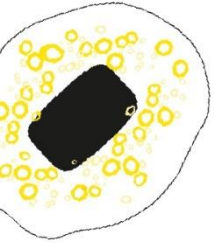


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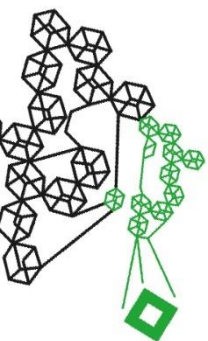
Promoting vegetable consumption among children through an interactive diner table

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Abstract

This bachelor thesis investigates if an application can be designed for an interactive diner table to encourage children at the age of 4 to eat more vegetables. Eating not enough vegetables can lead to health issues such as heart diseases because vegetables are an important provider of dietary fiber, vitamins and minerals. A concerning issue arises as many children develop an aversion to vegetables during their early years. Research shows that taste development occurs early in life, so it is important to address this issue at an early age, as establishing healthy eating habits at an early age has a significant impact on children's future dietary choices and overall wellbeing. By letting young children, at the age of 4, dine at a Sensory Interactive Table (SIT) this problem may be solved. On this table, animations will be showed with the use of LEDs that are placed underneath the surface in order to motivate children to eat more vegetables by providing positive feedback and giving them a clear goal. A total of 6 children participated in user tests for this experiment. Interviews were conducted both before and after the user tests and observations were made. These both were analyzed to achieve a comprehensive outcome in order to address the research question. The results demonstrated a positive influence on vegetable intake, with the majority of participants showing increased motivation to eat vegetables and engagement with the interactive features.

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1. Introduction

Vegetables are an important provider of dietary fiber, vitamins and minerals [1]. They have a positive impact on your health and are therefore important for a balanced diet. Not eating enough vegetables might result in a higher risk of developing, for example, chronic illnesses, heart diseases and cancer [2]. Research shows that taste development is formed at an early age. Therefore, it is important to start eating vegetables at an early age in order to get and stay healthy [3]. Unfortunately, this is often not the case. Children often develop an aversion to vegetables at a young age. Because they do not start eating it at an early age, it is a greater barrier to eating them later in life.

To avoid these problems, it is important to introduce children to vegetables at an early age so they become accustomed to the taste. Through interactive technology, this problem can be adjusted [4]. The technology that will be used in this research is an interactive diner table. This table can try to stimulate the eating behavior of children by using light and weight. Programming the table's technology to get children accustomed to vegetables in a positive way and enjoy eating them.

Therefore, the goal of this project is to encourage children to eat more vegetables and therefore eat healthier through this interactive diner table. To get this table to succeed the goal of this project, a number of things need to be explored. First, it is important to look at why eating vegetables is so important and what are the consequences of the lack of eating vegetables. In addition, the reasons why children do not want to eat vegetables should be considered. Getting to the root of the problem can help in finding a solution. Another thing to look at is whether there are already similar technologies that encourage children's eating habits. And why these technologies may or may not work well.

1.1 Research Questions

To investigate this, research questions have to be formulated. The main research question is:

To what extent can an application on the interactive diner table be used to help to encourage children to eat more vegetables at the age of 4?

To investigate the main research question, sub research questions have been formulated. Those sub research questions are:

Why is eating vegetables for children important?

What are the reasons children find it difficult to eat vegetables?

What are existing technologies modifying children's eating habits?

What are different techniques that can influence children's behavior?

1.2 Report Outline

To answer the main research question on how to design an application for the interactive diner table to encourage children to eat more vegetables at the age of 4 the complete process will be described in this report. Therefore there are several chapters in this report and the information needed for this bachelor thesis is presented in the following chapters. The first chapter is about the background research for this project. This chapter is there to answer some of the sub research questions and to get a better understanding and setting up requirements for the ideation phase. The next phase, the methods and techniques, will describe the methods that will be used during the rest of the project. The chapter about the methods and techniques is followed by the ideation phase, this is where the requirements and stakeholders for the project are identified and the first ideas are created. The ideation phase is being followed by the specification chapter. During the specification phase, the functional and non-functional requirements are established in order to get a more detailed understanding of the final concept. With those requirements the high-fi prototype can be realized during the realisation phase. The whole program will be designed and tested to the best result for the upcoming user tests. After the realisation phase, the high-fi prototype can be tested during the evaluation phase. User tests are conducted and their results are processed in order to draw a conclusion. Also the requirements made during the specification will be evaluated. After the realisation phase, the discussion can be done. The discussion includes results that had not been thought of beforehand and discusses recommendations and limitations. And after this, a conclusion can be made that answers the main research question: “To what extent can an application on the interactive diner table be used to help to encourage children to eat more vegetables at the age of 4?”

2. Background Research

To answer the main research question a comprehensive review of literature has been done. It covers literature about the importance of vegetable consumption among children, the reasons why children initially find it hard to eat vegetables, existing systems that through interactive technology or parenting techniques influence eating habits, and how colors affect children's behavior. The goal of this chapter is to provide readers a thorough overview of the state of the art in the fields of interactive technology and vegetable consumption. The application for the interactive diner table that will be designed to encourage children to eat more vegetables will be influenced by this research.

2.1 Importance of eating vegetables for children

It is important to know whether it is important for children to eat vegetables. And if it is, it is useful to know why it is important. This can help with the final design of the application.

2.1.1 Importance of eating vegetables in general

To find out why it is important for children to start eating vegetables at a young age, the first thing to know is why eating vegetables is important at all. Vegetables are an important source of vitamins, minerals, and dietary fiber, all of which are essential for proper growth and development. In particular, vitamin C, vitamin A, and folate are important for immune function, vision and brain development, respectively. In addition, vegetables provide a range of phytochemicals, such as flavonoids and carotenoids, which have been linked to a reduced risk of chronic diseases later in life [5]. According to Harvard University [6] consuming a diet high in fruits and vegetables has many health benefits, including reducing the risk of heart disease, stroke and some cancers. In addition, it can help maintain blood sugar levels, which in turn can regulate appetite.

Another study also investigates the evidence for the role of fruits and vegetables in the prevention of chronic diseases such as cardiovascular disease, cancer, and diabetes [7]. The review indeed found that a high intake of fruits and vegetables is associated with a reduced risk of chronic diseases, likely due to their high content of vitamins, minerals, fiber, and other bioactive compounds. So by this they are indicating the importance of eating fruits and vegetables. It can be concluded that vegetables are very important to reduce the risk of certain diseases and get a healthier lifestyle. Therefore it is important to eat enough of these and to start eating them at an early age.

2.1.2 Sugar-sweetened beverage consumption and childhood obesity

The issue of childhood obesity is getting worse. 39 million children under the age of five were either overweight or obese in 2020, according to the World Health Organization [8]. More than 340 million children and teenagers between the ages of 5 and 19 were overweight or obese in 2016. It has been

investigated why these kids end up being overweight or obese. Consuming sugar-sweetened beverages (SSBs) has been linked to increased fatness in children, according to Johnson et al. [9]. SSBs are a substantial source of added sugars in the diet, including soda, sports drinks, and fruit juices with added sugar. These extra sugars don't have the same satiety or nutritional advantages as entire meals, which results in empty calories and weight gain. In addition, the SSBs' high sugar content may cause insulin resistance, which may raise the risk of type 2 diabetes.

Children who drank more SSBs had a higher body mass index (BMI) and were more likely to be overweight or obese, according to the study [9]. According to these results, SSB intake should be reduced while nutrient-dense meals like vegetables should be encouraged as a means of preventing juvenile obesity. Numerous nutrients that are crucial for a child's health and development are present in vegetables. They can support kids in maintaining a healthy weight and are a great source of fiber, vitamins, and minerals. Additionally low in calories and rich in water, vegetables can help people feel fuller for longer and have less cravings for high-calorie items.

Vegetable eating is therefore essential for children's health, but SSB consumption has been linked to a rise in childhood obesity. Children can achieve a healthy weight and lower their chance of acquiring chronic illnesses by being encouraged to consume a variety of veggies and SSBs. By restricting the availability of SSBs in the house and providing a variety of vegetables, parents and other caregivers may play a significant role in fostering good eating habits.

2.1.3 Breakfast habits, academic performance, and vegetable intake

Eating vegetables is an important part of a healthy diet for children. Rampersaud et al. [5] found that children who regularly consume vegetables have better overall nutritional status, which can lead to better physical health and academic performance. In their study, children who ate breakfast regularly, which often included vegetables, had higher nutrient intakes and lower rates of obesity than those who skipped breakfast.

However, despite the benefits of eating vegetables which are stated before, many children do not consume enough vegetables. Rampersaud found that less than half of the children in their study consumed the recommended daily servings of vegetables. Encouraging children to eat vegetables can be challenging, but there are several strategies that may be effective. One approach in the research earlier mentioned, is to offer a variety of vegetables prepared in different ways, such as raw, cooked, or blended into a smoothie. Additionally, involving children in meal planning and preparation can increase their willingness to try new foods [5].

So consuming vegetables is crucial for children's health and development. Encouraging children to eat vegetables can improve their overall nutritional status, which may lead to better academic performance

and lower rates of obesity. Parents and caregivers can play an important role in promoting healthy eating habits by offering a variety of vegetables and involving children in meal preparation.

2.1.4 Conclusion

In conclusion, vegetable consumption for children is crucial, and this cannot be emphasized enough. Vegetables are a great source of dietary fiber, vital vitamins and minerals that are necessary for healthy growth and development. Vegetables also include a variety of phytochemicals that lower the change of developing chronic illnesses in later life. On the other hand, drinking sugar-sweetened drinks (SSBs) has been linked to increased child fatness, fueling the rising issue of obesity. Promoting a healthy weight and lowering the risk of acquiring chronic illnesses can be accomplished by encouraging kids to eat more vegetables while restricting their consumption of SSB. Additionally kids who consistently eat vegetables have higher nutritional states overall, which improves their physical health and academic performance. Therefore, by providing a variety of vegetables, including children in meal planning and preparation and restricting the availability of SSBs in the house, parents and other caregivers may significantly contribute to the promotion of good eating habits.

2.2 Reasons children find it difficult to eat vegetables – Literature review

There are several underlying reasons why children often find it difficult to eat vegetables. To understand more about these reasons and to find a solution to these reasons research has been done.

2.2.1 Factors that can influence children their eating behavior

The appearance of vegetables may cause children to eat more vegetables [10]. Cutting vegetables into tiny pieces helps boost children's acceptance for vegetables and preference for vegetables. This is due to the fact that cutting vegetables into smaller pieces can alter their texture. It makes it more attractive to children who might have trouble with bigger pieces of vegetables, because cutting them makes it simpler to chew and swallow. Children's acceptance of vegetables can also be increased by chopping them into amusing shapes like stars or hearts. The texture and taste of vegetables is a big problem for children and is also a main reason why children do not like to eat their vegetables. The taste of some vegetables is quite bitter which makes them unappealing to children because they often do not like this taste. Young children also like a sweet taste the most, and they miss this in vegetables, so they like the taste of vegetables even less [11]. Also eating vegetables costs more energy than it produces because of that they are low in calories which makes children reluctant to eat them [12].

The dietary habits of children, especially their consumption of vegetables, are greatly influenced by their parents. Through the parents' personal eating habits, the meals they provide, and the methods in which

they encourage children to eat, parents may affect their children. At a young age, children often enjoy doing the opposite of what their parents tell them to do. They enjoy saying "no" and therefore often refuse to eat vegetables because their parents want them to eat them. What can also be influential is that children see someone else at their table not eating something, and therefore don't want to eat it themselves. So parents have a great influence on their children's eating habits [13], [14]. This can be seen in a negative way, but parents can actually try to encourage their children to eat vegetables, for example by offering a variety of vegetables through choice architecture. If children can make a decision on their own which vegetable they want to eat, it encourages them to actually start eating it. This can be done, for example, by giving them a choice prior to eating or cooking two types of vegetables and then giving them a choice during dinner as to which one they want to eat. This therefore results in a higher intake of vegetables, because for children it feels like they have the power [15].

Schools also teach children about healthy eating, increasing their knowledge and hopefully encouraging them to eat more vegetables [16]. Letting children try out vegetables for a few weeks through a testing program and giving them lectures that are focused on the advantages of consuming vegetables will help them to eat more vegetables. "Smart Bodies" [17] works to promote children's health and happiness by encouraging them to engage in physical exercise and a balanced diet. Children who participate in the program will get the information and abilities necessary to make better decisions and lead healthier lives, by eating more vegetables for example or helping to prepare the vegetables for a meal. The program teaches the children about nutrition via hands-on activities, where they discover the health advantages of various vegetables. Children may try several vegetables as part of the program's taste testing and learn to appreciate their tastes and textures.

Media and advertisements are generally good at influencing people, including children. By using vegetables in a fun way in an advertisement, supermarkets are trying to have an effect on children. For example, the Dutch supermarket Lidl is also trying this through soft toys. They try to put vegetables and fruits in the picture through a savings campaign, called 'VitaMini', with soft toys in these shapes. For example, they have cheerful soft toys that resemble broccoli, mushrooms and eggplants. On the card of these soft toys are facts and tips about the corresponding vegetable or fruit so children can read them for more knowledge. [18] Children like saving actions and therefore often want to save all the toys they can. Parents can motivate their children to eat vegetables in order to get the toy they want and therefore children might start to eat more of their vegetables.

2.2.2 Common themes in these factors

Although there are many different factors that affect the eating behavior of children, a few common themes can be found in those factors. The factors that can be found in the previous paragraph are the 'appearance of the food', 'the taste preferences', 'the influence of their parents', 'school programs' and 'advertisement'. To divide these factors into different categories a model of eating behavior can be used.

This model offers several aspects influencing eating behavior to illustrate the psychological drivers of human eating behavior. The model represents internal and external factors where the internal factors include taste related features of food and the external factors include information, the social setting and the physical environment (Figure 1) [19]. The factors found in the first paragraph can be divided among these internal and external categories shown in this model.

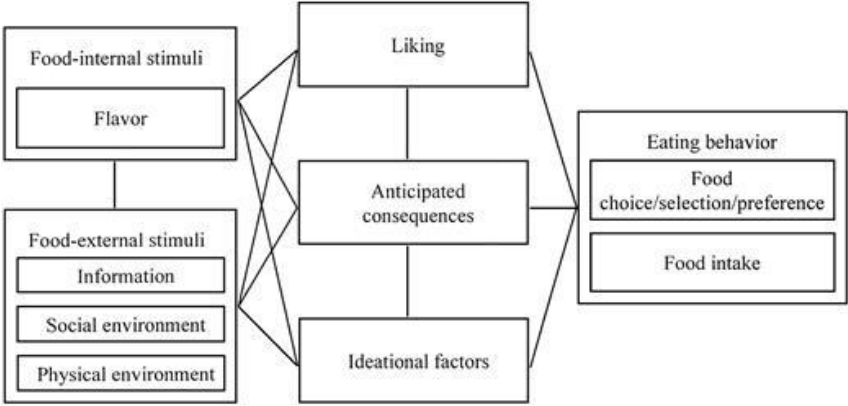


Figure 1: Model of eating behavior

The food internal stimuli ‘Flavor’, is the only internal stimuli and it includes among others the smell, taste and texture of the food as well as the appearance of it. Therefore from the factors found in the first paragraph the factors ‘appearance of the food’ and ‘taste preference’ both fall pretty clear into this category. These factors are about how the shape of the food and the taste of vegetables influences the vegetable intake of children which is therefore pretty much the same as what is meant by this category. Therefore these factors can be categorized under Flavor factors that influence the healthy eating behavior of children.

The first food external stimuli is ‘information’. This category refers to the information given to customers by, for example, the labels on the packaging or by how the information is verbally conveyed about the food to the customers. Information can have both positive and negative effects on children's eating habits, so it is important to convey this information in the best way possible. The factor found in the first paragraph that falls into this category is the ‘school programs’. During these programs, lessons are given to the children in school where they are taught a lot about eating vegetables and why it is important. These lessons often have a positive impact on children because they are introduced to vegetables in an educational way by, for example, preparing them themselves for a meal. The factor that also belongs to this category is ‘advertisement’. The stuffed toys the children can collect at Lidl have cards with information on them. This is also a way of teaching children new things and therefore belongs in the category information.

The second food external stimuli is ‘the social environment’. This category refers to the social aspects that can change eating habits. For example, the people around a person can have an influence on this

such as friends, family, parents, classmates etc. The factor found in the first paragraph that falls into this category is 'the influence of their parents'. Parents have a big role in influencing their children. They can be a bad influence because children often won't listen to their parents, but they can also be a positive influence through trying different parenting styles by giving their children a choice of vegetables to eat, for example. Parents are part of the children's social environment and therefore this factor falls into this category.

The last food external stimuli is 'the physical environment'. This category is about the accessibility and availability of food. None of the factors found in the previous chapter falls into this category and therefore this category is not relevant for this research.

2.2.3 Conclusion

The goal of this review was to get a better insight on what the different factors are that influence the healthy eating behavior of children, and to categorize these factors. Although it is mentioned that children frequently do not enjoy eating vegetables and might not eat enough of them, it is crucial to start teaching them to eat them at a young age. Factors such as the taste of the vegetables, the look of them, advertisement, the influence of parents on their children and school programs were discussed in this review. To categorize these factors the model has been used to divide them. They fitted into the following categories: Flavor, information and social environment. In order to promote good eating habits, the text highlights the significance of comprehending and dealing with the numerous factors that might affect children's eating behavior. Through the three categories, possible solutions such as giving children multiple options while eating can be looked at.

2.3 Existing Technologies

In order to see if there are already existing technologies that modify children's eating behavior, this was researched. By offering interactive and tailored feedback, these devices encourage children in the process of making healthy food choices. Those devices can provide feedback to children in various ways such as by light, sounds or images to help make dining an enjoyable and interesting experience for children.

Since some devices may provide a game in their product it is also important to know whether games can change children's eating behavior. This has been researched in study and presented in four different topics according to eating behavior [20]. They aimed to increase fruit and vegetable consumption, reduce snacking, promote healthy eating and encourage food discovery. Both serious games and gamification can increase kids' consumption of fruits and vegetables and encourage good eating habits by enhancing their knowledge. In order to promote the acceptability of novel foods and decrease fussy eating habits, they may also encourage kids to experiment with food. Rewards were frequently employed in studies as

game components to encourage behavior change. Game-based treatments have the potential to increase the consumption of fruits and vegetables and teach kids about healthy diets.

2.3.1 Mobile application to promote eating behavior in children

This project is for children with picky eating habits [21]. Picky eating behavior is a problem that children experience quite frequently. Therefore a system for interactive tableware was designed. A system was created that consists of two main components which work together to try to encourage the children to eat healthier. First there is an application for a mobile device that can be played with the other people at the table while eating (Figure 2). Secondly there is a plate with a weighting sensor that responds in different ways depending on the amount of food a child consumes and makes use of the game's rules (Figure 3).

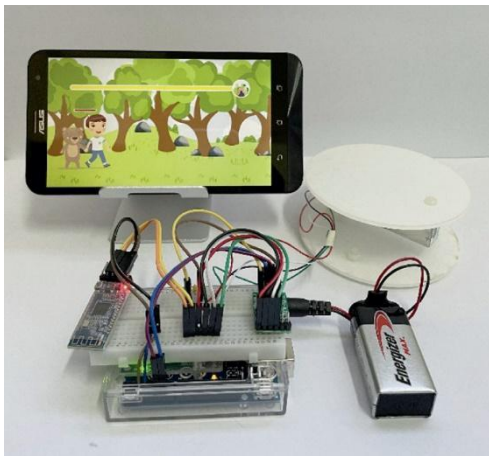


Figure 2: The mobile application game

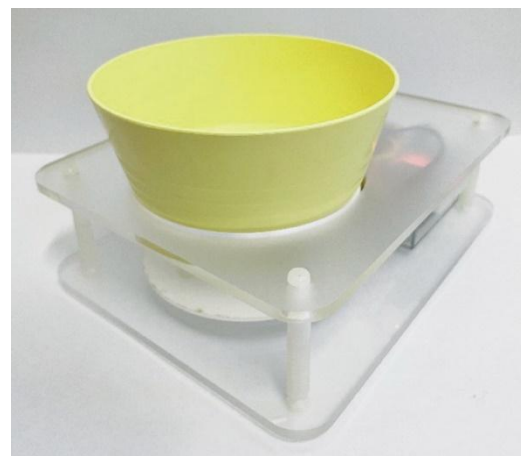


Figure 3: The scale with sensors

The goal of the game is to get the animals home. This is done by eating the food that is in the tray that is weighed. The weight data is sent via Bluetooth to the mobile app so it knows that food is eaten from the plate. The more food eaten from the plate, the lighter it weighed by the sensor and the closer they are to the end of the game. Because the lives of the animals decrease each time nothing is eaten from the right tray (the healthy one), children try to discover how to increase their lives. As soon as they find out that this can be done by eating from the tray with the healthy food in it, the idea is that they continue to eat from this tray and thus start eating healthier in a fun way.

