anything else you want to tell me?	The top selection button was a bit hard to press. Instead I would want to tap the words on the box
Additional observations/remarks	
	She fills in all the foods and believes she is done, I continue to ask her the remain question out loud and ask if she wants to continue on her own, and she intuitively picks it back up and continues answering
	Meal 3 she is presented with selecting the categories, and stares at the screen blankly, after a few seconds of silence, I reread out loud what is said on the screen and inform her of the movements she can carry out. From then on she understands it again
	Meal 3 she has one more food to categorize she flicks upward (hed je nog eits gegeeten) but in the process the reloading of the movement triggers the answer to be read as no. this invalidates the try and there is no way of going one step backwards. She is reassured that the tool made a mistake and that we will try again
	After finishing round 2 she's excited to start with the final round
	Questioned if krentenbol was bread
	Was repeatedly humming the start-up tune after the user testing
	In a side discussion with participant 2 she asks if it was easy for her to use, participant 2 answer no (due to the mis reading of her movement, and participant 1 answer it was easy for her

Appendix 8.2 - Participant 2

Column1	2
Was it fun to use?	I found it really fun to use
Did you find anything boring?	No
Did you like the sounds the tool made?	Yes, it was a really fun sound to hear *begins to hum the sound*
Did you understand the images, did it clearly show what it was	Yes, the word underneath the image really helped as the image was sometimes not clear enough.
What did you think of the screen	Screen was also good, I could read everything
Was the screen too big or too small	
Would you want to change the size of the box	
Was the tool too heavy	
Did you find it easy to use	Yes
Was there anything that you found difficult	
Did you enjoy personalizing the box	
Would you want to use it again	Yes
What did you think of having to rotate the cube?	I really liked moving the box up and down to change the answers but it was sometimes annoying that when I did like this “indicates tilting forward” that the box registered it as tilting backwards
Was it clear when to use which movement	Yes
Would you need your mum or dad to help you use it	I could do this without help, now that I know how to use it I could do it again all on my own
Would you take this tool with you to school to use it during lunch	
Is there anything else you want to tell me?	No
Additional observations/remarks	
	Filled in the same item twice
	Tool read the wrong interactin and needed restarting
	On the screen hoeveel heb je over, she has an answer but forgets how to select a response. I explain that there is a button on the top and then she remembers how to proceed
	She fills in food selection and doesn't continue answering the two question, I take over the interaction such that she can answer verbally. She then returns to continue herself
	Picks up the interactions much faster that participant 1
	Questioned if krentenbol was bread
	She starts discussing how the tool works for participants 1 but not for herself and that it will probably work again for participant 3. I step in and deflect the blame towards the tool being “tired rather than the participant doing something wrong”
	The list length feels long and makes her question if the category is even on the list.
	Wants to skip the colouring and wants to start with the questions

Appendix 8.3 - Participant 3

Column1	3
Was it fun to use?	Yes, it was fun to use
Did you find anything boring?	No not at all
Did you like the sounds the tool made?	Yes, very fun but I would want more sounds
Did you understand the images, did it clearly show what it was	Yes and I could look at the circle (referring to the circle of fruits and veggies on the screen) if my food was there.
What did you think of the screen	I would want the screen to be a bit it bigger
Was the screen too big or too small	I found it good and wouldn't change anything
Would you want to change the size of the box	No the size is good
Was the tool too heavy	It was a bit was a bit heavy especially if I have to move it and hold it up
Did you find it easy to use	Yes
Was there anything that you found difficult	
Did you enjoy personalizing the box	
Would you want to use it again	Yes
What did you think of having to rotate the cube?	
Was it clear when to use which movement	
Would you need your mum or dad to help you use it	I wouldn't need any help from them
Would you take this tool with you to school to use it during lunch	Yes
Is there anything else you want to tell me?	No
Additional observations/remarks	
	Questioned if krentenbol was bread
	Is this half if I head the fruit and the veggie? I answer yes. I don't like thkrenten bol so I would only eat half of it
	What is the plus and the minus for, I explain its for these two question because you use more or less to answer
	Proceeds to start a new entry to explain how the wording of how much did you eat is wrong. Hehe het zegt hoe veel hed je over terwijl het zou moeten zeggen hoe veel heb jegeegeeten
	humms the starting sound

Appendix 8.4 - Participant 4

Column1	4
Was it fun to use?	Yes because it look nice and it was fun to press and turn the tool
Did you find anything boring?	No
Did you like the sounds the tool made?	Yes but I wouldn't change anything
Did you understand the images, did it clearly show what it was	Yes. Zoet beleg, ja, looks at me for confirmation, dat mag jij kiezen…..silence.. or will je dat ik jou help? Ja, what is zoet, honig, jam, haagelslaag, dus heir zit er niets zoets
What did you think of the screen	
Was the screen too big or too small	
Would you want to change the size of the box	
Was the tool too heavy	
Did you find it easy to use	Hesitantly responds yes, I follow up with a question regarding the text, was it easy to read the text, kind of
Was there anything that you found difficult	
Did you enjoy personalizing the box	
Would you want to use it again	Yes
What did you think of having to rotate the cube?	I liked it but sometimes I went the wrong way
Was it clear when to use which movement	Yes most of the times
Would you need your mum or dad to help you use it	Yes, maybe a bit
Would you take this tool with you to school to use it during lunch	Yes
Is there anything else you want to tell me?	No
Additional observations/remarks	
	Questioned if krentenbol was bread
	Regarding 2.1 , I didn't properly read the words, observers asks if it was difficult. No because I already understood what I had to do
	I would want to game on this
	Due to language limitation they needed to be reassured of what they read
	Needed to be reassured that there Is no right or wrong answer for the personal preference question
	Tool registers down instead of up, catches him by surprise but he quickly recovers.
	After filling in meals he thinks he is done, I remind there are 2 more question
	Mag Ik nu naar min en plus gaan, ja, daan ga ik nu en betere smile invullen
	He re-enacts the smiles seen and connects with the responses
	Seems as though the last screen with lots of text if not registered and just says yes
	Shows intrinsic motivation to log more food items when offered the choice of meal 3 he want to do all the options
	There are raisins in krentenbol so I will also put that for fruit

Appendix 8.5 - Participant 5

Column1	5
Was it fun to use?	Yes it was fun to press and turn the tool, and to read the text
Did you find anything boring?	No
Did you like the sounds the tool made?	I always found it fun to listen too, I wouldn't change anything
Did you understand the images, did it clearly show what it was	sometimes yes but other times not, was question if she could remember which were difficult but she couldn't remember
What did you think of the screen	it was big enough to see
Was the screen too big or too small	I like it like this
Would you want to change the size of the box	No
Was the tool too heavy	No
Did you find it easy to use	Yes
Was there anything that you found difficult	
Did you enjoy personalizing the box	
Would you want to use it again	Yes I want my own one
What did you think of having to rotate the cube?	
Was it clear when to use which movement	Yes
Would you need your mum or dad to help you use it	No
Would you take this tool with you to school to use it during lunch	Yes
Is there anything else you want to tell me?	No
Additional observations/remarks	
	Participant hums the starting sound
	Raisin in krentenbol are also fruit
	Tries pressing the answer on screen rather than rotate