BACHELOR THESIS

JUST-IN-TIME INTERVENTION:

INCREASING YOUNG ADULTS' FRUIT INTAKE IN AN ENGAGING WAY

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03/07/2020

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Abstract

Consuming an adequate amount of fruits is very important to maintain one’s health and prevent many diseases. Because of the health benefits, the World Health Organization recommends people to consume 200 grams of fruits per day. However, less than a quarter of European young adults follow this dietary guideline. Because young adults usually do not have a direct parental control to monitor their eating behavior, their lifestyles are typically associated with unhealthy diets. Therefore, fruit consumption should be promoted among young adult populations. To facilitate fruit consumption, a physical environment can be altered by using a just-in-time intervention. A just-in-intervention can give support in appropriate situations like as a food choice situation, where a person decides what to eat. However, just-in-time interventions usually have a lack of engagement. Therefore, the focus of this research is to create a just-in-time intervention to increase young adults’ fruit intake in an engaging way.

To come up with the best solution, the Creative Technology Design Process was used. It consists of 4 steps: ideation, specification, realization, and user evaluation. The result of this process was an idea to create a smart fruit bowl that gave just-in-time reminders to increase young adults’ fruit intake. The smart fruit bowl also involved fruit facts to engage the users.

The prototype of this idea was tested for 7 days by 2 specific participants. To compare the effect of the smart fruit bowl in fruit consumption, the regular fruit bowl was also tested on the same duration by the same participants. The result showed that the fruit consumption using the smart fruit bowl was lower than the fruit consumption using the regular fruit bowl. Although the smart fruit bowl did not increase the participants fruit intake, the participants felt reminded to eat fruit and were aware of the available fruits when using the smart fruit bowl. The low fruit consumption using the smart fruit bowl might be caused by the redundancy of the reminders and the lack of user engagement. Therefore, the appropriate user engagement and food choice situation may need to be addressed in the future work. Furthermore, creating a fruit intake tracking seems a more promising direction to be incorporated in the fruit bowl, because it allows users to reflect on their fruit intake.

Acknowledgements

First, I would like to thank my supervisors, Janet van den Boer and Roelof de Vries, who guided me and gave me constructive feedback throughout the completion of my bachelor graduation project. I felt honored and glad to be supervised by them. Also, I would like to thank Femke Nijboer, for being a supportive and caring critical observer. Not forget to mention, I would like to thank to Alfred de Vries for lending me most of the electrical components that I used for my project. Lastly, I would like to thank the participants of my research, who willingly used my prototype for 7 days and iteratively gave me feedback throughout the development process in my project.

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Chapter 1- Introduction

Consuming enough fruits is important to sustain one's health and prevent noncommunicable diseases. The importance of fruit consumption is reflected by many dietary guidelines. One such dietary guideline is from the World Health Organization, which recommends people to consume 200 grams of fruits per day [1]. The reason why an adequate fruit consumption is recommended is because fruits contain many nutrients that are necessary for our health. Fruits contain antioxidant nutrients, which can potentially delay cognitive decline and prevent progression to dementia [2]. Additionally, fruits contain vitamins and minerals, which can reduce the risk of noncommunicable diseases, such as obesity, cardiovascular diseases, stroke, gastrointestinal disorder and most cancers [3]. Therefore, an adequate amount of fruit should be consumed every day.

Although it is recommended to eat an adequate quantity of fruits, most of the fruit intake among western countries does not meet this international fruit intake recommendation. It is reported that only 14.1% of European adults consume an adequate amount of fruits and vegetables as recommended by the dietary guideline [4]. Fruit consumption among adults should be encouraged because the consumption of unhealthy foods, consisting of sweet, savory and salty snacks, has increased over 35 years from 1977 to 2012 among adults [5]. Young adult populations seem more prone to eat these unhealthy foods because young adults may have a greater freedom to eat unhealthy food due to a decreasing direct parental control during the transition from adolescence into adulthood [6]. Additionally, young adulthood is usually characterized by the consumption of a poorer quality diet and significant weight gain due to the influence of an obesogenic environment, which mostly occurs at home [7,8]. Due to these reasons, increasing the fruit consumption among young adults in a home environment is the focus in this research.

Fruit consumption is complex and is the result of processes interacting at various levels: the food, the individual, and the environments. People tend to eat unhealthy food, as it is palatable thus making people feel rewarded and motivated to consume it more, compared to fruits [9]. Moreover, individual factors, like high self-efficacy, might influence fruit consumptions, as it increases a motivation to eat healthily [10]. Although existing interventions, such as dietary apps, have predominantly focused on individual factors like self-efficacy, the impact of these interventions seem limited and ineffective due to an insignificant change in fruit consumption [11]. One of the reasons that these interventions could not be as effective as promised is because they may not take into account other determinants of influence, like the physical environments. Therefore, it is crucial to explore the physical environments to address the low fruit consumption among young adults in a home setting.

Fruit consumption among the European adult population could be increased through the physical environment by enhancing the visibility and accessibility of fruits. A study revealed that college students consumed more apple slices when the fruit is more proximate and visible in a kitchen setting [12]. However, placing fruits in a common area is sometimes not enough to get people to notice it and be engaged to take one. Here technology can come into play. It could enhance the visibility of fruits using visual and auditory cues, which are not only noticeable but also appealing, which might result in a greater user engagement. In a similar scenario, Playful Tray engaged children to eat healthy foods by displaying their favorite cartoon characters on a tray, which contains a bowl of nutrition-rich food [13]. Such technologies could be adopted for young adults to make them notice the presence of fruit and make them engaged to consume fruits.