2.3.2 Sensor-embedded fork

This project is a fork, called “HAPIfork”, that is designed to help people eat more slowly and mindfully [22]. The goal of the HAPIfork is promoting healthier eating habits for people. It features sensors that can track an user’s eating pace, the length of the meal and the number of bites consumed in addition to an accelerometer that is incorporated right into the device. The information is then wirelessly sent to a smartphone app, where users can monitor their eating patterns and get advice on how to do it better.

During their meal if the fork notices that you are eating too fast, it will vibrate to let the user know that they are eating too fast and need to slow down. This fork is not specified in helping children.

There is a fork that is specified in helping children to have a balanced diet, the sensor embedded fork [4] (Figure 4). Parents face a lot of challenges in encouraging their children to develop healthy eating habits. This paper addresses the possibilities of computer technology to make mealtimes more pleasant for children. A technique is suggested to encourage children to consume a range of meals depending on their colors by enhancing a simple utensil, the fork, with sensors. The system, which includes the smartphone game 'Hungry Panda', is designed to make it easier for parents and kids to do at-home food education activities. Straightforward color-based food selection techniques might supplement children's dietary education and serve as a substitute for more intricate nutritional instruction.



Figure 4: Sensor embedded fork

2.3.3 FunEat

FunEat is an interactive tableware that was designed for improving eating habits in children [23]. For developing children, a healthy diet is crucial. However a lot of kids exhibit picky eating habits which can lead to a number of health issues like a weakened immune system. This study focuses on using interactive animation and gamified design to help kids form good eating habits. They created an interactive animated diner plate system that may offer assistance to children while they are eating. It consists of a sensing diner plate and a tiny projector.

The dinner plate system consists of a plate consisting of four different areas that can hold different kinds of food. Each of this area has a weighing sensor in it that detects if food is being eaten from that place. The projector will project animated pictures onto the plate according to the weight changes that are being made. The loudspeaker will also play music according to the weight changes and it is placed next to the plate. This can all be seen in figure 5.



Figure 5: FunEat diner plate

The plate is a combination of a gamification and a playification. The growth rate (on the top left) of the pet depends on how complete and picky the child playing the game is eating. When the plate notices a weight change, meaning the child is eating, the pet will move to the associated place to encourage the eating behavior. When the plate notices that from a certain area not enough food is being taken, it means that the child probably does not like the food placed in that area. The pet will move to that certain area to remind the child to also eat from that place and to encourage them. This will also be done with the help of sound effects. In the end when the complete plate is empty, so all the food is being eaten by the child, the child has won the game, which is why this plate is a gamification. The plate can also be seen as a playification when the winning element will be left out. Then there is just a happy rabbit hopping around trying to remind the child to also eat from the plates he is eating less of at the time. Because of the immediate feedback that is given throughout the game the children's attention will be kept. The outcomes of the tests demonstrated that the approach had an advantageous impact on enhancing their eating routines.

2.3.4 iEat: An Interactive Table

iEat is an interactive smart restaurant table that aims to improve restaurant experiences by giving users a natural way to interact with the table [24]. The installation works with a projector, a camera and a sensor. The projector will project the corresponding feedback onto the table that is observed by the camera and the Kinect sensor. A Kinect sensor is a sensor that detects movement, so that it notices when something is being moved in front of the sensor. Infrared light sources are tracked by the high camera and by evaluating the depth and spotting the plates on the table, the Kinect is used to follow the plates. The infrared light pens will only display something when the table is being touched by someone. The table provides different tasks that can be done by people who are attending the table like ordering food, reading the menu or playing games.

2.3.5 YummyTricks

YummyTricks is a serious game that is designed for children to learn to get healthier eating habits [25]. They tend to focus on letting children make their own decisions in which type of food they will eat without parental influence. With the ultimate goal of getting children to eat healthier by themselves. This game is being designed to use on a mobile device with a touch screen. Through playing games, children will get more information about nutrients, and why these nutrients are important. YummyTricks consists of different types of games. One game is to learn about the different types of food by catching them with a basket. The name that is shown on the basket represents the food that the children must catch in order to complete the game. In this way, they can learn the differences between different types of food, such as the difference between fruits and vegetables.

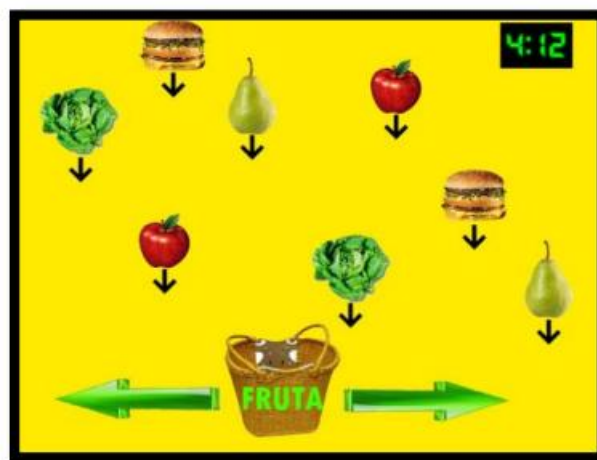


Figure 6: YummyTrick game

According to this research such applications can successfully engage kids in play while teaching them appropriate eating habits. By playing games, children are more motivated to play it repeatedly because they are motivated to win the game.

2.3.6 Time to Eat

Time to Eat is a game that is designed to use on a mobile phone that intends to encourage children to get healthier eating habits [26]. They designed their game to be used on a mobile phone due to the increase in cell phone use among children. They try to reach the goal of encouraging children to get healthier eating habits by letting the users send images of the food they consume during the day to a pet. They need to take care of this pet by eating healthy food. The emotional state of the pet depends on the food intake of the children (Figure 7). So the healthier the food in the picture, the better the health of the pet and the better the outcome of the game.



Figure 7: Emotional state of the dog

Taking care of a virtual pet is often used in games that are designed for improving health. There are a lot of existing examples of virtual pet games like the Tamagotchi where children needed to take care of their own pet. In such a game there are no negative outcomes in the outside world if they fail to take care of their virtual pet and they can provide more regular engagement, which makes it perfect for children to play with [27].

2.3.7 Gamification and Playification

To make the interactive diner table a playful table the use of gamification or playification can be implemented. Game-based methods can alter kids' eating habits. Games can have a favorable impact on kids' consumption of fruits and vegetables as well as their knowledge about healthy eating. They can also engage kids in interacting with new foods and promoting food discovery. Positive connections between the enjoyable aspects of games and the intended eating behavior, such as consuming vegetables might be transmitted [28]. Gamification refers to the use of game design elements such as points, challenges and being able to actually win the game [29]. The goal of making something gamification is to encourage children to reach a specific goal by doing tasks, which can make the game more enjoyable for children. Gamification can also help to make learning more enjoyable and interactive for children. By incorporating elements of gameplay, such as points, badges, and leaderboards, into educational activities, children are more likely to remain engaged and motivated to learn. But games can also be stressful. Children often want to win a game and when they don't they leave with a bad or sad feeling. This is not something the table wants to achieve.

For kids, play is a universal language. Games that consist of playification may be used for a variety of pediatric situations, from educational techniques to therapeutic approaches [30]. So, they can also be used to teach children to start eating healthier. Playification refers to the use of play-based elements such as storytelling [29]. There are no rewards, no points and there is no winning system. It can be used in educational contexts to make learning more fun and engaging. It's just about having fun and not about achieving a certain goal. A goal can be achieved while having fun, but when this goal is not achieved there would be no negative effect. The only drawback might be when there is no chance to actually win the game that children are also not motivated to participate in it.

2.4 Existing education techniques

To know if there already are existing educational techniques that aim to promote the consumption of fruit and vegetables among children research has been done into this.

2.4.1 Authoritative parenting

An authoritative parenting style has been found to be associated with better eating behaviors in children. Children raised by authoritative parents were more likely to have healthy eating habits, including consuming more fruits and vegetables, than children raised by permissive or authoritarian parents [31].

Authoritative parents often use a positive approach to food and eating, emphasizing the importance of a balanced diet and modeling healthy eating behaviors. They encourage their children to try new foods and provide healthy options at meals, while also setting clear expectations for behavior and enforcing reasonable limits. In contrast, permissive parents may allow their children to have more control over their food choices, which can lead to a higher consumption of unhealthy foods. Authoritarian parents, on the other hand, may use strict rules and punishments related to food, which can lead to a negative relationship with food and an increased risk of disordered eating.

Overall, an authoritative parenting style can have a positive influence on children's eating behavior. By modeling healthy eating behaviors, providing healthy food choices, and setting reasonable limits, authoritative parents can help their children develop healthy eating habits and avoid the negative consequences of unhealthy eating.

2.4.2 Taste lessons

Children can also be taught to eat different foods. They can get help with this through different programs that their primary school can follow.

One example of such a program is Smaaklessen [32] it is a teaching program for elementary school students focused on nutrition and taste. The purpose of Taste Lessons is to make children aware of what they eat and why they like or dislike certain foods. The program was developed by Wageningen University & Research and is used by many elementary schools in the Netherlands.

During Taste Lessons, children learn about different tastes, how foods are made and where they come from, and what constitutes a healthy diet, among other things. The lessons are built around the five senses: seeing, smelling, tasting, feeling and hearing. Through tasting assignments and other activities, children are encouraged to try new foods and develop their taste buds. So this allows them to be taught, or given help in eating vegetables. Children may participate in a tasting, for instance, when they sample various meals and attempt to identify the flavors they are tasting. To assist the kids focus on their sense of taste and avoid being distracted by other sensory inputs, this can be done with the use of a blindfold.

And so by following this program, elementary schools also hope that they will encourage children to eat more vegetables.

Another example of such a program is **‘Ik eet het beter’** [33]. "Ik eet het beter" is a curriculum for elementary school students focused on nutrition, health and exercise. The goal of the program is to make children aware of the importance of healthy food and sufficient exercise for a healthy lifestyle. The program was developed by supermarket Albert Heijn in cooperation with the Voedingscentrum and is offered to elementary schools in the Netherlands.

During this program children gain insight into what healthy food is and its effect on their bodies. They learn about the different nutrients, how they are processed in the body and why they are important for a healthy body. In addition, children are encouraged to get enough exercise and are given information about a healthy lifestyle in general.

The curriculum consists of several components, including interactive lessons at school, an online platform with information and assignments, and field trips to, for example, a farm or supermarket. The program targets grades 5 through 8 of elementary school and can be taught by the teacher. So with “Ik eet het beter” children are encouraged to make conscious food and exercise choices, which can contribute to a healthy lifestyle in the long term.

2.4.3 Choice architecture

Studies have been conducted on the influence of choice on children's eating behavior, particularly regarding vegetable consumption. It is generally believed that giving children freedom of choice in choosing foods can contribute to a higher intake of vegetables.

This was also shown in a study to find out how children’s preferences and vegetable consumption would change if they were served a choice of vegetables at dinner [34]. In their study there participated 150 children between the ages of 4 to 6. Those 150 children were able to choose between three different conditions to take their vegetables. The first one was the discrete choice condition (DCC), in this condition children were able to pick the vegetable they would like to eat before they started their meal so only one vegetable would be prepared for the meal. Secondly there was the continued discrete choice plus variety condition (CDCP), in this condition multiple vegetables were prepared and children were able to choose which of these vegetables they wanted to eat during their meal. And thirdly we have the no-choice condition (NCC), in this condition children did not have a choice at all and they just needed to eat the vegetable that was chosen for them.

This study found that the amount of vegetables that were eaten by the children was much higher in the choice conditions (DCC and CDCP) than it was in the no-choice condition (NCC). Between DCC and CDCP, there were no variations in the participants’ overall vegetable intake. These findings show how

giving young children a choice might improve their intake of vegetables. The effect of option availability is thought to be driven by a higher level of intrinsic desire and larger degree of personal control.

2.4.4 Conclusion

In conclusion, there are a number of current educational strategies that can have a positive impact on children's eating behaviors. By offering appropriate food alternatives, modeling good eating behaviors and setting realistic boundaries, authoritative parenting, for instance, can aid children in forming healthy eating habits. Children may learn about nutrition, taste and healthy food options via taste lessons, which also motivates them to try new foods. The flexibility to eat their vegetables can boost children's intake of vegetables. The choice architecture can also have a substantial influence on this. If parents for example provide their children with 2 different options of vegetables during their meal, it would improve their vegetable intake. Overall these methods have the potential to encourage children to eat healthily and can eventually lead to a better way of living.

2.5 Light, Colors and shapes

There are different factors that can have an influence on children's behavior. These factors may influence their experience while eating dinner. By changing these different factors the ideal setting for eating healthier can be found. Therefore research needs to be done in what way these factors can have a positive impact on children.

2.5.1 Impact of colors on children and eating behavior

Research has shown that children respond more positively to light and bright colors such as blue, green and pink and that children had negative reactions to the dark colors such as black, brown and green [35]. Also, children often associate the color red with something negative and green with something positive. So by using the right colors in the interactive dinner table, you can try to stimulate children's eating behavior.

The influence of these colors in combination with food are just a bit different. Here red is actually accosted to something sweet, which therefore would not necessarily mean something negative [36]. Children often like sweet food, and therefore the color red in combination with food is actually something positive for them. They also like food with the colors of, for example, pink and orange in it.

2.5.2 Impact of ambient light colors on eating behavior

Ambient light can have an impact on the food intake among people. Changing light can change the atmosphere in the room, and this atmosphere, in turn, can have negative or positive effects on eating habits. The choice of making unhealthy eating decisions is higher when the brightness of ambient light in a room is low [37]. Dim ambient lightning therefore also results in a higher intake of calories. Also,

people in dimmed light and soft music often consume less food and eat their food slower than when people eat in a brighter light with louder music [38]. So it is better to eat in a room with a brighter light. This is because the more alert we are, the better choices we make [39]. Our emotional moods, cognitive associations and general conduct are all impacted by illumination. The brighter the surroundings we are in, the more attentive our brain gets. Dim lightning lowers mental awareness, which may cause people to make worse decisions like eating unhealthy food.

2.5.3 Impact of shapes on children

There are several geometric shapes that can influence the creation and the feeling of a design. The shapes most common in designs are squares and rounds, which is why people often feel most comfortable with these shapes [40]. Squares are often compared to figures representing stability. Children often think of play blocks when they think of squares and because of this, they will feel secure with squares. But children feel most secure with circles, they encourage warmth, cohesion and openness.

2.5.4 Impact of motion and animations on children's behavior

Motions and animations can have an impact on the general behavior of children. They can trigger different types of emotions, both positive and negative. Research shows that people are generally more quickly drawn to an object that is static in the beginning and starts moving when is being triggered than an object that is constantly moving. They prefer onset motion instead of continues motion [41]. However, with young children this is slightly different. Their attention is easily drawn by just adding motion in an animation. The child's focus remains on the continues animation rather than the environment they are in. and are quickly drawn to movements around them [42].

2.6 The interactive diner table

Since the application that will be designed for this project needs to be carried out on an existing interactive diner table it is useful to know what this table exactly is, what it is doing right now and how it actually works.

The Sensory Interactive Table (SIT) is an interactive diner table to support eating behavior in a social dining setting [43]. The table is specifically made to employ interactive features and sensors to promote healthy eating habits among diners in a social dining environment. The SIT is a measuring device that can pick up on a variety of dining-related elements, including the presence of food, the movement of utensils, and the number of diners in attendance. To ultimately develop a successful dietary support system, SIT enables us to study how people eat while they are in a social setting with other people around them, the social interactions and how the feedback from the LEDs have an impact on people's eating behavior and their response to this feedback in real time.

The SIT is an instrumented, interactive table that has LEDs and load cells implanted just below the top surface. 199 independently programmable, hexagon-shaped modules make up the table top (Figure 8). Each model contains one load cell and 42 RGB LEDs. The load cells gauge the weight of the plates or cups that are standing on the table. As a result, several overt and covert characteristics of eating behavior connected to mass such as bite size, the overall amount of food on a plate, or the eating speed synchrony among tablemates become measurable. For this Graduation Project the overall amount of food on a plate is useful to measure the amount of vegetables that are eaten. Unfortunately the load cells are not working for this project. As a result, the table must be manually controlled by the researcher when food is eaten. In addition, the LEDs shown in figure 9 can provide feedback to the users of the table through showing different colors and patterns.

Through Unity, a program can be created and executed on the table. This program controls the different load cells and all the different LEDs in a way to influence eating habits.

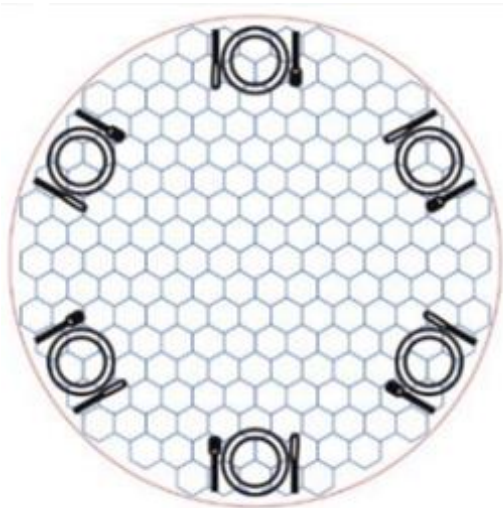


Figure 8: The 199 hexagon-shaped modules



Figure 9: The LEDs providing feedback

2.7 Conclusion background research

To design a program for the interactive dining table, a few things must be taken into account. First, a big factor influencing children's eating habits is their parents. Designing the table to incorporate an authoritative parenting style into the table should solve this problem. Research has also shown that when children are given freedom of choice in choosing their food, they take greens more and more easily than when they have no choice. Also, it has a positive impact on vegetable intakes to give children positive information about vegetables, this will make them learn more about them and appreciate vegetables more. Children are often stimulated by a game where they have to accomplish something or when playing with something. It therefore is important to implement something like a gamification or a playification. A combination of the two would be best, it should not be a game that can give off negative

consequences, but there should be something of a game element to really motivate the children. To impart a positive feeling to children, it is also important to pay attention to color. Light colors like green, blue and pink have positive associations and children respond more cheerfully to them than to the darker colors.

3. Methods and Techniques

To design a program for the interactive diner table the Creative Technology Design Method created by Mader and Eggink [44] will be used. This design process is a process that was created for Creative Technology students and it combines methods from engineering and design in a spiral model with diverging and converging (Figure 10). This method consists of four different phases: ideation, specification, realisation and evaluation. In the first three phases diverging and converging will be used. They all start with a diverging phase to explore multiple ideas and open the design space, followed by a converging phase to reach a certain solution and reduce the design space. This space is shaped by the designer’s expertise, tastes and willingness to take risks as well as judgments based on needs and knowledge that is currently known. The spiral model is used so that various steps will be taken in the process in a logical order to guide designers along an individual path.

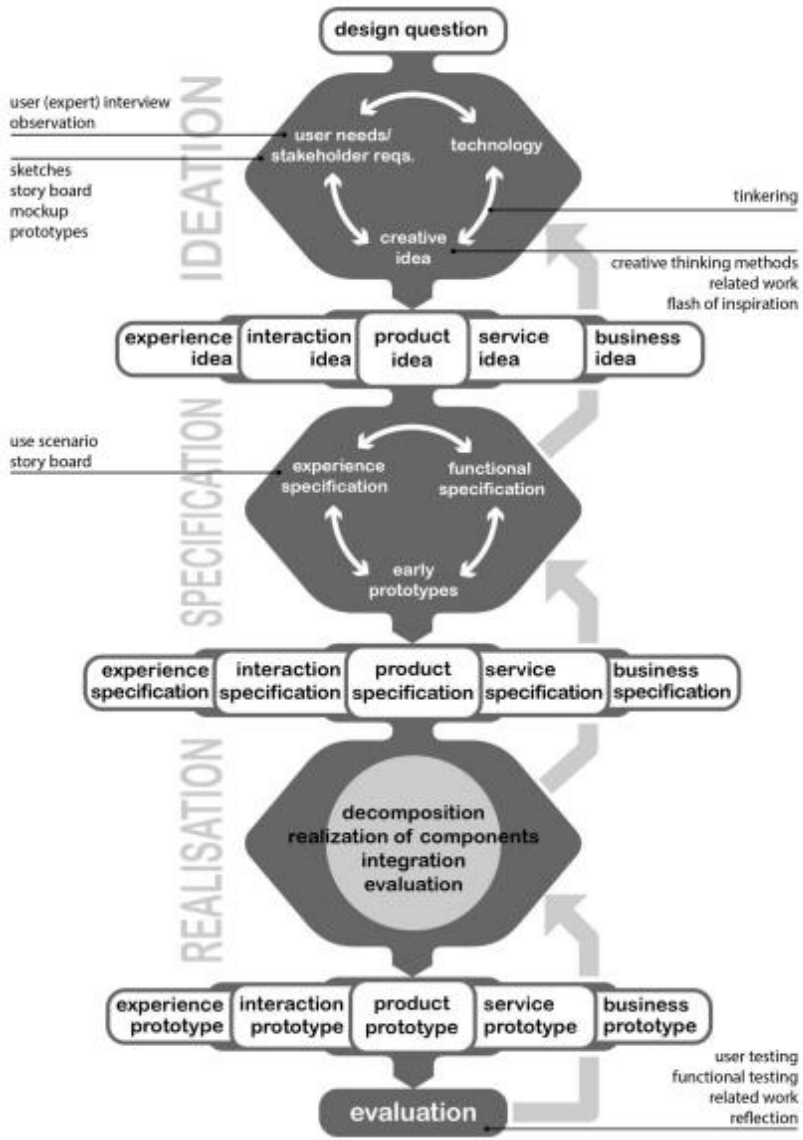


Figure 10: The Creative Technology Design Method

3.1 Ideation Phase

This is the first part and the first phase of the design process. During this phase the information that was found in the background research will be used to generate some first concepts for a final product. It involves a definition of the problem, idea generations through brainstorming identifying stakeholders and the user needs. The result of this phase will be a project idea with the associated problem requirements.

3.2 Specification phase

During the specification phase the final idea from the ideation phase will be specified with the functional requirements that were made. This will be done through finalizing the requirements that were made in the ideation chapter to know more about the details of the final concept. After this phase the final requirements for the final concept are made.

3.3 Realisation phase

After the specification and the ideation phase there will be a final concept with final requirements, so that the final product can be realized. During this phase, the program is constructed, tested and improved until it satisfies all needs and standards. Everything together at this step, and any required coding is written. The goal of this phase is to create a functional high-fi prototype.

3.4 Evaluation phase

This is the last phase of the project. The final product will be tested and will be evaluated if everything that was strived for has been met. It will look at if all the requirements identified during the phases have been met and if it actually works and satisfies the users. This will be done during observations while testing the product and the interview after the test.

4. Ideation

Through the information that was gathered in the previous phase, in this chapter initial ideas could be made for a program on the interactive diner table.

4.1 Stakeholder analysis

Individuals, people or organizations that may have an impact on or be impacted by this project are referred to as stakeholders. The process of identifying stakeholders, examining their goals, expectations and possible effects, and formulating plans to manage their engagement and expectations is known as a stakeholder analysis. The analysis may identify possible conflicts and because of the analysis management plans to deal with the possible conflicts or risks can be designed. Connections and trust can be built with the stakeholders which will improve the chances that a project will be successful. Certain stakeholders are more powerful or influential than others.

A table is created that provides this overview and allows for the values and identifications of the stakeholders. First the stakeholders need to be identified and their power and interests needs to be stated. The stakeholders that were found are: children's, parents, education systems at schools, restaurants. Their interests and power can be seen in the following table (Table 1):

| Stakeholder | Power | Interest |
|---------------------|---|---|
| Children | Children are not the decision makers of buying the table in the end. So their power may be lower. | They are the ones who ultimately need to start using the table and benefit from it so that they start living a healthier life. |
| Parents | The parents are the ones deciding if they want to purchase such a table and if they are going to use it for their children. So their power is quite high. | Parents will probably have a high interest in the health and well-being of their children. |
| Restaurants owners | They also have the power to decide if they want such a table in their restaurant, but they do not have the power to make significant decisions about the implementation of the table. | The table may be attractive for families with children who are looking for a fun and healthy dining experience. But the interests of the restaurant owners would be high. |
| Educational systems | Their power could be high as well, if they are being involved during the process of making the table. | They want to teach children the importance of vegetables and want to teach them to eat more of it, so the table might be a helpful solution for their lessons. |

Table 1: Stakeholders and their powers and interests

After identifying the stakeholders and knowing how much power they have or how high their interest is, they could be placed in an interest grid. This is a grid that has an overview of how to manage the stakeholders during the project. The higher the power and interest, the closer to manage them. This can be seen in the following figure (Figure 11):

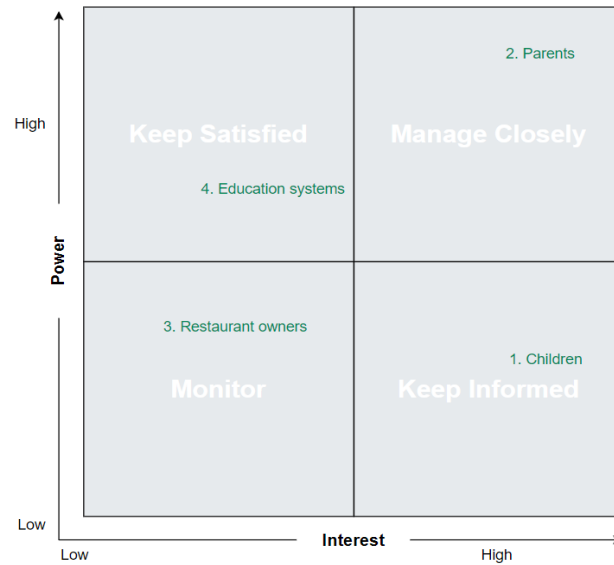


Figure 11: Interest Grid

4.2 First requirements

For this graduation project to succeed it is important to establish requirements that must be met. These requirements will be set up by the information found in the background research to understand more about user needs. They will be established by the MoSCoW method [45]. This method contains requirements that: Must have, Should have, Could have or Won't have to be considered to prioritize the requirements that are being made.

During the first brainstorm session some requirements were made that were found in the background research. These requirements are:

- The animation needs to support children to eat vegetables
- When children are eating vegetables they will be rewarded through interactive feedback
- The animation on the table has some gamification or playification feature
- The table provides bright ambient light in order to get children to eat healthier
- Children should be able to choose between different vegetables
- The animation should be colorful and visually appealing to capture children's attention and engage them in the eating process
- The animation should include interactive elements that encourage children to participate in the eating process
- The animation should be child-friendly
- Children must easily understand the animation

4.3 First brainstorm session

During the first brainstorm session with some parents, a mind map was made with some first ideas for the program on the interactive dinner table where the requirements from 4.2 were kept in mind.



Figure 12: First brainstorm session mind map

4.4 First ideas

After the brainstorm session, some first general ideas could be made. In each of the following ideas, children are given the choices of several vegetables during meals. These would be the choice of two different vegetables to ensure that the children eat more vegetables as examined in the background research. These vegetables will be placed on a different plate than the rest of the food in order to measure if the vegetables are actually being eaten.

4.4.1 Colorful Circle

The first idea generated was the colorful circle idea. The table begins by projecting the rainbow in dull light colors. (Figure 13), the more vegetables eaten the brighter and the fuller the rainbow becomes (Figure 14). The colors will all be light pastels because children see them as something positive. Also chosen are the colors of the rainbow, because those colors are associated with positive thinking, which will lead to a positive experience for children.

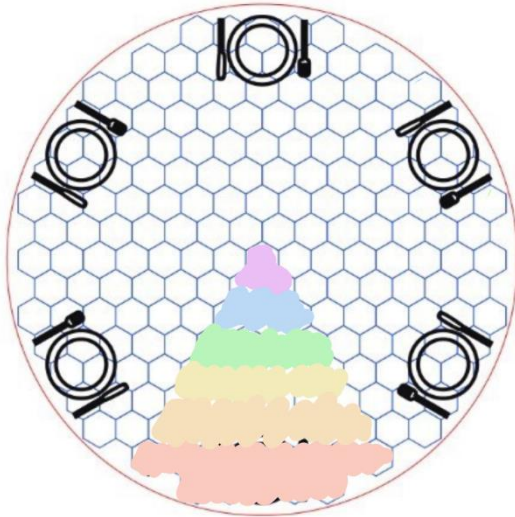


Figure 13: Begin state Colorful Circle

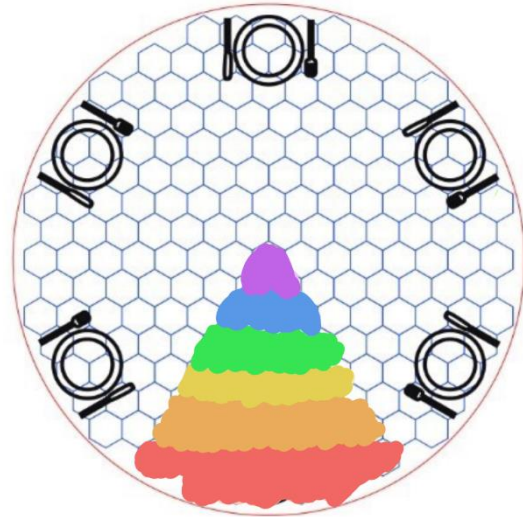


Figure 14: End state Colorful Circle

It is sort of a mix of gamification and playification. The more they eat, the more complete their rainbow will be, but they only will succeed their meal in a completely positive way once their rainbow is completely full. They can associate this with winning and they can make a game out of it, the first to complete their rainbow will be the winner. But there is no negative effect if this goal is not achieved, they will only end up with a slightly less full circle. Once the first few vegetables were eaten, the rainbow would begin to be filled. The effect during the first few bites would be greater than during the later ones so that the effect could be clearly transmitted to the children (Figure 15). So after a few bites, the rainbow would already be largely filled (Figure 16).

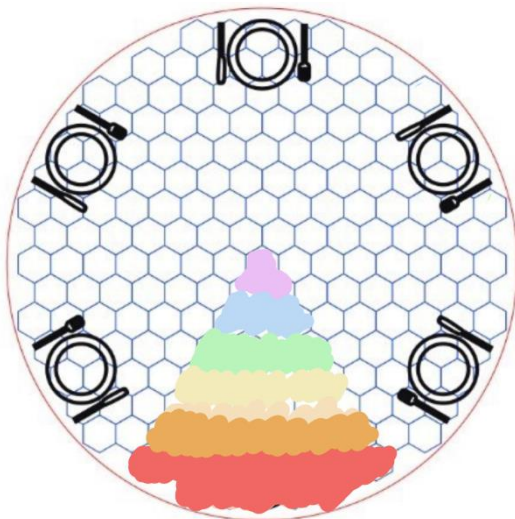


Figure 15: After first bites

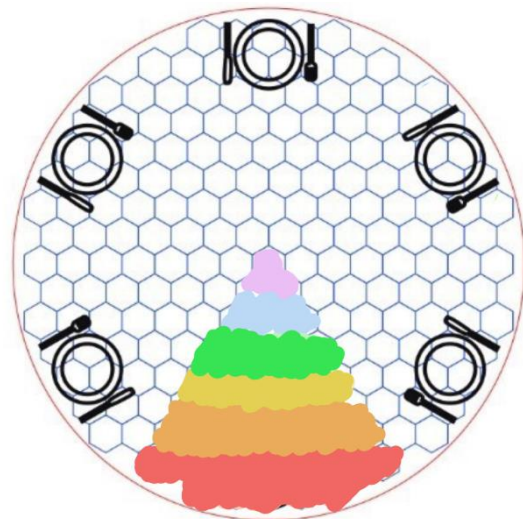


Figure 16: After a few bites

Since children's attention is drawn to animations, the rainbow is filled with animation instead of the colors appearing static. Once eaten, the entire rainbow is filled with the color of the rainbow in a smooth

animation to clearly show the children how far along they are. So the rainbow is then filled with that entire color once (Figure 17).

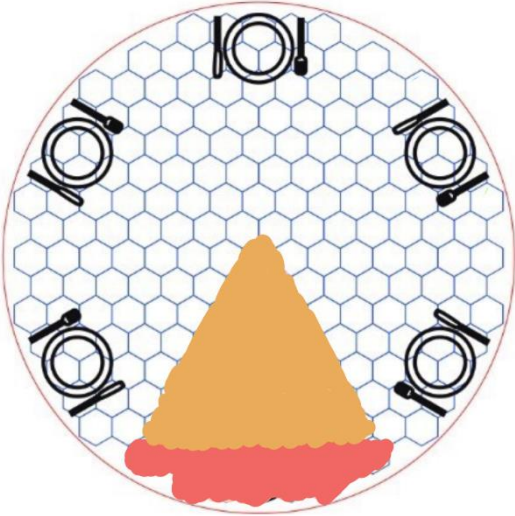


Figure 17: Filling animation

| Requirement | Has been met? | Explanation |
|--|---------------|--|
| The animation needs to support children to eat vegetables. | Yes | The rainbow will be filled once vegetables are being eaten which shows they are doing something good. |
| When children are eating vegetables they will be rewarded through interactive feedback. | Yes & No | The rainbow will fill up once they start eating their vegetables, but it may not feel like a reward for children. |
| The animation on the table has some gamification or playification feature. | Yes | Since everyone at the table has their own rainbow and everyone is eating, things will constantly change in someone’s rainbow. There is always something to look at on the table. |
| The table provides bright ambient light in order to get children to eat healthier. | Yes | Once the rainbow starts to fill, the colors will get brighter. |
| Children should be able to choose between different vegetables. | Yes | There will be a plate with two different sort of vegetables on it. |
| The animation should be colorful and visually appealing to capture children’s attention and engage them in the eating process. | Yes | There will be the colors of the rainbow. |
| The animation should include interactive elements that encourage children to participate in the eating process. | No | When nothing is being eaten, nothing will happen. |
| The animation should be child-friendly. | Yes & No | The animation itself is child friendly. But since everyone on the table has their own rainbow, it can give children the feeling they are battling against their parents which can create a battle between them and children might feel sad when they ‘lose’. |

| | | | |
|--|---------|--------------|---|
| Children must easily understand the animation. | | Yes & No | Children will easily recognize the colors of the rainbow, but it might be hard to detect for children that the goal is to complete the rainbow. |
| Total: | 5 x Yes | 3 x Yes & No | 1 x No |

Table 2: Requirement overview Colorful Circle

4.4.2 Pick your color

Each person has two different transparent bowls or plates in front of them, under which two different colors are projected. The shape of the colors are chosen to be a circle since children feel most familiar with this shape. There are two different versions for this idea. The first idea is to project the color of the accompanying vegetables that are inside the bowl. So when there is broccoli inside a bowl, the color under the bowl becomes green, and when there is eggplant, the color becomes purple (Figure 18). As soon as a tray is eaten from, cheerful sparkles will appear to give positive feedback and signal to the children that they are doing something good (Figure 19).

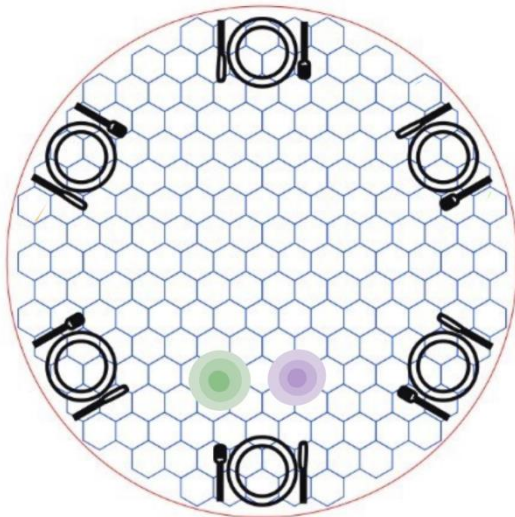


Figure 18: Beginning state Pick Your Color

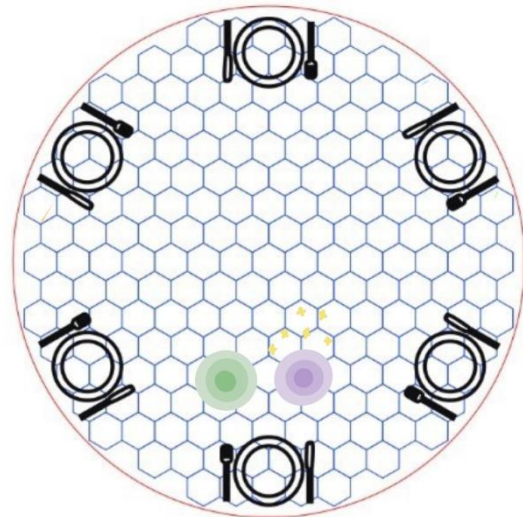


Figure 19: Shooting sparkles

This idea always provides the opportunity to choose between two different vegetables since background research had shown that this had a positive effect on vegetable intake. Below the trays, the colors are played in animations with the circle growing and shrinking each time. The colors always remain visible but become brighter and lighter to make the growth animation visible (Figure 20 and 21). By adding an animation and making sure that something is constantly moving, children's attention is captured and they will focus on the table.

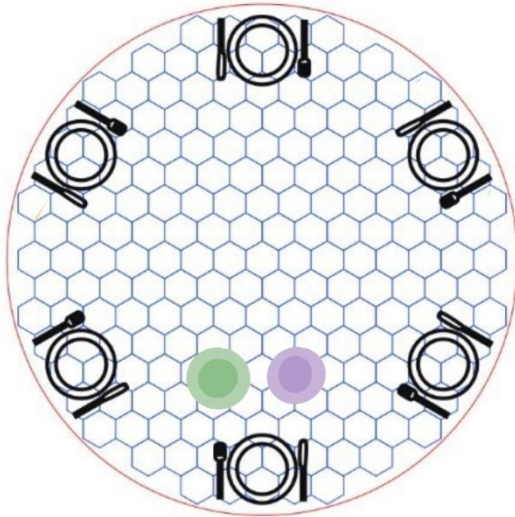


Figure 20: Growing animation 1

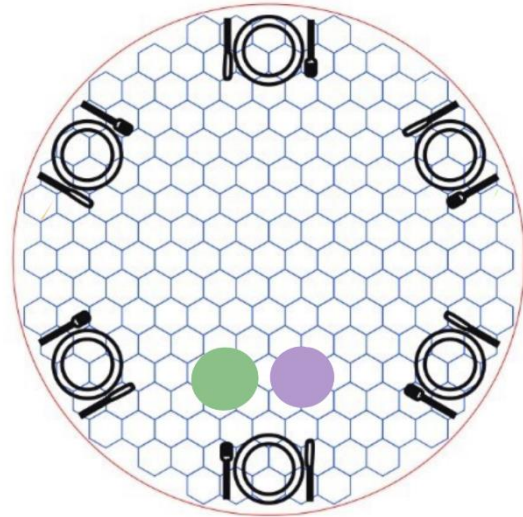


Figure 21: Growing animation 2

When it is detected that nothing is eaten at all or only vegetables are being eaten from one of the two bowls, different things will happen to the animations. If the table detects that only one bowl is being eaten from, the table would try to get the focus on the other bowl. This is done in three different ways. In the first way, the animation is stopped under the bowl that is eaten from and would continue under the one that is not eaten from (Figure 22 and 23). This draws the children's attention to the other bowl.

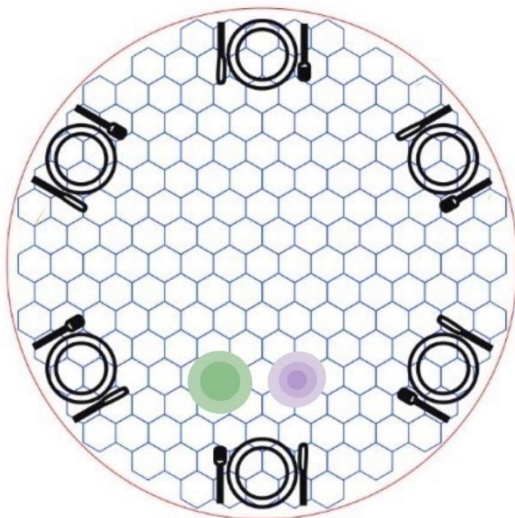


Figure 22: Growing animation green 1

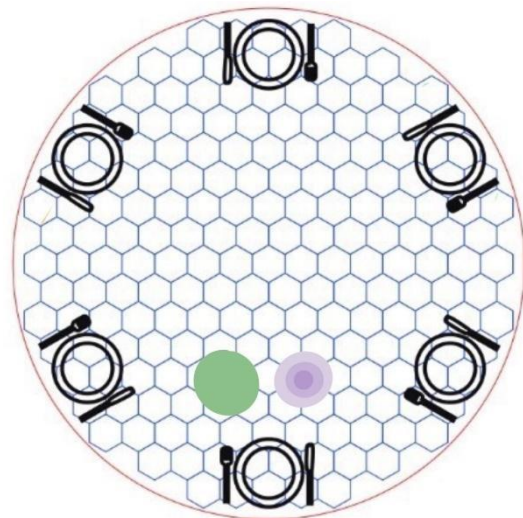


Figure 23: Growing animation green 2

If this first way still does not bring the desired effect, the brightness of the tray that does get eaten from goes down (Figure 24). Because the trays are transparent, the brightness of the light passes through them. By lowering the light on one tray, the other tray appears even brighter, and the study showed that children are attracted to bright light and eat more healthily as a result.

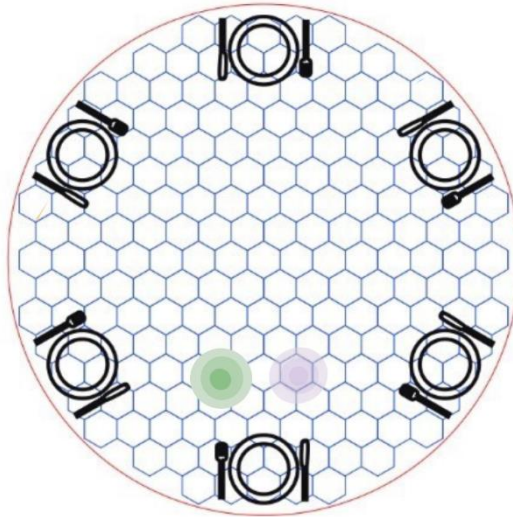


Figure 24: Lower the brightness of purple

The last way is to flip the colors under the bowls (Figure 25). The children may like one color more than the other and eat from that bowl because of this. By reversing the colors, the preferred color is projected under the less "tasty" bowl which may result in them starting to eat from the other bowl.

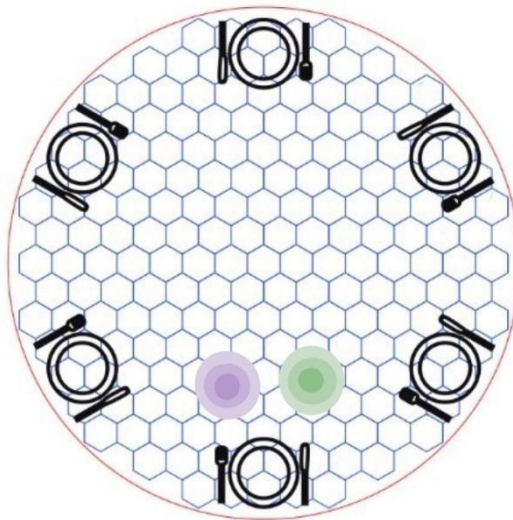


Figure 25: Flip colors under the bowls

| Requirement | Has been met? | Explanation |
|---|---------------|--|
| The animation needs to support children to eat vegetables. | No | The only thing that will happen is that sparkles will be shown once vegetables are being eaten. There is nothing else that indicates besides the sparkles that vegetables are being eaten. |
| When children are eating vegetables they will be rewarded through interactive feedback. | Yes | Once a vegetable is being eaten, sparkles will show in order to provide the positive feedback. |
| The animation on the table has some gamification or playification feature. | Yes | There is some playification, once they eat their vegetables, sparkles will be shown in order to engage the children. |

| | | | |
|--|----------|---|--------|
| The table provides bright ambient light in order to get children to eat healthier. | Yes | The closer their hand will get to the bowl, the brighter the light will be. They can play with this. | |
| Children should be able to choose between different vegetables. | No | They do have two different plates in front of them with two different sort of vegetables on it. But in this idea, their own choice is encouraged by getting the focus on the other vegetable than they actually want. Which therefore makes the idea of them being able to choose for themselves not applicable here. | |
| The animation should be colorful and visually appealing to capture children's attention and engage them in the eating process. | Yes | There will be different colors on the table. | |
| The animation should include interactive elements that encourage children to participate in the eating process. | Yes | Every time something is being eaten sparkles will show. And the animation of the circles that are growing underneath the plates is constantly happening to drag their attention to the table. | |
| The animation should be child-friendly. | Yes & No | It is child friendly, there is no competition going on. But it may not be completely child friendly since this animation will manipulate the freedom of choice of children. | |
| Children must easily understand the animation. | Yes & No | Children can understand that the sparkles mean something good. But it might be hard for children to understand that the animation want to get them to pick from the other plate. It may be already an accomplishment for them to even eat the vegetables. | |
| Total: | 5 x Yes | 2 x Yes & No | 2 x No |

Table 3: Requirement overview Pick Your Color

4.4.3 Conquer Lands

Everyone at the table starts with an even-sized field of their own color, their "country". The middle square is the winner's square, since everyone now has an even sized country it is a neutral color that no one has, red in this case (figure 26). By eating vegetables the table measures that the weight gets lighter and your land will get bigger by 'capturing' squares from neighbors making their squares smaller. The one who has the most squares at that time wins the middle square and it thus becomes that person's color. So the one who has the middle square (Figure 27), at the end of the meal, and thus has eaten the most vegetables, wins this time (green in this case).

This example focuses on gamification. As the background research showed, gamification can also help make learning more fun. Adding a winning element to this can encourage children to try harder to win. As a result, they become more motivated to actually eat the vegetables. At the end of the meal, you can see who won because the middle box is that person's color. To add to the positive effect, all the colors are in cheerful colors and the whole table would become the color of the winning person. This color would then be a bright color. Because the parents offer their children two different options of vegetables, the children have a choice in this and it feels to them like they have more freedom.

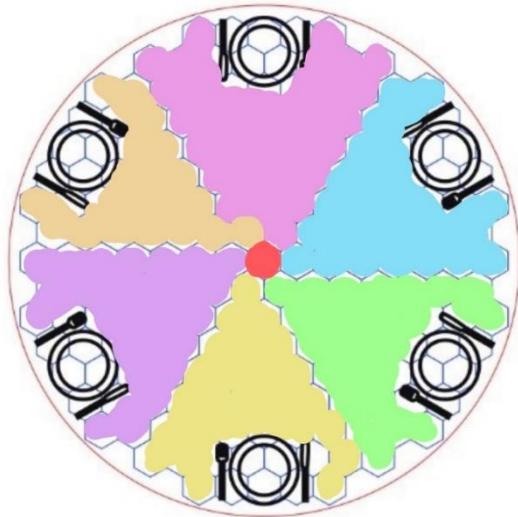


Figure 26: Conquer Lands start setup

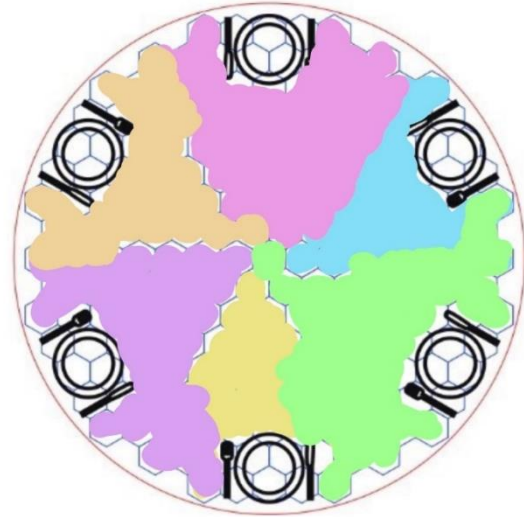


Figure 27: Conquer Lands game

| Requirement | Has been met? | Explanation |
|--|---------------|--|
| The animation needs to support children to eat vegetables. | Yes | The more vegetables are being eaten, the bigger the land. Therefore children want to eat vegetables. |
| When children are eating vegetables they will be rewarded through interactive feedback. | Yes | They will get more tiles in their color. |
| The animation on the table has some gamification or playification feature. | Yes | There is some playification in the idea. |
| The table provides bright ambient light in order to get children to eat healthier. | Yes & No | The colors will be in bright light, but the brightness of the color will not change during this idea. Therefore it won't have an effect. |
| Children should be able to choose between different vegetables. | Yes | There will be a plate with two different sort of vegetables on it. |
| The animation should be colorful and visually appealing to capture children's attention and engage them in the eating process. | Yes | There are bright colors on the table. |
| The animation should include interactive elements that encourage children to participate in the eating process. | No | When nothing is being eaten, nothing will happen to drag the attention of the children to the table. |
| The animation should be child-friendly. | No | They are competing against their parents, which may not be fair. |
| Children must easily understand the animation. | No | It might be hard for children to understand that they need to get as much tiles as possible. |
| Total: | 5 x Yes | 1 x Yes & No |
| | | 3 x No |

Table 4: Requirement overview Conquer Lands

4.4.4 Bouncing balls

There are two versions of this idea. The first one is that once eaten from the plate with vegetables on it, balls will appear on the table, these balls will just fly around in a random direction. The more eaten from

the plate, the more balls will appear (Figure 28). If no food is eaten from the plate for a while, the balls will also disappear.

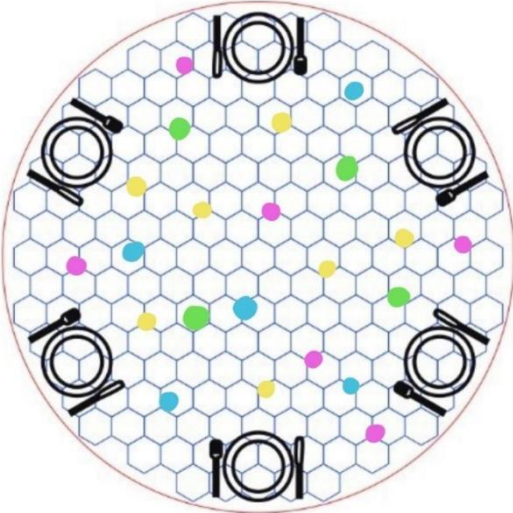


Figure 28: Bouncing Balls game 1

Children will enjoy watching this because the different balls also bounce against each other and there is a lot to see while eating. A variation on this interaction could be that once the balls bounce against each other that they form a bigger ball together, hopefully at the end of the meal there is 1 big ball that fills the whole table and thus the meal is successful because enough vegetables have been eaten.

The second version of this game will be that every person has their own colors and therefore their own balls (Figure 29). The more a person eats, the more balls in their color will appear on the table (Figure 30).

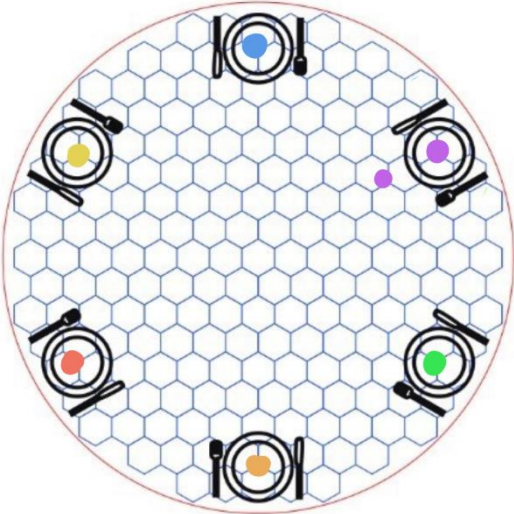


Figure 29: Bouncing Balls game 2

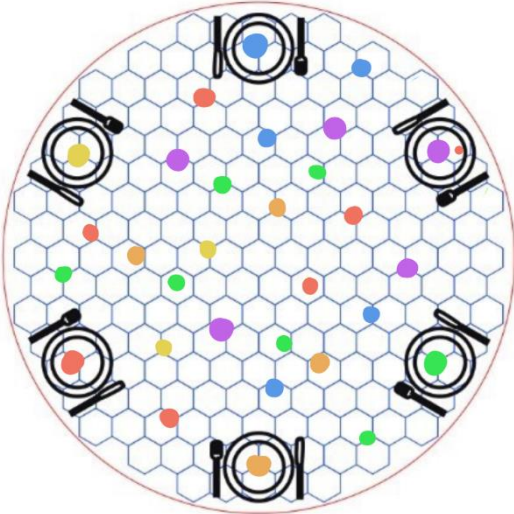


Figure 30: Everyone has their own color

The balls are shot in a random direction as soon as something is eaten and will then fly around on the table and collide with the other balls (Figure 31).

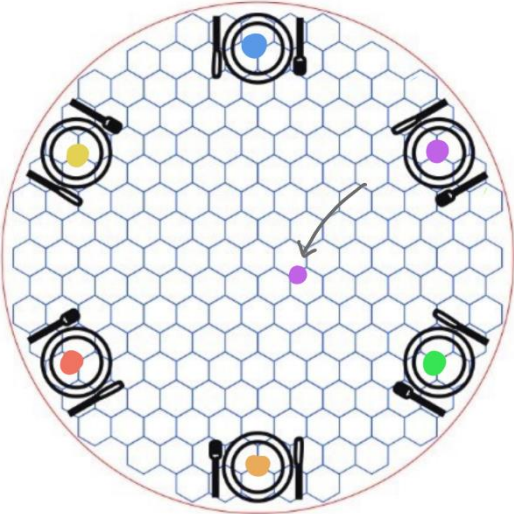


Figure 31: Balls shot

When no vegetables are being eaten for a long time, the balls will gradually disappear and the field becomes empty (Figure 32).

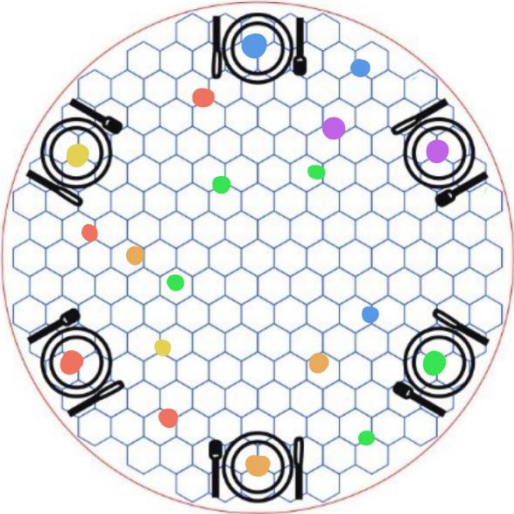


Figure 32: Balls disappear

This idea shows an example of playification rather than gamification. The children cannot win or lose the game; they can only have fun. Because they can watch moving balls while eating their vegetables, they are distracted from everything else and will have fun while eating. They will start to have a fun association to eating vegetables because of this. However, gamification can be made of it. This can be done in several ways. The one who has collected the most balls at the end of the meal then wins. The table will then become that full color to make this clear. Another idea could be that the more eaten, the bigger that person's ball gets. The one with the biggest ball at the end of the meal wins the game.

| Requirement | Has been met? | Explanation | |
|--|---------------|--|--------|
| The animation needs to support children to eat vegetables. | No | It does not support children to eat more vegetables since not a lot is happening besides some balls that are floating. | |
| When children are eating vegetables they will be rewarded through interactive feedback. | Yes | They will be rewarded by showing balls once vegetables are being eaten. | |
| The animation on the table has some gamification or playification feature. | Yes | The balls will bounce around and they can watch this happen. | |
| The table provides bright ambient light in order to get children to eat healthier. | No | The balls will be in bright light, but this won't have any effect on their eating habits. | |
| Children should be able to choose between different vegetables. | Yes | There will be a plate with two different sort of vegetables on it. | |
| The animation should be colorful and visually appealing to capture children's attention and engage them in the eating process. | Yes | There will be different colors on the table for every person. | |
| The animation should include interactive elements that encourage children to participate in the eating process. | Yes | Every time something is being eaten a ball will be shot. | |
| The animation should be child-friendly. | Yes & No | The first one is child friendly. But the second version is more of a game and children are battling against their parents the second version isn't as child friendly as the first. | |
| Children must easily understand the animation. | No | It is easy for children to understand, but it may be hard to detect how many balls everyone has. They will just like watching the balls but may have no clue what the idea is. | |
| Total: | 5 x Yes | 1 x Yes & No | 3 x No |

Table 5: Requirement overview Bouncing Balls

4.5 Final idea

To arrive at the final design, we looked at which idea best met the requirements. In table 6 you can see an overview of how many requirements were met in every idea.

| Idea | Yes | Yes & No | No |
|-----------------|-----|----------|----|
| Colorful circle | 5 | 3 | 1 |
| Pick your color | 5 | 2 | 2 |
| Conquer lands | 5 | 1 | 3 |
| Bouncing balls | 5 | 1 | 3 |

Table 6: Requirement overview

All of the ideas meet 5 requirements, but Colorful circle and Pick your color both have the least ‘No’s’ and are therefore the two best options. Also, a few of the requirements that are not met at colorful circle are actually met at pick your color. Therefore the two ideas were combined together to come to a final concept.

4.5.1 The process of the final idea

Since the ‘colorful circle’ concept was the best idea according to the requirements, it was chosen as the foundational basis for the final concept. To also meet the requirements that were not fulfilled by the initial idea, the second-best concept, ‘Pick your color’ was also examined.

The first requirement that was not met was ‘when children are eating vegetables they will be rewarded through interactive feedback’. Filling the rainbow didn’t feel like enough feedback for children to eat more vegetables. Therefore the decision of using sparkles from the ‘pick your color’ idea were chosen. By implementing sparkles children will get a better understanding that they are doing something good when they will eat their vegetables. To make the children even more aware that it is important to eat vegetables, negative feedback can also be used. If nothing is eaten from the bowl of vegetables for a long time, the color under this bowl will blink harder and may eventually change color to make it even clearer that vegetables should be eaten.

The second requirement that was not met was ‘the animation should include interactive elements that encourage children to participate in the eating process’. If nothing is being eaten for a while, nothing will happen on the table with the rainbows and the children will get easily distracted. Therefore the use of the colorful circles with the growing and shrinking animation underneath the plate with vegetables on it from the ‘pick your color’ idea was chosen. The use of a circle underneath a plate that is constantly growing and therefore there is constantly something happening will drag the attention from the children and therefore their focus will stay on the table and not on the surroundings. The difference with the original idea is that there is only one circle in front of everyone instead of two. On this circle a plate will be placed with two different kind of vegetables on it. This was chosen because with the original idea you take away the aspect with children having a choice in the vegetable they want to choose by manipulating it to focus on the other plate. By putting the vegetables on one plate with one circle they will always eat from this circle and thus always have their own choice of which vegetable they want to eat, without manipulating their choice.

The third requirement that was not met was ‘the animation should be child-friendly’. The general idea was that everyone at the table would get their own rainbow that they needed to fill, only this causes competition to take place at the table and the child is disadvantaged because they generally eat less and would never win because of this. This is contrary to the very idea of letting children leave the table with a positive feeling. To solve this problem, one large rainbow is projected in the middle of the table where

everyone works together to make it full to promote cooperation rather than competition. The table also begins by projecting the rainbow in dull light, and the more vegetables eaten the brighter the rainbow becomes. The aspect of the rainbow was still chosen to provide a clear goal during the meal, where the objective is to fill the rainbow completely.

The fourth, and final, requirement that was not met was ‘Children must easily understand the animation’. By providing both feedback through the shooting sparkles and the rainbow that will fill up once they start to eat their vegetables it will hopefully be made clear enough to the children that the goal is that they will eat more vegetables. Since there now is only one rainbow where both child and parent will be working together on to fill it, the child can also copy what their parent is doing in order for them to completely understand it.

4.5.2 Colorful Growth

To summarize, the final concept that emerged from combining the ‘Colorful Circle’ and ‘Pick Your Color’ ideas is called ‘Colorful Growth’ (Figure 33).

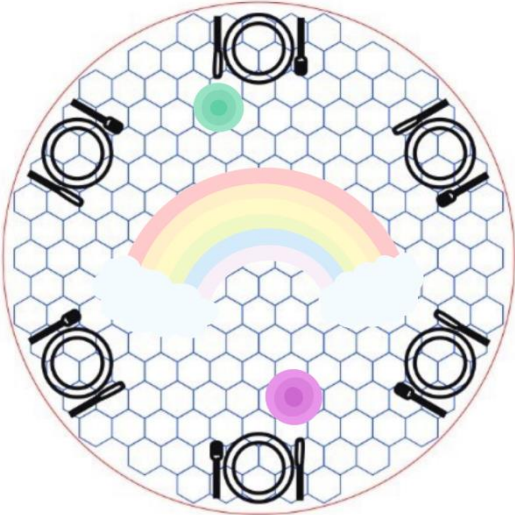


Figure 33: Colorful Growth

There will be one rainbow in the middle of the table that will be shown in a dull color when the diner begins. Everyone will have one plate in front of them with their general meal, and one with their vegetables on it. Underneath the plates with the vegetables on it there will be a growing circle to bring the children’s attention to the table and especially to that plate (Figure 34 and 35).

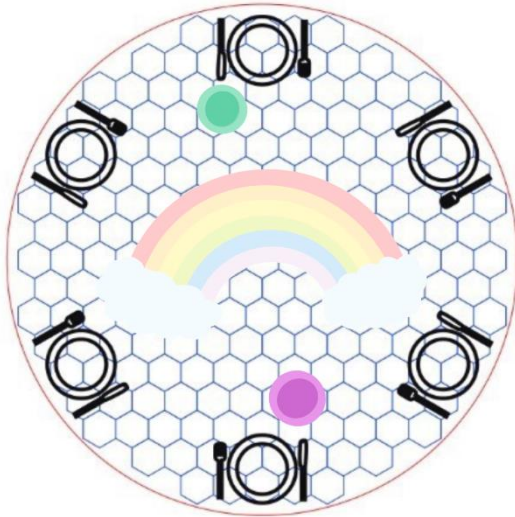


Figure 34: Growing circles 1

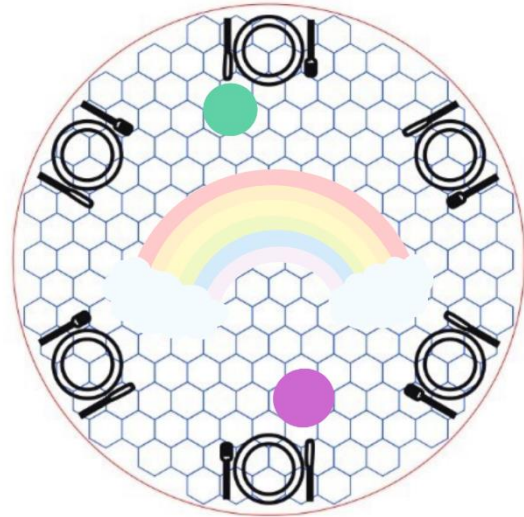


Figure 35: Growing circles 2

Once a vegetable is being eaten, sparkles will be "shot" from the plate with the vegetables on it to the rainbow and the rainbow would be filled piece by piece. Each time a bite is taken a piece is added (Figure 36 and 37).

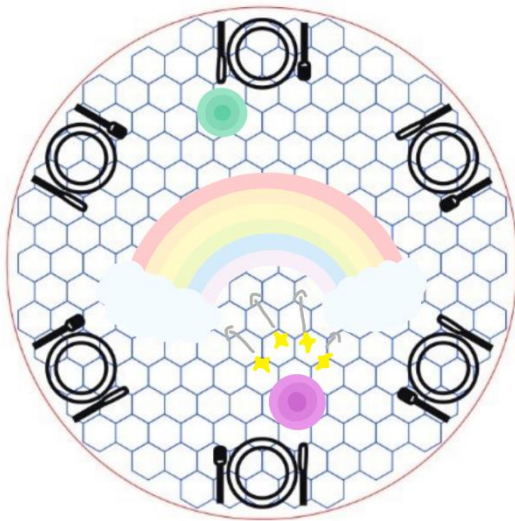


Figure 36: Shooting sparkles

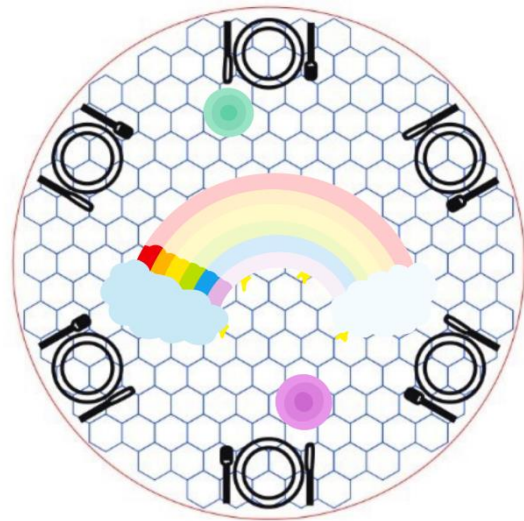


Figure 37: Filling rainbow

When vegetables are not eaten for a long time, the color flashes faster and eventually changes to a red color (Figure 38).

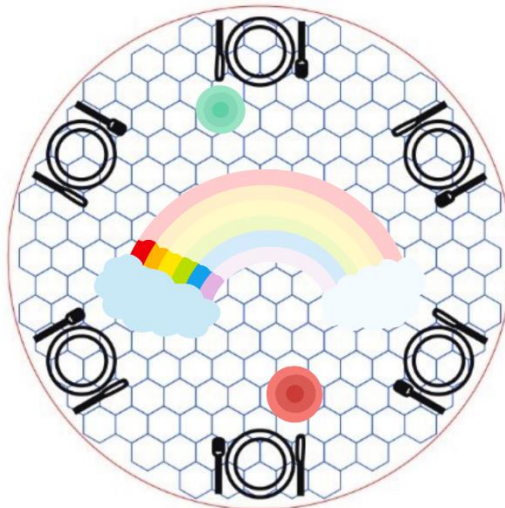


Figure 38: Changing color to red

As more vegetables are eaten, the rainbow becomes increasingly filled (Figure 39). When enough vegetables have been eaten, the rainbow is completely full and an end animation is played (Figure 40).

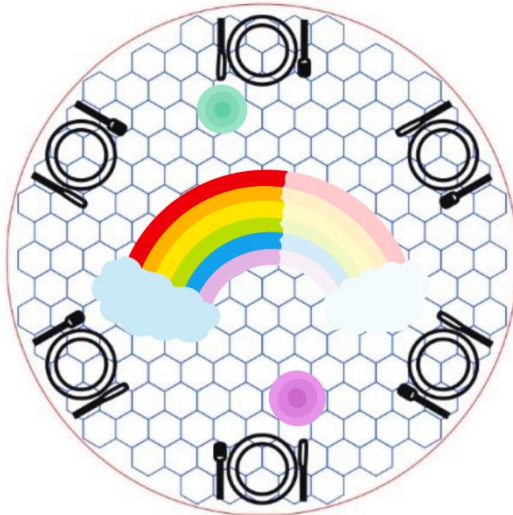


Figure 39: Filling the rainbow



Figure 40: End animation

The only requirement that was hard to fulfill with the animation on the interactive diner table is ‘Children must easily understand the animation’. In order to also succeed this requirement, parents will be able to help their children to recognize what is happening and therefore letting their children understand the animation by cooperating an authoritative parenting style. Since the authoritative parenting style has showed an increased vegetable intake among children, parents are asked to adopt this parenting style during the experiment. Parents need to be both responsive and demanding.

5. Specification

During the specification phase, the final idea generated in the ideation phase, as described above, will be further developed by specifying the functional requirements. This phase aims to finalize the requirements outlined in the ideation chapter, providing more detailed information about the final concept. By the end of this phase, the final requirements for the interactive diner table will be established. The success-rate of these requirements will be discussed in chapter 7.

5.1 Functional requirements

Functional requirements describe the specific features and functionalities that the interactive diner table must possess in order to fulfill its intended purpose. The requirements are categorized using the MoSCoW method, indicating the priority of each requirement: Must have, Should have, Could have, or Won't have.

5.1.1 Must Have

These requirements are critical and must be fulfilled for the interactive diner table to be considered successful.

- Two or three participants must be able to eat at the same time.
- The interactive diner table must present a circle under the plates with the vegetables on it in front of both the child and the parent.
- The table must include a constant animation underneath the plates in order to get the attention of the children.
- A rainbow must be positioned at the center of the table.
- Once the child eats a bite of its vegetables, the shooting sparkles must be triggered in order to give positive feedback.
- Once the child eats a bite of its vegetables, the rainbow must fill up by piece by piece with brighter colors
- The interactive dining table should have elements that can be clearly understood by children aged 4.

5.1.2 Should have

These requirements are important for the overall effectiveness and user experience of the interactive diner table.

- The table should provide a gamified or playful element to engage children and encourage their participation in the eating process.

- Bright ambient lighting should be integrated into the table design to create a visually appealing and inviting atmosphere, promoting healthier eating habits.
- Children should be able to choose between different vegetables.
- The interactive animation should be colorful and visually attractive.

5.1.3 Could have

There are no could have requirements for this experiment.

5.1.4 Won't Have

These requirements are explicitly not included in this research with the sensory interactive diner table, either because they are not feasible or because they conflict with the main objectives of the project.

- The table won't have any integrated audio or sound effects as part of the interactive animation.

5.2 Non-Functional Requirements

Non-functional requirements define the qualities and characteristics that the interactive diner table should possess, ensuring that it meets certain standards of performance, usability, and aesthetics.

- The interactive animation should be user-friendly.
- It must be easily understood what is displayed on the table.
- The system must react quickly to the user interaction.
- The system must be easily controlled.

6. Realisation

After the specification and the ideation phases, a final concept with defined requirements was created to proceed with the realisation of the ultimate prototype. During the realisation phase, the prototype is made, tested and improved until it satisfies all needs and standards.

6.1 Method of realisation

To realize the final prototype, Unity and procreate were used. Unity was used to run the animations on the table. Unity is a game engine and development tool used for creating interactive experiences, including video games, VR applications, AR applications and simulations. The table was already fully programmed in Unity so that the animations would work on the real table, leaving only the need to create an own animation. Procreate was used in combination with an Ipad and an Apple Pencil to make drawings that would be implemented in the animations.

6.2 ProCreate

In order to show a rainbow on the table, it was chosen to draw the rainbow itself in ProCreate. The steps made from filling the rainbow were all drawn in advance in this program so that they could be easily animated in unity.

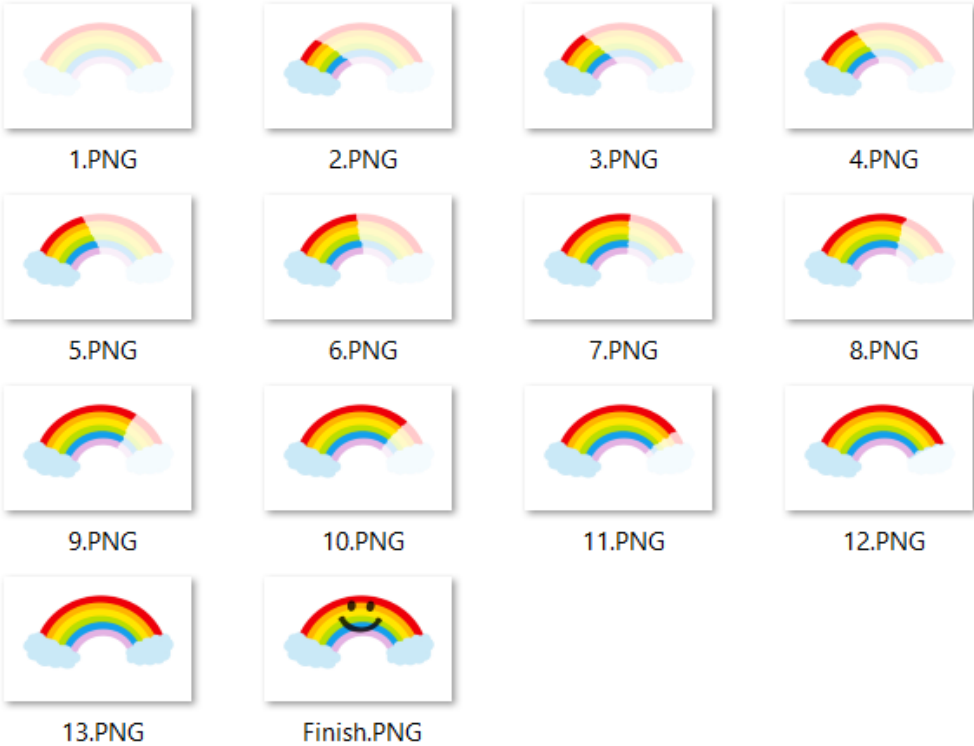


Figure 41: Rainbows in ProCreate

6.3 Unity

As already explained, the table was already made in Unity (Figure 42). The table consists of 199 hex modules with each 43 LEDs in it. By selecting those modules you could easily change their colors to the preferred color (Figure 43).

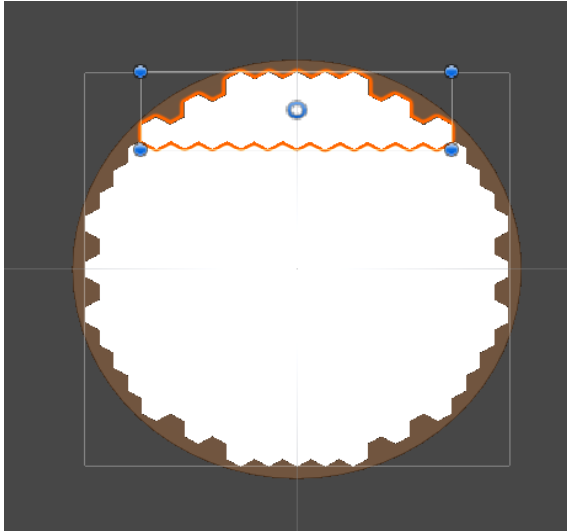


Figure 42: Table in Unity

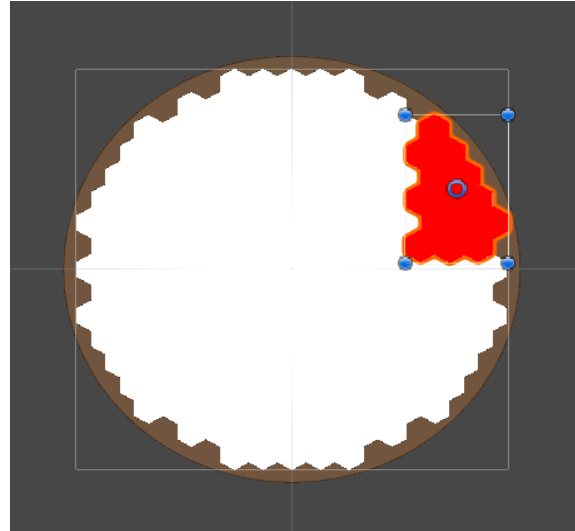


Figure 43: Change color of the modules

For the animation of ‘Colorful Growth’ no individual hexagons had to be adjusted to the desired color. Instead objects and images will be placed on the table in order to show the right animations.

6.3.1 Growing circles

For the growing circles, two or three circles were placed on the table. These circles were selected from the assets folder of the table and their colors were adjusted to the preferred colors, pink and green and blue (Figure 44 and 45). Two versions were created in order to give the participants a choice in how many people they wanted to come with.

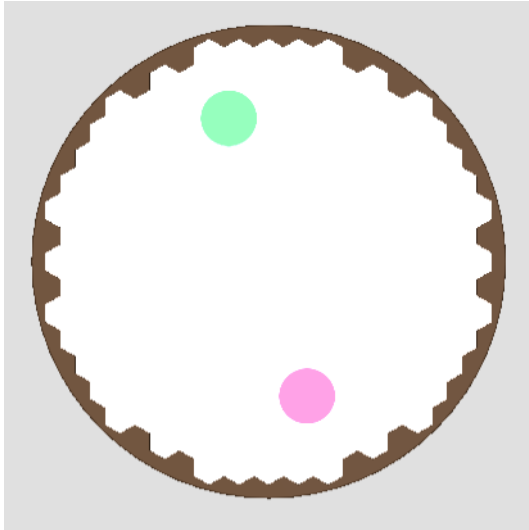


Figure 44: Pink and green circles

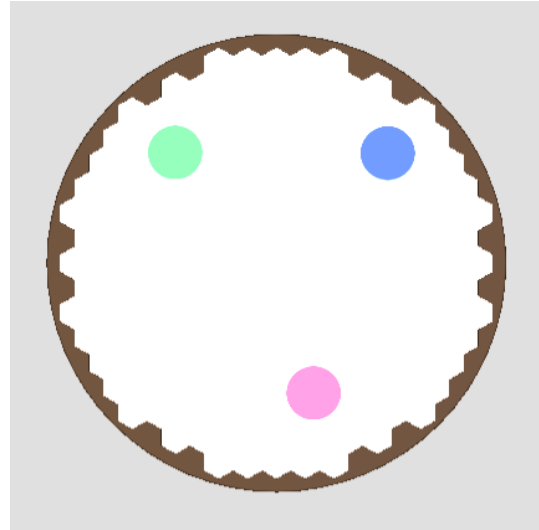


Figure 45: Pink, green and blue circles

Both circles have independently 6 different sorts of animations which can be changed by manually clicking the corresponding key since the loads cells were not working yet. How those animations can be triggered together with their corresponding keys can be found in Appendix A.

6.3.2 Growing Rainbow

For the rainbow, one rainbow was placed in the middle of the table. As you can see in figure 46, the rainbow will be shown in a dull color in the beginning of the diner.



Figure 46: Beginning status of the rainbow



Figure 47: Ending status of the rainbow

Once a bite is taken of the vegetable, the rainbow would be filled step by step, resulting in a full bright rainbow at the end (Figure 47). These steps can already been seen in Figure 41. How the animations work and how they will be triggered can be found in Appendix B.

6.3.3 Shooting Sparkles

Lastly the stars needed to be animated which will be shown once a vegetable is being eaten. The stars are constantly stored underneath their colorful circles (Figure 48). Once a bite is taken, the stars will appear from behind the circle and they will be shot in the direction of the rainbow (Figure 49). How these animations are triggered and more details about the animation can be found in Appendix C.

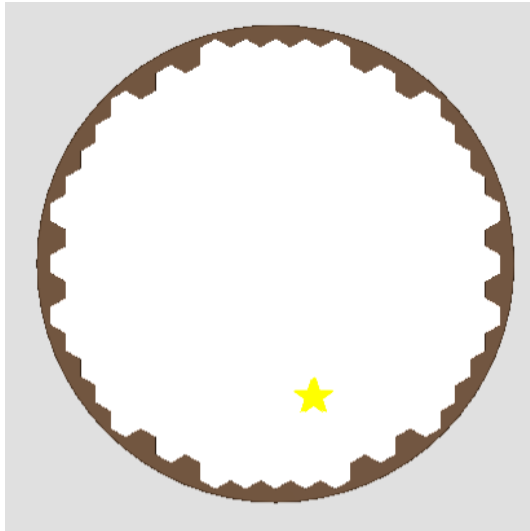


Figure 48: Stars that are stored underneath pink

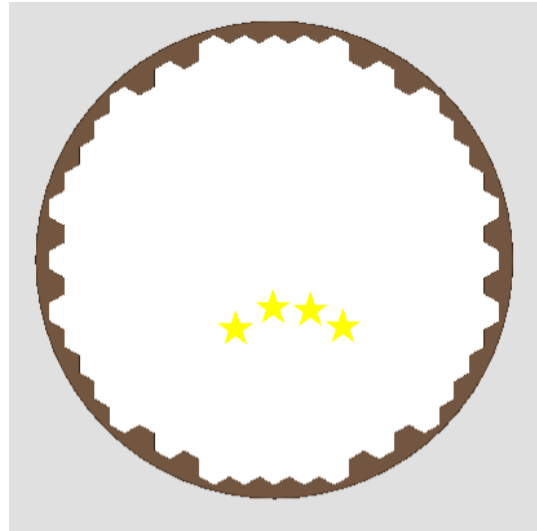


Figure 49: Stars that are shot from pink

6.3.4 Colorful Growth

By combining the growing circles animations, the rainbow animations and the shooting stars animation, the final animation of ‘Colorful Growth’ was made (Figure 50, 51 and 52). A choice was made to have the rainbow for one circle properly projected in the right direction. At this circle the child would take a seat so that it is most clearly recognizable to the child that this is a rainbow and so that they do not have to see it upside down.



Figure 50: Two person Colorful Growth



Figure 51: Three persons Colorful Growth



Figure 52: Real setup of Colorful Growth on the SIT

The keys that were used to trigger all the animations can be found in Figure 53. The explanation of these keys can be found in Appendix A, B and C.



Figure 53: Keys to trigger the animations

7. Evaluation

After the realisation, the evaluation phase with the user tests was conducted. This chapter will look into the experiment, the preparations before the experiment, if the requirements were met and the results of the user tests in order to give a solution to the research question

7.1 Participants

The final sample of participants consisted of a total of 4 parents who wanted to participate with 1 child, and 1 parent who wanted to participate with 2 children, making a total of 6 children and a total of 5 experiments.

The selection of participants for this study aimed to include parents and their children in the age range of 3-5. The only inclusion criteria was that the parents needed at least one child in the specific age range to be able to participate together in the experiment. Participants were found by asking around among acquaintances who might know people who want to participate in the experiment. Contact was then made between the interested parents and the researcher. The parents were provided with detailed information about the study, including its purpose, procedures and potential benefits.

| Participant ID | Age | Gender | Test number |
|----------------|-----|--------|-------------|
| 1 | 5 | Male | 1 |
| 2 | 5 | Female | 2 |
| 3 | 3 | Female | 3 |
| 4 | 4 | Male | 4 |
| 5 | 5 | Male | 4 |
| 6 | 5 | Female | 5 |

Table 7: Demographic characteristics of participants

7.2 Materials

The materials used for this experiment were the following:

- Laptop running with the Unity program on it
- The Sensory Interactive Diner Table (SIT)
- Video camera mounted above the SIT
- Plates, cutlery, glasses (etc.)
- Food
- Wireless keyboard

7.3 Procedure

7.3.1 Overview of user tests

The purpose of the user test was to observe and evaluate how the animation on the interactive diner table affected the amount of vegetables consumed by children. Parents had been sent some final information prior to the visit about the parenting style they were expected to adopt during this experiment. This information was sent to the parents in advance so they could read it quietly at home rather than having to do it on the spot with their children present. This file with the information can be found in Appendix D. Questions about this file could be asked over text.

Before the user test, the meal had to be prepared (Figure 54) and the table had to be set (Figure 55). As you can see in the picture, for the meal it was chosen to do ‘aardappels groente vlees’ as we call it in the Netherlands. It means potatoes, vegetables and meat and it is quite a basic meal which most of the Dutch families are familiar with. As you can see in the picture below, two different sort of vegetables were placed on a see through plate above the colorful circle and on their normal plate they got some baked potatoes and some meat.



Figure 54: The meal that is being prepared

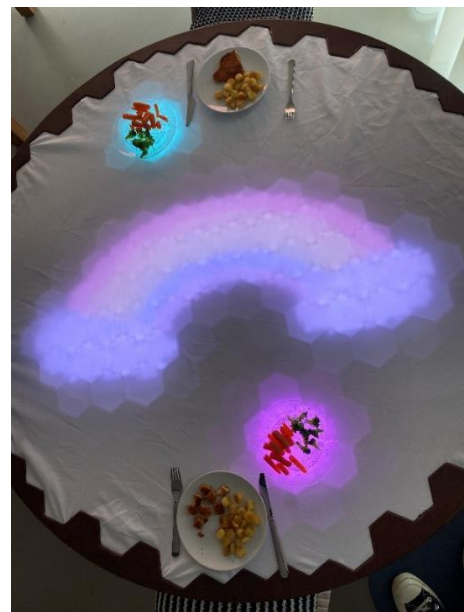


Figure 55: Set up of the table with the food

During the user test during, the researcher took a seat in the observation room located above the room in which the experiment with the SIT took place after the information form (Appendix E) was given, the consent forms (Appendix F) were signed and the final explanation was given. The researcher could watch the room through the video camera that was mounted above the SIT, but the participants could not see the researcher (Figure 56).



Figure 56: Overview of observation room

During the user test, the researcher closely examined the live camera footage to ensure that the necessary animations could be triggered at the right moment. As soon as a bite of the vegetable was placed in the mouth of either the child or the parent, the animation of shooting sparkles appeared at the respective plate, rainbow was filled step by step until the rainbow was completely filled and the final animation started playing (Figure 57). The complete step-by-step procedure of the user tests can be found in Appendix G.



Figure 57: Final animation

7.3.2 Interview procedure

Interviews were conducted during the user tests to gather qualitative insights and feedback directly from the participants, allowing for a deeper understanding of their perceptions, experiences and thoughts related to the experiment.

Pre-experiment interview questions with parents

This interview attempted to acquire preliminary data on their child's eating preferences, routines and any particular obstacles they encountered when it came to vegetable consumption.

1. How would you describe your child's eating habits when it comes to eating vegetables?
2. What are some challenges you encounter while trying to get your child to eat vegetables? Are there specific reasons why your child is reluctant to eat vegetables?
3. Have you previously tried methods or strategies to get your child to eat more vegetables? If so, which ones and what was the result?
4. Do you think an interactive dining table with an animation can help your child eat more vegetables? Why do you think so?

Post-experiment interview questions with children

This interview aims to elicit comments and insights into the meal intervention experience, the child's reaction to the meal and the animations and any noteworthy experiment-related findings. Parents were also invited to express their ideas for future interventions.

1. What did you think of the interactive diner table and the animation, did you like it?
2. What did you like the most about the table?
3. Did you like the food?
4. Would you like to eat at this table more often?

Post-experiment interview questions with parents

1. Did you notice any changes in your child's eating behavior during the experiment? If so, what changes were they? Was there an increase in the consumption of vegetables? And if so, to what extent?
2. Were there any challenges during the experiment? If yes, which ones? And how did you try to deal with them?
3. Do you think the interactive dining table and animation can have a lasting effect on your child's eating behavior in the long run? Why or why not?
4. What were your overall impressions of the interactive dining table and animation? Did you find it helpful and effective in promoting your child's vegetable intake? Why or why not?
5. In general, how does your child feel about the vegetables that were presented now? Does he always find it difficult to eat these?

7.4 Data analysis

To see the final results of user testing, a data analysis must be done. For this experiment, both qualitative and quantitative data analysis was done. During the experiment, observations were made of the child's behavior at the table with the use of the installed video camera above the table and an interview took place both before and after the experiment. After the experiment, the video footage was watched back, the interviews were written out and a data analysis was done. The written out interviews can be found in Appendix H. For the interviews a qualitative data analysis method was done, the thematic analysis. This involves identifying patterns and themes in textual data in order to give a better insight of the results of the user tests. For the video footage an observation chart was created which was filled in after the experiment. These observation charts of every user test can be found in Appendix I. The charts consist of who took a bite of their vegetable at what time, and what the reactions were when vegetables were being eaten and the animation was shown. The findings in these charts were combined with the results of the interviews, enriching the identified themes with findings during the observations.

7.4.1 Results of the data

The first, and probably most important result, was that there was an **increased amount of vegetable consumption** among a majority of children according to the parents. No measurements were made of those children eating their vegetables without the use of the SIT, therefore the opinions of the parents are leading. All parents mentioned that their children didn't like to eat vegetables normally when they are at home. During the experiment 4 out of 6 children completely finished their plates and 4 out of 5 parents noticed a positive change in their behavior regarding their vegetable consumption. Although 2 of the 6 did not empty their plates, their parents said it was a big step even for their children to eat vegetables at all. And the fact that their child had therefore tasted a vegetable by itself was already a very big improvement for them.

Enjoyment of the Table: In all the interviews, so 6 out of 6 children, the children expressed a positive attitude toward the table with animations. They found it enjoyable and expressed a desire to eat at such a table more often. During the observation of user test 4, comments such as "this is so cool," "I want this table at home" were made by the child during the meal indicating that he really enjoyed the experience. Even the children who did not eat their plates empty during the user test indicated that they did enjoy eating at the table. When the question "would you like to eat at this table again?" was asked to the child in user test 3, that did not finish her plate, the response was a very enthusiastic "yes" accompanied by a big smile on her face. The vibrant colors, the rainbow filling up, and the stars caught their attention and motivated 4 out of 6 to continue eating.

Motivation through Goal-Oriented Gameplay: The animations on the table, particularly the rainbow filling up and the stars, served as a goal for 4 out of 6 children. They felt motivated to eat their vegetables

in order to complete the rainbow or see more stars. This goal-oriented gameplay element seemed to positively influence their eating behavior. For example, during user test 1 the comment "It is just like a game!" was made by the child and during user test 4 the comment was made "You have to eat quicker mom, we have to fill the rainbow" by one of the sons. Also, during user test 4 it could be seen that they really turned it into a game because they did not want to lose, and because of this they continued eating as fast as possible.

Negotiation Tactics: In the other 2 user tests, children were observed using negotiation tactics to influence their parents' eating behavior. They attempted to persuade their parents to eat vegetables by emphasizing the importance of filling the rainbow. It was clear to them that there was a goal, but this goal was not compelling enough for them to become motivated to eat their own vegetables. However, they were interested in completing the rainbow, so they were attempting to encourage their parents to eat their vegetables. In total there were 3 out of 6 children that tried to negotiate with their parents. The child in user test 5 was motivated to complete the rainbow by eating her vegetables, but she also tried to negotiate with her mother. During the observations it can be seen that the daughter keeps playfully trying to convince her mother to participate in eating her vegetables. When the mother showed that nothing happens if she ate a vegetable from the plate of her daughter, the daughter realized that she had to do it herself and she continued to eat her vegetables.

Parental influence: During the observations it was clear that the parents had a big influence on their children's eating behavior. The parents were always the ones that needed to take the first bite in order for their children to follow. At first this happened by 5 out of 6 children. All parents took the first bite and once the parents were able to show that something would happen if they ate their vegetables, the 5 children also wanted something to happen at their plate and therefore they started trying vegetables as well. The effect only lasted with 4 out of 6 children. Those 4 children were engaged by their parents during the whole meal. After the child in user test 1 tends to lose interest and does not want to continue eating his carrots, the father tries to help by saying "Let's do the last part of the rainbow together". This motivates the child enough to eat the last bite and fill the rainbow completely. One child was not entertained from the beginning on because of the stars her father saw, but the other child lost her interest and her mother was not able to get her child to eat vegetables any more. In the observation of user test 2 it can be seen that the son starts to take a bite because he saw the stars his mother got when his mother took a bite from her vegetables. It was evident that this was indeed the reason he started eating vegetables.

7.5 Functional and Non-Functional requirements results

| Functional requirements | Met or not? |
|---|---------------|
| Must have | |
| Two or three participants must be able to eat at the same time. | Met |
| The interactive diner table must present a circle under the plates with the vegetables on it in front of both the child and the parent. | Met |
| The table must include a constant animation underneath the plates in order to get the attention of the children. | Met |
| A rainbow must be positioned at the center of the table. | Met |
| Once the child eats a bite of its vegetables, the shooting sparkles must be triggered in order to give positive feedback. | Met |
| Once the child eats a bite of its vegetables, the rainbow must fill up by piece by piece with brighter colors | Met |
| The interactive dining table should have elements that can be clearly understood by children aged 4. | Partially met |
| Should have | |
| The table should provide a gamified or playful element to engage children and encourage their participation in the eating process. | Met |
| Bright ambient lighting should be integrated into the table design to create a visually appealing and inviting atmosphere, promoting healthier eating habits. | Met |
| Children should be able to choose between different vegetables. | Met |
| The interactive animation should be colorful and visually attractive. | Met |
| Non-Functional requirements | |
| The interactive animation should be user-friendly. | Met |
| It must be easily understood what is displayed on the table. | Met |
| The system must react quickly to the user interaction. | Met |
| The system must be easily controlled. | Met |

Table 8: Requirement results

After the user tests this table could be filled in and it can be seen that all the requirements except 1 were met as shown above in Table 8. Because it was not entirely clear to some children at the beginning when the stars came, the requirement "The interactive dining table should have elements that can be clearly understood by children aged 4." is partially met.

8. Discussion

The findings of this study provide valuable insights into the development of an interactive dining table application aimed at promoting vegetable consumption among 4-year-old children. The results revealed a positive impact on vegetable intake, aligning with the research question of **to what extent can an application on the interactive diner table be used to help to encourage children to eat more vegetables at the age of 4**. Since the results revealed a positive impact on the vegetable intake we can say that it is possible to design an application for the interactive diner table that can encourage children to eat more vegetables at the age of 4. However, it is difficult to know to what extent this is since no control group was used. For example, no 0 measurement was used in this experiment, so only the parents' opinions can be relied upon and not the children's actual vegetable intake. For further research it is important that this 0 measurement is done without the animation on the table to see how much vegetables the children actually consume during a normal meal.

One interesting finding was the influence of parents on children's vegetable consumption. Although the initial focus was on the interactive features of the dining table, it became clear during the user tests that the presence and behavior of parents had a substantial effect on the children's eating habits. Children were more likely to eat vegetables when they observed their parents eating them and receiving stars. This observation emphasizes the crucial role parents play in shaping their children's dietary behaviors and highlights the importance of parental modeling. That parents had a crucial role in their children eating habits was already discussed during the factors that can influence children their eating behaviors in 2.2. Children often like to copy what their parents are doing. If their parents are not eating any vegetables they will also refuse it, and if their parents are eating vegetables and get rewarded for eating them children are willing to try them as well [46]. Parents and children influence and respond to each other's eating behavior.

Furthermore, the emergence of the goal element in the form of filling the rainbow demonstrated an unexpected but notable impact on the children's motivation to consume vegetables. While the original requirements did not explicitly include a goal-oriented aspect, the children's engagement and enthusiasm were clearly heightened by the objective of completing the rainbow. This finding suggests that incorporating a goal or achievement element into the interactive dining table tool can enhance children's motivation and promote greater vegetable intake. This could also be found in some of the existing technologies that were researched during the background research. When playing the Yummytricks game children were more motivated to play it repeatedly because they were motivated to win the game [25]. Also the game Hungry Panda had a significance influence on the vegetable intake among children because of their goal element [4]. Children wanted to continue eating their vegetables because they wanted to receive as much points as possible to get a more impressive animation in the game.

Also the animation of the red circle when not enough vegetables were being eaten didn't work. The animation had to be used during 3 experiments. One Child mentioned that he didn't even notice his color changing, and the other 2 children mentioned that they didn't feel like eating more vegetables when their color changed to red. They didn't want to eat vegetables anymore at all because of this. Therefore the use of negative feedback in this case didn't work. Although this was not found during the background research, it turns out that the brains of children aged 4-6 tend to respond more to positive feedback than to negative feedback [47]. This was reflected in increased electrical activity in the brain and an intrinsic increase in motivation with positive feedback. For future research it would be interesting to see if there are things that do work in order to get the children to eat more vegetables when they don't want to eat them initially. If there is something that does trigger them to try and eat more vegetables.

8.1 Limitations

It is important to acknowledge the limitations of this study. The study focused on short-term effects, and it remains unknown whether the observed positive changes in vegetable consumption can be sustained over the long term. Since the research is about trying to get children to eat more vegetables, further research must be done into whether the long-term effect does not cause new eating problems such as generally eating more before the final product can be used.

Another limitation was the relatively small group of participants. Since it is difficult to find 4-year-old children willing to participate, the target group was already adjusted to 3-5 years old. For a full experiment with reliable results, a total of 6 participants is not enough, but for now it gives a good indication.

Parents had not been told clearly enough prior to the experiment that they should not inform their children that it was about eating vegetables during the experiment. This should have been made clearer so that the children started it without any expectations. Now some children already knew what the idea was and that they had to eat vegetables and went there with a different idea than the children who did not know about anything yet. Also, using user interviews during the ideation phase would have been useful to do. The final idea is now based purely on the use of requirements and not on the opinion of parents and children, while they play an important role in this.

The last limitation was that it was sometimes difficult to tell during the experiment when someone actually put a vegetable in their mouth and not. As a result, it occasionally happened that someone did not receive any stars or that it took a little longer for the stars to appear on the table.

8.2 Recommendations

During user testing, positive outcomes also emerged. Such as the use of positive feedback. This did have a clear impact on the children's behavior. Once they were rewarded by stars appearing on the table and filling the rainbow, they became more motivated to eat more. The children also liked the use of lots and bright colors on the table. As soon as they walked in, they immediately went to see what was on the table. Therefore it is recommended to make use of positive feedback and a lot of colors when working with young children.

It is also recommended to ask the parents before conducting the experiments about the individual preferences of the different types of vegetables their children eat. For this experiment broccoli and carrots were used, but if there were children who did like both of these vegetables, the experiment wouldn't work. In the case of this study, this did not have an influence on the results, 2 parents actually mentioned that their children did like one of the vegetable normally, but those children tried the other vegetable they normally did not prefer during this meal. And the other parents mentioned that their child did not like both of the vegetables. So for this research it did not have an influence on the results.

8.2.1 Future work

Future research should explore the use of different vegetables and individual preferences. For future research it would be best to ask the parents in advance which vegetables their children absolutely do not like. These vegetables should then be offered during the experiment to be sure that the children do not like those vegetables.

A repeated study could also be executed for future work. Instead of letting the children only come and eat at the table for one time, it would be interesting to see what happens when they eat at the table again, to see if the results are the same as the first time. If the table will be used multiple times with the same children, it could be researched if the use of multiple animations would work in order to keep the children engaged. This also results in research into if there is a long-term effect in eating behavior noticeable with the use of the SIT. This would require some longer research. They would have to eat the meal several times at the table, and then it would also have to be investigated whether they eat the same meal at home without using the table. Research could also be done into when children come and eat more often at the table, this may also result in a negative effect when they start to eat at home without the table and refuse to eat their vegetables since they want to get rewarded in order to eat them.

Since an interactive dining table is not feasible to have at home right now, we could also look at future work without it with the given recommendations. One idea could be to have a tablecloth with an running animation on it that can be controlled by parents at home through a Bluetooth device. The current final idea could then be visualized on this tablecloth. Another idea could be to build an app that could be

displayed on a tablet or TV and controlled by the parents. This app then will show an animation for each bite of vegetables eaten by the children. This makes it easy to create multiple animations so that it remains exciting for the children which animation is coming. This app is also easier to use if long-term research needs to be done.

9. Conclusion

In conclusion, this study aimed to develop an interactive dining table application to encourage vegetable consumption in 4-year-old children and looked at to what extent this application can change this by answering the following research question: **to what extent can an application on the interactive diner table be used to help to encourage children to eat more vegetables at the age of 4.**

The results demonstrated a positive influence on vegetable intake, with the majority of participants showing increased motivation to eat vegetables and engagement with the interactive features. Therefore it can be said that it is possible to design an application for an interactive diner table that is able to encourage children to eat more vegetables to a certain extent. There are some factors that will require future research. For instance, doing the experiment with a 0 measurement in order to know how much vegetables were consumed during a meal without the SIT. Additionally, the long-term effects of an application on the SIT should also be thoroughly investigated before the final product can be used. However, for now, it can be stated that such an application for an interactive diner table needs to have at least the following aspects to encourage children to eat more vegetables. The influence of parents must be considered and must be taken into account, the use of an animation to keep the attention of the children at the table, and the use of positive feedback in combination with a clear goal in order for the children to be motivated to eat more vegetables.

Appendices

Appendix A Growing Circles keys

In the picture below you can see an overview of the animations that can occur in the pink circle (Figure 58).

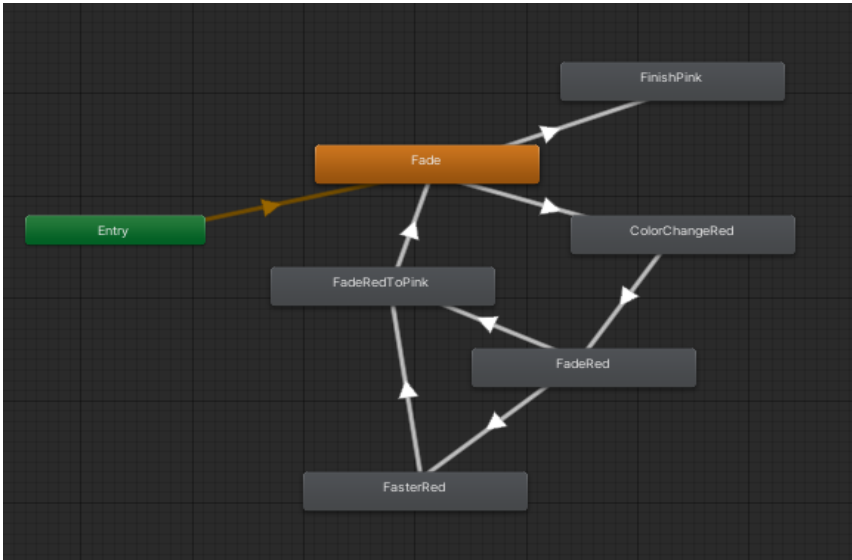


Figure 58: Overview of animations

The **Fade** animation is the animation that is constantly happening to get the children’s attention. The circle will constantly appear and disappear by changing the transparency of the color. This can be seen in figure 59, 60 and 61.

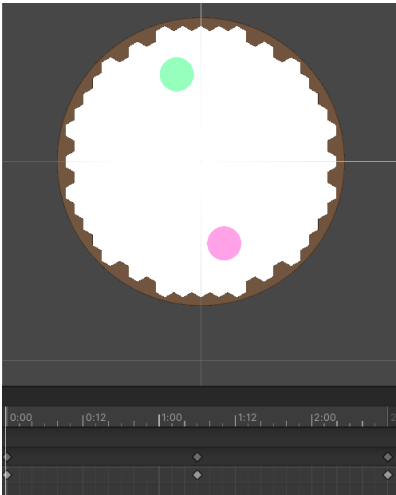


Figure 59: Starting phase

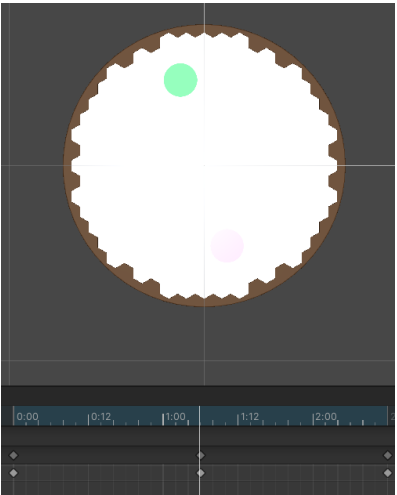


Figure 60: Fading pink

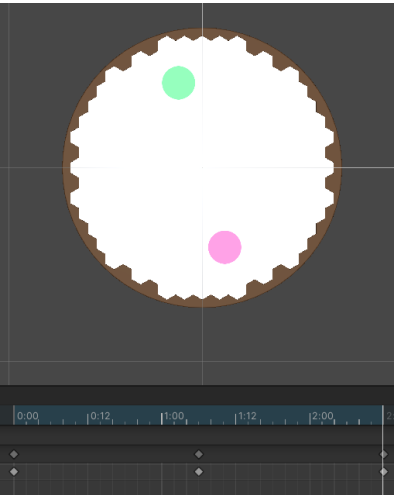


Figure 61: Back to starting phase

The **ColorChangeRed** animation is executed when '8' is being pressed and is the animation where the color of the circle will change to a red color when the person sitting at that circle is not eating enough of their vegetables (Figure 62 and 63).

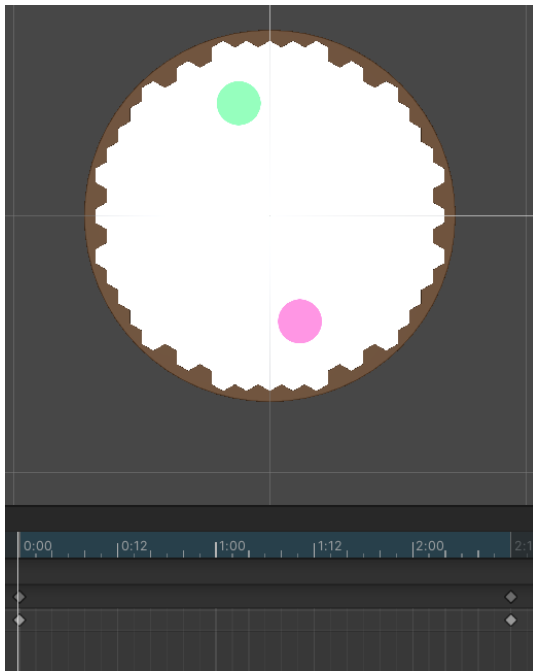


Figure 62: Starting phase pink

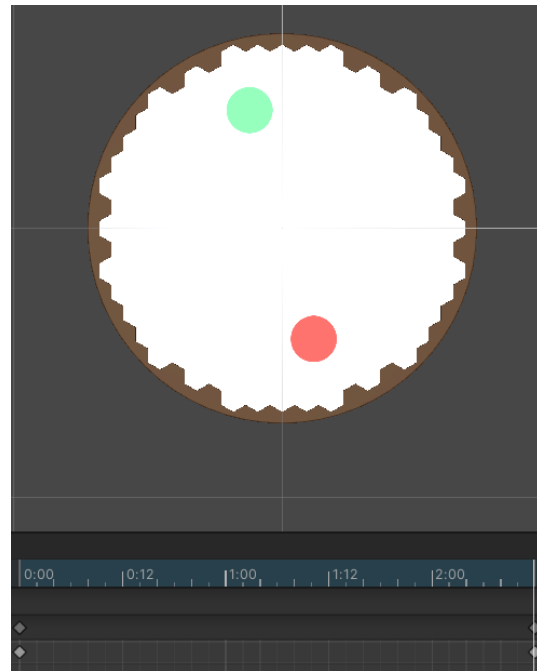


Figure 63: Pink becomes red

The **FadeRed** animation is the same as the fade animation and will automatically begin when the **ColorChangeRed** animation is finished, but instead of the original color the red color will now fade in the same animation as before. The **FasterRed** animation, executed when '9' is being pressed, is for when the person still does not eat enough of their vegetables. The fading animation will start to fade faster than before. The **FadeRedToPink** is executed when '0' is being pressed. When the person starts to eat vegetables again the red color will fade to the original color, pink in this case, and will start the fade animation automatically again.

Once the rainbow is completely filled, the animation is finished and the **FinishPink** animation will be executed by pressing 'F'. The pink color then will fade away and will not be shown again (Figure 64 and 65).

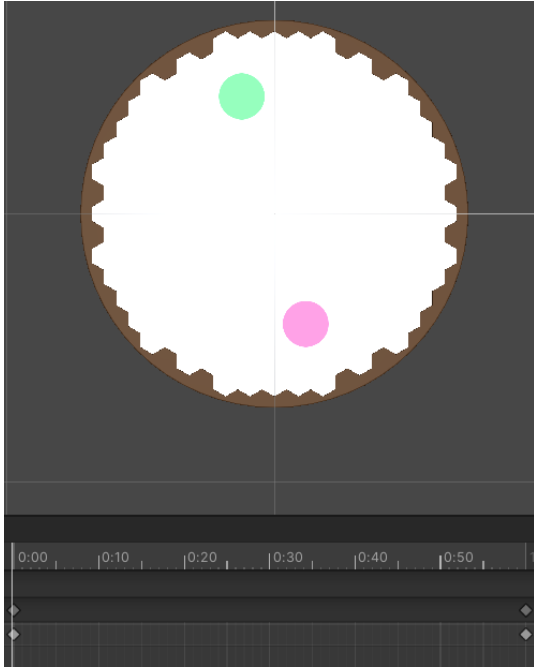


Figure 64: Pink before finish

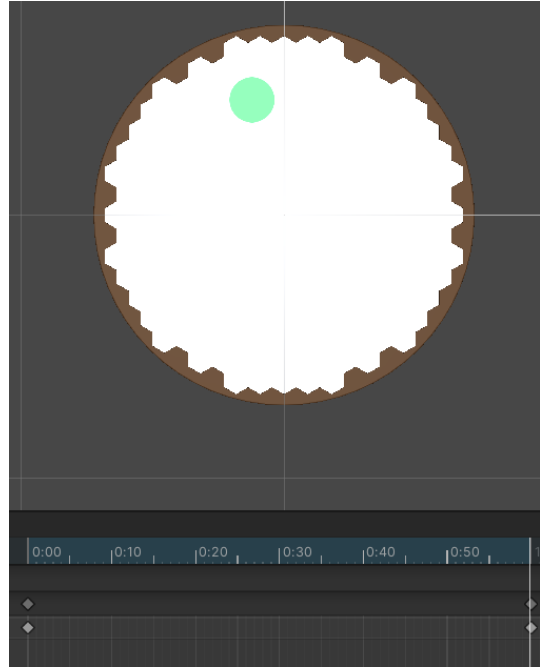


Figure 65: Pink disappears

Appendix B Growing Rainbow keys

In the picture below you can see an overview of the animations that can occur in the rainbow (Figure 66).

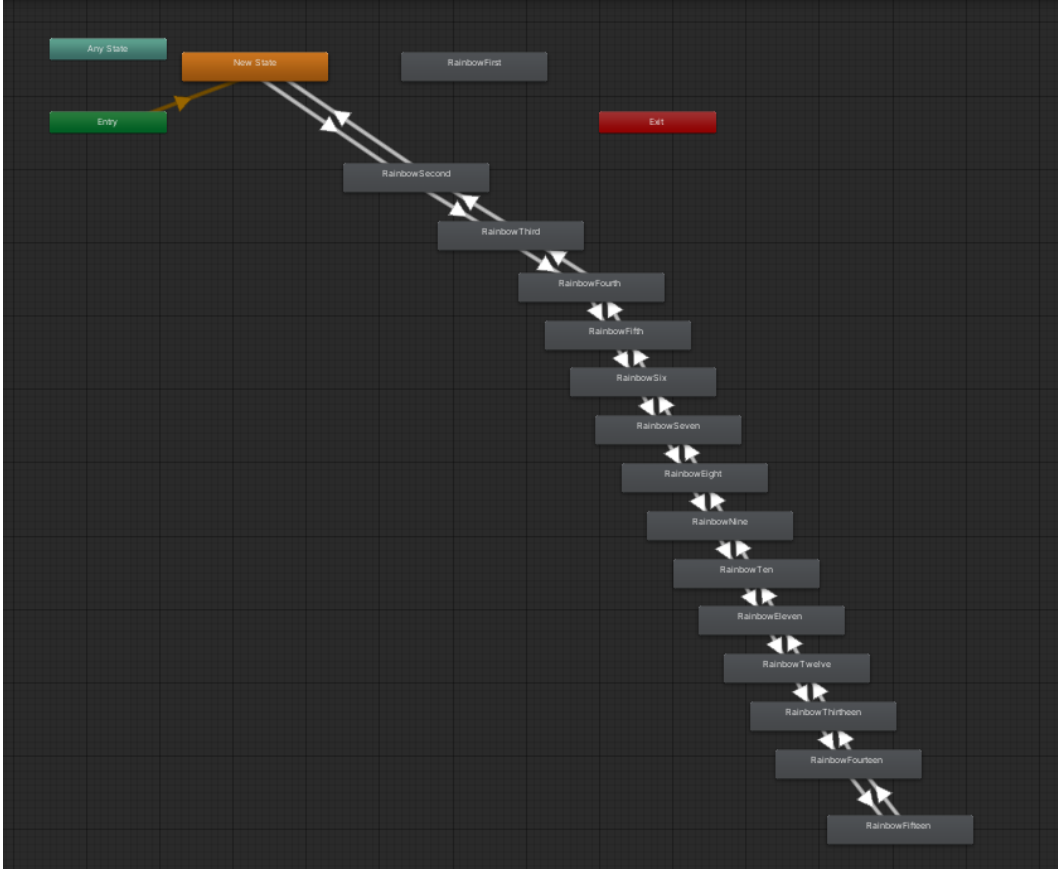


Figure 66: Overview of rainbow animations

The rainbow begins in the dull version, its beginning state (Figure 67).

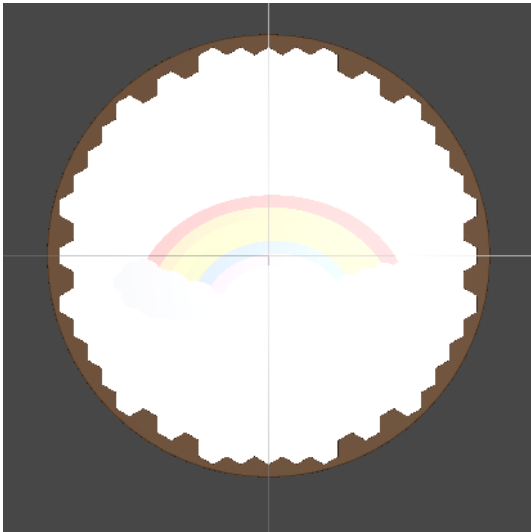


Figure 67: Rainbow beginning state

Every time the right or left arrow is pressed, the rainbow will change to a fuller or emptier rainbow. Right means fuller, left means emptier. The overview of the pictures can also be seen in figure 41. Every time the right arrow is pressed the rainbows state goes from RainbowX to RainbowX+1, for example as you can see in the animation overview above, after RainbowSecond comes RainbowThird etc. Once the rainbow is in its last state, RainbowFourteen (Figure 68), the finish animation, RainbowFifteen, can be triggered by pressing 'F' (Figure 69).

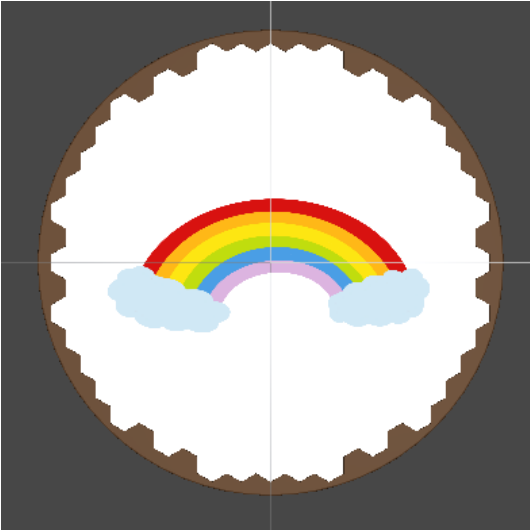


Figure 68: RainbowFourteen



Figure 69: RainbowFifteen

Appendix C Shooting Sparkles keys

In the picture below you can see an overview of the animation of the shooting stars from the pink circle (Figure 70).

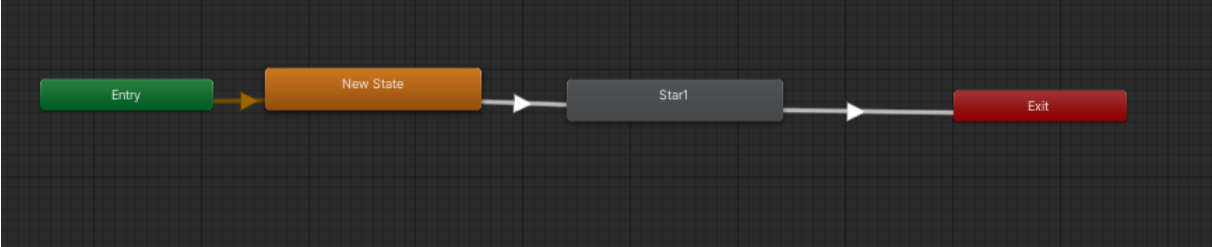


Figure 70: Overview of stars animation

The only animation that happens in the star is the ‘star1’ animation. This animation represents the stars shooting from the circle to the rainbow (Figure 71 and 72). This animation occurs when ‘p’ is being pressed for the pink circle and ‘g’ is being pressed for the green circle.

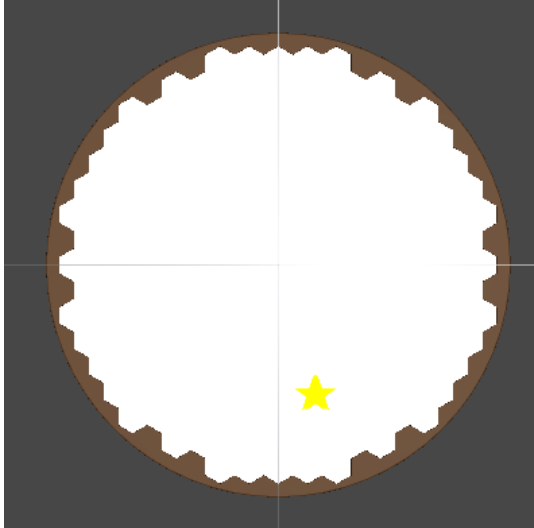


Figure 71: Stars shown

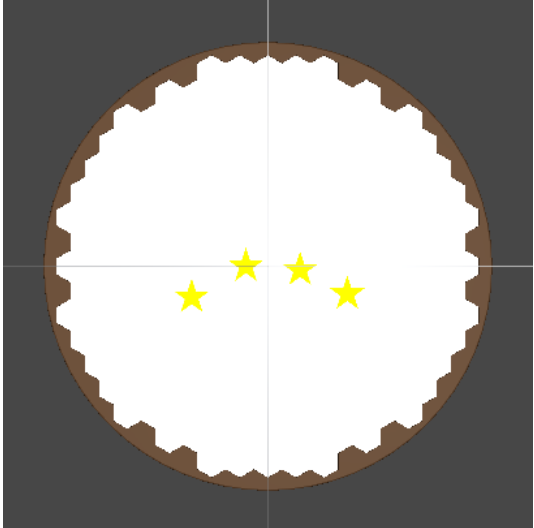


Figure 72: Stars shot

When the star animation is not triggered, so no vegetables are being eaten, the stars are laying underneath the circle with their opacity to 100. This is done because once the circles play the fade animation and becoming more transparent up you would see the stars underneath the circle. By changing the transparency of the stars to 100 in the beginning, you won’t see them. Once the stars are being triggered, their transparency first changes very quickly and then they are shot to the rainbow (Figure 73 and 74).

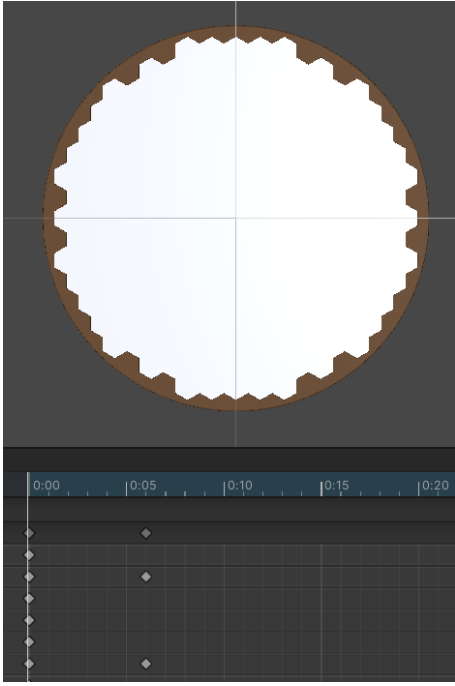


Figure 73: Stars not shown yet

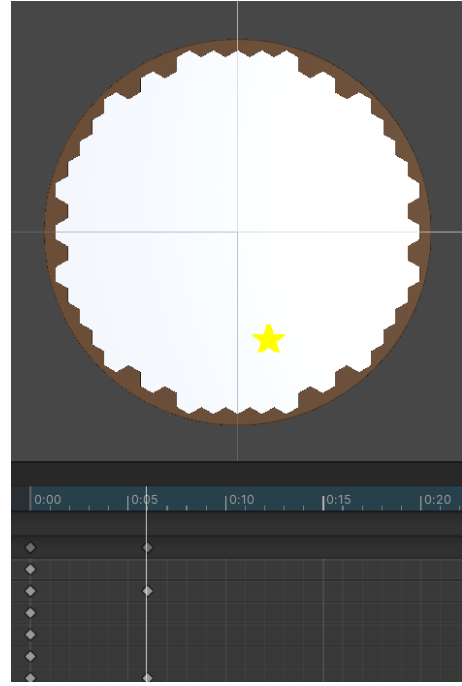


Figure 74: Stars shown

Appendix D Information prior to the experiment

Allereerst wil ik u nogmaals hartelijk bedanken dat u bereid bent om deel te nemen aan mijn onderzoek. Ik waardeer uw medewerking enorm.

Ik begrijp dat het eten in deze onderzoeksomgeving best spannend kan zijn voor uw kind. Wellicht heeft u vragen over wat u het beste wel en niet kunt doen tijdens het experiment. Om u te helpen, geef ik hieronder wat instructies die u op uw gemak kunt doornemen. Elk kind is anders en reageert op zijn eigen manier in verschillende situaties. Het kan zijn dat uw kind zich anders gedraagt dan thuis. Dit is helemaal niet erg. Ons doel is om een positieve ervaring te creëren.

Mocht u op enig moment het gevoel hebben dat u of uw kind liever wilt stoppen met het experiment, voel u dan ten allen tijde vrij om dit aan te geven. Uw comfort en welzijn hebben de hoogste prioriteit.

Om ervoor te zorgen dat alle kinderen in dit experiment op een vergelijkbare manier instructies ontvangen, volgen hieronder enkele aanwijzingen/instructies. Tijdens het experiment willen we zoveel mogelijk de autoritatieve opvoedingsstijl toepassen. Dit betekent dat we geen dwang willen uitoefenen op het eetgedrag van uw kind. Een autoritatieve opvoedingsstijl is een evenwichtige benadering waarbij ouders zowel responsief als veeleisend zijn. Ze zijn open voor communicatie met hun kinderen, tonen begrip voor hun gevoelens en meningen, en bieden een veilige omgeving. Tegelijkertijd stellen ze duidelijke grenzen en regels, met respectvolle uitleg en redenering. We vragen u niet om uw persoonlijke opvoedingsstijl te veranderen, maar alleen om tijdens het experiment een autoritatieve aanpak te hanteren.

Hieronder vindt u bepaalde voorbeelden:

- Probeer de aandacht van uw kind te richten op de maaltijd en de interactieve eettafel door bijvoorbeeld interessante aspecten van de animatie te benadrukken of verhalen te vertellen die verband houden met de groenten op het bord.
- Als uw kind probeert op te staan of van tafel weg te lopen, kunt u rustig en vriendelijk aangeven dat we tijdens de maaltijd aan tafel blijven.
- Moedig uw kind aan om op een respectvolle manier te communiceren waarom hij of zij weg wil gaan, en bied indien mogelijk een oplossing of compromis aan dat het kind tevreden stelt zonder de maaltijd te verstoren.
- Als uw kind het erg spannend vindt en bijvoorbeeld aan geeft dat die op schoot wilt zitten kunt u aangeven dat het belangrijk is om aan tafel te blijven zitten tijdens de maaltijd. Als dit niet werkt is het geen probleem om uw kind op schoot te nemen en samen van het bord te eten.

Ik wil nogmaals benadrukken dat het te allen tijde mogelijk is om te stoppen met het experiment als u of uw kind dat wilt. We streven naar een omgeving zonder strijd of tranen. Mijn doel is om een

ontspannende en positieve ervaring te creëren, zowel voor u als ouder als voor uw kind. Uw comfort en welzijn hebben de hoogste prioriteit, en we willen ervoor zorgen dat uw deelname aan het experiment een positieve en plezierige ervaring is.

Mocht u zich in een situatie bevinden waarin u twijfelt over wat u moet doen, vertrouw dan vooral op uw gevoel. U kent uw kind het beste en weet wat het beste werkt voor hem/haar.

Nogmaals bedankt voor uw deelname en uw waardevolle bijdrage aan mijn onderzoek. Als u nog vragen heeft, aarzel dan niet om ze te stellen.

Appendix E Information Brochure

Information form

Purpose of the study

In this research, a new interaction was designed for the Sensory Interactive Table. This table can provide feedback to users via LEDs to encourage eating habits. This study looks at vegetable intake in 4-year-old children. Vegetables are an important provider of dietary fiber, vitamins and minerals and are therefore important for a healthy lifestyle. Children often find it difficult to eat vegetables for a variety of reasons. To solve this problem, a program was designed that is played on this table to try to encourage children at the age of 4 to eat more vegetables. This is done by having the LEDs respond through an animation to the eating behaviors observed.

What will happen during the session?

This test will take approximately 15 minutes. Before the test takes place, a few questions are asked orally to the child, after this the family can take a seat at the table and the experiment begins. During the test, the child would take a seat with the entire family or part of the family at the dinner table with the task of simply pretending they are eating at home. By playing different animations on the table, the researcher tries to encourage the child to eat from the vegetables. During the test the researcher will watch the participants eat and make observations about the behavior during the meal. No tasks are given other than to simply sit at the table and eat dinner like they do at home. After the test is finished, the child is asked a few more questions. After these questions are answered, the experiment is finished and the family can pack their stuff and go home.

Benefits and risks of participating

The risks of participation to this study is that the information of the participants will be used in the study. All results that will be used in the study will be anonymous. A benefit of this study could hopefully be that the child would leave with a positive feeling after the experiment and would indeed from now on to eat more vegetables.

Withdraw from the study

The participant is allowed to withdraw from the study at any time, including up to one week after the survey is already conducted. After this time it would no longer be possible, because the data has already been used in the research. The participant does not have to provide a reason if they wish to withdraw from the study. Once the withdraw is indicated within the specified amount of time, immediate action is taken and the associated information would no longer be used.

For children, parents or authorized persons may indicate to withdraw from the study at any time if they feel that their child is uncomfortable and does not want to continue anymore.

Use of deception

This research involves the use of deception, where the operation of the table may be presented differently from its actual functioning. The use of deception is necessary to observe participants' reactions and behaviors within a realistic context. Following your participation in the research, a debriefing session will be conducted where we will provide full disclosure regarding the deception used in this study.

Personal information

The personal information that we will be asking from the participants are their age and gender. This will help the study categorize information when needed. The participant has the right to request access to their personal information at any time during or after the study and they have right to ask if the data can be removed from the study.

Retention period of the research data

The research data will be stored till 2 months after the study.

Contact details for further information about the study:

Marin Grinwis (researcher) m.grinwis@student.utwente.nl

J.A.M. Haarman (supervisor) j.a.m.haarman@utwente.nl

Contact Information for Questions about Your Rights as a Research Participant

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: ethicscommittee-CIS@utwente.nl

Appendix F Consent Form

Consent Form for *Creative Technology*

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes

Yes No

Taking part in the study

I have read and understood the study information dated [DD/MM/YYYY], 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 to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.

I understand that taking part in the study involves that behaviour is being observed and that researchers are taking notes of this behaviour during the test and that a video recording is being made. The video recording will be destroyed in one month after the study.

Use of information in the study

I understand that information I provide will be used for only the report of this study. This report will be stored for at least 5 years in the data base of the University of Twente.

I understand that personal information collected that can identify them, such as age and gender, will not be shared beyond the study team.

Consent to be Audio/video Recorded

I agree to be audio/video recorded.

Deception

I understand that some information is withheld for me during this study, but that this missing information will be told afterwards through a debriefing.

Signatures

Name of participant Signature Date

For participants unable to sign their name, mark the box instead of sign

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Name of legal representative Signature Date

Researcher name Signature Date

Study contact details for further information:

Marin Grinwis

m.grinwis@student.utwente.nl

Appendix G Complete step-by-step procedure

1. Getting everything ready and cooking the meal

Before the participants arrived, everything was set up for the user test. The observation room was prepared, the food was cooked, the table was set, and the house was cleaned up to create a neat atmosphere.

2. Welcoming participants and showing the room

Once the participants arrived, they were warmly welcomed and given time to explore the room. Plenty of time was taken for this so that the children could feel comfortable for a while and not rush into the experiment. Any questions or concerns raised by the participants were addressed to ensure their comfort and understanding.

3. Signing the consent form

In order for the participants to participate in the experiment they needed to sign a consent form (Appendix E). In order to better understand the consent form an information brochure was also given to them to read before signing the form (Appendix F). Once the consent forms were completed, participants were able to participate in the experiment and the user test could continue.

4. Pre-experiment interview questions

The parents were interviewed by the researcher before the experiment started.

5. Seating at the table

After the interview was conducted, participants were guided to be seated at the interactive diner table with the prepared meal on it.

6. Final information

Before initiating the experiment, the researchers provided a brief overview of the upcoming activity. The researcher explained that they could just have a regular meal together, without mentioning that the experiment is about eating vegetables. It was also mentioned that something can happen to the rainbow, and that it would be really nice to try to complete the rainbow.

7. Start of the experiment

The researcher goes to the observation room and begins to record the table with the cameras. From this room, the researcher observes the child's eating behavior and changes the animations on the table regarding their vegetable consumption. Once a vegetable was eaten, an animation needed to be played by pressing keys on the wireless keyboard.

8. Post-experiment interview questions

After the meal, the researcher returned to the participants in the dining room and tell them the experiment is finished, thank them for their participation, and conducted a final interview with both the child and the parent.

9. Reward for the child and participant departure

As a token of appreciation for the children's participation, each child was given a small reward in the form of an ice cream and a bubble blast. Parents were also offered to reimburse travel expenses. This served to positively reinforce their involvement and cooperation during the user test.

Appendix H Written out interviews

User test 1:

Prior to the experiment, the father indicated that his son is very inconsistent with eating vegetables. He enjoys eating certain vegetables, but he resists and shows reluctance when it comes to consuming many other vegetables. Especially the raw vegetables are generally accepted, but as soon as the vegetables are cooked there is a considerable resistance. It was further indicated that they have not tried any specific strategies to get him to eat more vegetables, eventually he does eat them when necessary, but without any particular approach in place.

After the experiment, the child indicated that he really enjoyed eating at the table. However, the first thing he did say was that he really didn't like the carrots, but had eaten them because he wanted to complete the rainbow. He found the rainbow to be the most enjoyable part and it motivated him to continue eating, but the stars were also a motivation for him. He liked getting them and therefore wanted to eat more to see more stars. He also indicated that he would like to eat at this table more often.

After the experiment, the father indicated that he had definitely noticed a difference in his son's eating behavior. He noticed that his son found it much easier than usual to eat his vegetables, and that he completely finished all his vegetables on his own without his father having to say anything about it. According to the father, this was due to the fact that the animation on the table represented a game, and his son had a goal while eating, which really motivated him to eat more. The father did not encounter any other challenges during the meal because his son quickly understood what needed to be done to fill the rainbow and to see the stars and started doing it on his own. However, he indicated that he does not know to what extent it would have a long-term effect, the game aspect would become less engaging and lose its novelty over time. By making different animations and therefore different game forms this could be remedied. The father also indicated that his son normally likes broccoli, but typically refuses to eat carrots at home.

User test 2:

Prior to the experiment, the father mentioned that his daughter is somewhat selective when it comes to eating vegetables, but not the pickiest. To encourage their daughter to eat more vegetables, they received tips from a counseling office such as incorporating vegetables into meals in a way that makes them difficult to pick out. This approach has helped them and is frequently practiced at home. However, she remains quite selective in what she eats overall. She also really doesn't like meat and, for example, when they eat pasta at home she purposely avoids the vegetables and meat.

After the experiment, the child indicated that she found the table to be very enjoyable, especially watching the rainbow fill up (animation was showed even though the plate wasn't finished to let the daughter see what would have happened if she finished her plate). However, she mentioned that she

genuinely didn't like the vegetables and therefore she had hardly eaten any of them. Despite the circle under her plate turning red and flashing faster due to her limited vegetable intake, it did not motivate her to eat more. However, she did indicate that she would like to sit at such a table more often.

After the experiment, the father indicated that he had not noticed any change in his daughter's behavior when it came to her vegetable intake. Normally, she attempts to eat a bit of everything at home, but during the experiment, she completely refused to do so. However, he did notice that she willingly ate her meat during the experiment, even though she usually avoids it at home. He also observed her engaging in negotiation tactics. She tried to persuade her father to eat her vegetables because she wanted the rainbow to be filled, but she didn't want to do it herself.

User test 3:

Prior to the experiment, the mother indicated that her daughter's eating habits regarding vegetables were special and nonexistent. Her daughter is a very picky eater and absolutely refuses to eat vegetables. The only way she would occasionally eat them is if they were incorporated into a meal where the vegetables were not visible. The mother indicated beforehand that she hopes the table will have an effect on her daughter because it is truly a problem for them.

After the experiment, the child indicated that she liked eating at the table and that she liked watching the animations. She particularly enjoyed seeing the stars and said she would like to eat at the table again. She claimed to have liked the vegetables, but her body language and her mother's reaction suggested otherwise.

After the experiment, the mother indicated that she did notice a slight change in her daughter's eating behavior. Although she didn't eat much of her vegetables, she had willingly tried everything on her own, which was already a significant accomplishment. She had at least taken a bite of both vegetables, even though she strongly dislikes broccoli at home. The only vegetables her daughter does like are raw carrots, she doesn't like anything else. According to the mother, it was quickly clear to her daughter what the intention was, she could name what she saw and therefore paid extra attention. She does not think the table would have a long-term effect since it was new this time. If a long-term effect is desired, there should be different types of animations to choose from in order to sustain the novelty factor.

User test 4:

This user test consisted of one mother together with two of her children who were within the age range. Since the three of them sat at the table at the same time it falls under 1 user test.

Prior to the test, the mother indicated that both of her sons' eating habits regarding vegetables are not great. They often refuse to eat their vegetables and when they do have to eat them, they do so with a lot of reluctance. They often claim in advance that they find it disgusting without even tasting it.

Furthermore, at home she does notice that her sons influence each other, if one refuses to eat their vegetables, the other often follows suit, and vice versa. One strategy they have already tried at home is to reward their children through stickers if they eat their vegetables. They can save up these stickers and use them for fun outings. For example, if they have 5 stickers they can choose to go to the pool for a day. They did notice at home that this method had some influence on them at the beginning, but after a while it did not work very well anymore

After the experiment, both children indicated that they really enjoyed it. They particularly liked the different colors they saw and the stars caught their attention the most. The stars combined with filling the rainbow motivated them especially to continue eating. They also indicated that they liked the food, including the broccoli. They wanted to eat at the table more often to see even more stars.

After the experiment, the mother indicated that she was pleasantly surprised with the results; she had never experienced this before. There was a clear effect of the table on her children as they finished their vegetables very quickly. She also noted that they didn't even touch the other food because they were so eager to complete the rainbow by eating their vegetables first. They also very easily figured out what the purpose of the table was and therefore started eating their vegetables very quickly. Normally, they don't enjoy eating both vegetables at home; they are okay with carrots, but they genuinely dislike broccoli, yet during the experiment, they found both vegetables tasty. She indicated that she was curious to see what it would be like if the experiment were conducted with other kinds of vegetables that would be a lot less accessible.

User test 5:

Prior to the experiment, the mother indicated that her daughter is not very good with eating vegetables. She often resists consuming vegetables when she has to eat them during dinner. The only way her daughter would eat vegetables was if they were incorporated into a meal, such as lasagna. This is also the strategy they often use at home to ensure that their daughter consumed an adequate amount of vegetables.

After the experiment, the child indicated that she really enjoyed eating at the table. She especially liked the rainbow as it became fuller and thus the colors became brighter. She also liked the little stars. When the color beneath her plate of vegetables changed, she understood that she should eat her vegetables. She also indicated that she liked the food and expressed a desire to have a similar table at home to enjoy the vibrant colors more frequently during meals.

After the experiment, the mother observed a noticeable positive change in her daughter's eating behavior regarding vegetables. Her daughter quickly figured out what was intended and started to try the vegetables on her own, whereas at home she does not. Even though her daughter still did not like broccoli at home, she willingly took a piece of it during the experiment. She also indicated that at one point her

daughter started trying to negotiate with her mother that her mother had to eat her vegetables because she wanted to get the rainbow full. She thinks the table can indeed have a long-term effect by using different animations, for example.

Appendix I Observation charts

User test 1

Father = F and Son = S

Broccoli = B and Carrot = C

| Who | What | When | Observations of behavior |
|-------|------|-------|--|
| F | B | 01:54 | Both did not notice something happening |
| F | C | 02:25 | Son surprised |
| S | B | 02:47 | First bite → enthusiastic |
| F | B | 02:57 | Dad takes bite → nothing happens |
| S & F | B | 03:36 | Second bite → Son is mocking the dad that he get stars and the dad gets nothing. |
| F | C | 04:07 | ‘Maybe if we eat more, we will fill up the rainbow completely’ |
| F | C | 04:18 | ‘If we eat everything, we could fill the entire rainbow’ |
| S | B | 04:49 | ‘Do I have to eat the carrots?’ |
| S | B | 04:52 | Enthusiastic |
| S | B | 05:05 | He doesn’t want to eat his carrots |
| F | C | 05:21 | Dad is pointing to the carrots |
| S | B | 05:25 | Very enthusiastic |
| F | C | 05:37 | Child doesn’t want to eat his carrot so the father gets the stars. The son doesn’t understand. |
| F | B | 05:39 | Dad is now mocking the child for getting stars. |
| S | C | 05:50 | Son eats his first carrot, and cheers because he gets the stars. |
| F | C | 06:13 | Dad eats carrot without stars |
| S | B | 06:20 | ‘I will eat everything!’ |
| S | B | 06:26 | ‘It is just like a game!’ |
| S | C | 07:31 | Son gets enthusiastic after taking another bite. |
| S | C | 08:26 | Another bite |
| F | C | 08:40 | Dad also gets the stars |

| | | | |
|-------|---|-------|--|
| S | C | 09:05 | 'I do not like these carrots' → takes another bite. |
| S | C | 09:10 | Another bite |
| F | B | 09:25 | Father is disappointed because he didn't get the stars. |
| S | C | 09:40 | 'Father says, let's do the last part of the rainbow together.' |
| S & F | C | 10:05 | Son and Father both take a bite |
| S | C | 10:46 | Son takes his last bite |
| S | | 10:55 | Rainbow appears, son is waving to the rainbow. |

User test 2

Father F and Daughter D

| Who | What | When | Observations of behavior |
|-------|------|-------|---|
| F | B | 00:49 | Takes a bite |
| D | B | 01:21 | Daughter is not getting excited by the stars of her dad. |
| D | C | 01:47 | With not that much enthusiasm she takes another bite |
| F | B | 02:32 | Takes a bite, and exaggerates his happy reaction |
| D & F | | 02:49 | Looking at the table |
| F | C | 03:07 | Father points to the rainbow |
| F | | 03:18 | Father proposes completing the rainbow |
| D | C | 03:49 | Daughter tries to negotiate with her father to let him eat the vegetables. |
| D | B | 04:36 | Tries another piece of broccoli unhappily. |
| D | B | 04:58 | Resists eating carrots but eats voluntarily meat (she never eats meat voluntarily at home). |
| F | C | 05:14 | Father points to the carrots. |
| D | | 05:25 | She noticed the light turning red under her plate but doesn't react to it. |
| F | C | 05:37 | Father eats carrots and getting stars. |
| F | B | 05:39 | Father tries to convince his daughter to get stars. |
| D | C | 05:53 | Daughter tries a carrot, sees the stars but does not react. |

| | | | |
|---|---|-------|--|
| F | C | 06:09 | Father eats carrot and gets excited from the stars. |
| D | | 06:24 | Expresses that she likes it but does not want to eat more. |
| D | | 06:47 | Describes that she wants to eat at the table again. |
| F | B | 07:27 | Last try of the father to convince the daughter. |
| D | C | 08:03 | Daughter doesn't want to eat anything anymore |

User test 3

Mother M and Daughter D

| Who | What | When | Observations of behavior |
|-----|------|-------|---|
| M | | 00:40 | Making sure that the daughter understands the assignment |
| M | B | 01:00 | Takes the first bite and reacts enthusiastically. |
| D | | 01:23 | Daughter asks if the mother can eat all of the vegetables. |
| M | C | 01:47 | Takes another bite and is happy. |
| D | C | 02:09 | Takes a bite by herself, not reacting very excited. |
| M | | 02:17 | Asks if she liked it. |
| M | C | 02:45 | Takes another bite. |
| D | B | 03:03 | Tries a broccoli, and is not enthusiastic by the taste. |
| D | C | 03:21 | Another bite but seems not hyped to take another bite. |
| M | C | 03:47 | After she saw the stars she tried to push her daughter. |
| D | C | 04:27 | She was noticing the stars. |
| D | B | 04:36 | She was getting unhappy. |
| D | | 04:43 | 'Can we stop, I am not hungry anymore' |
| M | | 05:02 | She tried to let her eat something but the daughter did not want to eat more. |

User test 4

Mother = M, Son 1 = S1 and Son 2 = S2

| Who | What | When | Observations of behavior |
|-----|------|-------|---|
| S1 | | 00:11 | Look at the cool colors under the plates. |
| M | C | 00:58 | Mother reacts very enthusiastically to the stars. |

| | | | |
|-------------|---|-------|---|
| S2 | C | 01:03 | Takes a bite because he saw the stars from his mother |
| S1 | C | 01:05 | Takes a bite because he saw the stars from his brother |
| S1 | B | 01:20 | Takes quickly another bite, it looks like he wants to race. |
| S2 | B | 01:30 | Mother said 'take a broccoli and see what will happen' |
| S1 | B | 01:30 | He does not wants to lose so he takes another bite. |
| S1 & S2 & M | | 01:35 | 'This is so cool' → everyone is laughing |
| S1 | C | 01:37 | Takes another bite |
| S2 | C | 01:43 | He is cheering because he got the stars. |
| M | | 01:50 | 'I need this at home!' |
| S1 | B | 01:58 | Takes 2 pieces of broccoli in 1 bite. |
| M | | 02:13 | 'S1 has almost finishes his plate' |
| S2 | B | 02:15 | Quickly takes 3 pieces in 1 bite to beat his brother. |
| S2 | B | 02:29 | He is cheering |
| S2 | | 02:42 | 'I want this table at home' |
| S1 | C | 03:08 | Eating his last piece of vegetable. |
| S2 | C | 03:21 | Cheering after he gets stars |
| S2 | | 03:32 | 'You have to eat quicker mom, we have to fill the rainbow.' |
| S2 | C | 03:47 | Quickly eats a lot of carrots and is cheering. |
| S2 | C | 04:21 | Nothing happens after a small bite |
| S2 | C | 04:37 | Sees that the rainbow is moving after a big bite and is cheering. |
| S2 | C | 04:59 | S2 is counting the bites he has left. |
| S2 | C | 05:25 | Takes 3 of the 4 pieces in 1 bite |
| S2 | C | 05:35 | Finishes his plate |
| M | | 05:48 | Reacts very enthusiastic about the filled rainbow |
| S1 & S2 | | 05:59 | Trying to touch the stars |

User test 5

Mother M and Daughter D

| Who | What | When | Observations of Behavior |
|-------|------|-------|---|
| M | B | 01:21 | Begins the experiment with a bite. |
| D | | 01:35 | Daughter's surprise evident as she sees the stars. |
| D | B | 02:03 | The daughter independently takes a bite. |
| M | C | 02:31 | Encourages the idea of filling the rainbow |
| M | C | 02:45 | Proposes completing the rainbow by eating the vegetables. |
| D | B | 02:59 | Is not amused by the vegetables and tries to convince the mother to eat her vegetables. |
| D | B | 03:13 | Is not pleased by her mothers reaction. |
| D | B | 03:27 | Initially resists, but tries to explores the concept. |
| M | C | 03:41 | Draws attention to the red colors underneath the plate. |
| M | B | 04:23 | Mother trying to push the daughter to try the broccoli. |
| D | | 04:37 | Color change beneath her plate signaled the child to eat. |
| D | B | 04:51 | She was surprised and ate a broccoli. |
| M | B | 05:05 | Animatedly relates eating to an exciting game |
| D | B | 05:19 | The Daughter said 'I want a similar colorful table at home.' |
| M | C | 05:33 | Daughter eagerly anticipates her next bite. |
| M | C | 05:47 | Mother points to the blinking red color. |
| D | C | 06:01 | Daughter enjoys receiving her own stars |
| M | C | 06:15 | The mother did finish her plate. |
| D | C | 06:29 | She saw the stars from her mother and immediately ate another carrot. |
| D | | 06:43 | Because of the bite, the color went to the original color. She reacted with 'wow'. |
| M | | 06:57 | Mother gave her a thumbs up. |
| M & D | | 07:11 | Daughter keeps playfully trying to convince her mother to participate in eating her vegetables. |

| | | | |
|---|---|-------|--|
| M | C | 07:20 | Mother shows that no stars appear when she takes a bite of the vegetables of her daughter. |
| D | C | 07:25 | Daughter takes another bites and realizes she has to do it on her own. |
| D | C | 07:30 | Daughter almost finishes the entire plate, but is not hungry anymore. |
| D | B | 7:40 | Takes last bite because she want to fill the rainbow |
| D | | 07:39 | Sees the fulfilled rainbow and is very happy! |

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