To implement a technology in the physical environment, just-in-time interventions (JITI) can be considered as a suitable approach to support fruit consumption, because it can detect the user's eating context. Just-in-time interventions (JITI) can be defined as an intervention design that provides support at the right moment in an eating context [14]. The eating context can be interpreted as a food choice situation, which is a situation where individuals choose and decide what food to eat [15]. By using a JITI, fruits could be offered in an appropriate food choice situation, which might increase the fruit consumption of young adults.

The goal of this graduation project is to promote fruit consumption among young adults in a food-rich environment, namely a person's home. In order to achieve the goal of this thesis, a main research question must be answered*:*

How can a just-in-time intervention be developed using technology to engage young adults and increase their fruit consumption in a home setting?

To understand relevant timings to intervene, a food choice situation should be defined. Moreover, what sensors to detect the food choice situation should be determined. Lastly, engaging cues to eat fruits must be discovered. Thereby, the following sub- questions are specified:

- What would be a relevant **food choice situation** to intervene in using this technology?

- How can the technology sense the **food choice situation** of young adults in a home setting?

- What kind of interaction or response can be used to engage the users?

To realize this project, the research questions need to be answered by doing some literature research on the related topic. After gaining some insights from the literature, an ideation process will be done using brainstorming and mind mapping approaches to explore potential ideas for this project. Subsequently, an idea will be chosen and specified by creating personas or a storyboard to understand in which scenarios the idea or intervention can be used. Afterwards, a prototype will be created using Arduino boards, sensors (ultrasonic sensors) and actuators (LEDs, a speaker and an LCD screen). Lastly, a user evaluation will be done at the researchers' house, instead of at the eHealth House, due to the Covid-19 pandemic. The fruit intake will be recorded to see if users are more engaged to eat fruits.

Chapter 2 - State of the Art

The state of the art consists of two sections. The first section will explain about literature review on the definition, delivery methods, and applications of just-in-time interventions for health behavioral change. Also, it will describe existing engaging technologies to improve dietary habits. At the end of this section, several studies on fruit intake interventions among young adults will be discussed. The first section of the state of the art was used to understand the existing work related to this project and to give inspiration in creating the most appropriate intervention.

The second section of the state of the art will investigate contextual factors associated with unhealthy eating. There are 4 factors that are going to be discussed: Individual factors, social factors, physical environment factors, and activities. The reason to observe the contextual factors through literature research is that it can be used to define an appropriate food choice situation to offer fruits as healthier alternatives. The second section of the state of the art was used to answer the first sub-question of this research.

I. Just-in-time interventions and technologies to improve healthy diets in engaging ways

The aim of this graduation project is to create a just-in-time intervention to promote fruit consumption in an engaging way. To realize this project, how a just-in-time intervention can be implemented and what engaging elements can be involved in this project, should be investigated. This leads us to the main question of this literature review. *How can a just-in-time intervention be developed using technology to engage young adults and increase their fruit consumption in a home setting?*

To address low fruit consumption among European young adults, a just-in-time intervention can be created, because it has been broadly used for health behavioral change method and has shown significant health improvements for the users [16]. The intervention could be placed in physical environments, such as at home, to detect relevant eating contexts. However, user engagement in this intervention is sometimes overlooked, which makes the use of this intervention unsustainable [17]. Therefore, engaging elements should be incorporated in the just-in-time intervention that will be created to promote fruit intake.

This literature review consists of three parts. The first part will discuss the meaning of just-in-time intervention and its applications for health behavioral change. The second part will present several technologies in a physical environment that engages the users to improve their dietary habits. The third part will discuss several studies that are used to promote fruit consumption among young adults. Finally, the literature review will conclude with how a just-in-time intervention can be used to promote fruit consumption and what engaging elements are needed for this project.

Just-in-time interventions for health behavioral change

Just-in-time interventions have been broadly used for health behavioral changes. Nahum-Shani et al. [14] define a just-in-time intervention as an intervention design that provides supports at the right time and in an appropriate context. Next to that, Nahum-Shani et al. [14] highlight the difference between just-in-time interventions (JITI) and just-in-time adaptive interventions (JITAI) by explaining that the adaptive concept takes into account individual's internal states. For example, JITI would provide supports to remind the user to not drink too much when the person is at a bar, while JITAI would provide supports by suggesting the person, who is at the bar, to stop drinking due to an increasing level of blood pressure [18]. The application of JITAI may lead to some problems, such as unrecorded physiological data, which can cause fatal inaccurate reporting and lack of receptivity because the user is under the influence of the unwanted behavior [19]. Moreover, Lindenberg et al. [20] argue that most of the unwanted behaviors occur due to cues induced by the environment, instead of psychological conditions. According to these papers, JITI may have fewer risks and be suitable to reduce cues induced by the environments.

Just-in-time interventions can be delivered by different kinds of technology. Feldman et al. [21] demonstrate the delivery of JITI using email reminders that are utilized by healthcare practitioners to monitor their patients with heart failure. Besides, JITI can be delivered via mobile apps, which have been broadly used to collect information and provide behavioral health-related services [22]. Due to the prevalence of mobile phone ownership and the high accessibility of mobile apps, more and more people use this kind of technology to give prompts related to health interventions. Another form of JITI deliveries is wearables. Reader and David [23] argue that wearables like smartwatches can support health in everyday living because it has various embedded sensors, such as optical sensors, contact sensors, and accelerometers, to monitor a user's physical activities or physiological measures, and it is increasingly available as a customer device. However, Chang et al. [24] contend that the use of wearable may not be optimal for a JITI, because some people may be reluctant to use this technology due to a lack of data privacy, affordability and user engagement. To sum up, the typical delivery methods for just-in-time interventions are mobile apps, emails, and wearables.

The types of JITI delivery that were previously mentioned have been commonly used in smoking cessation. This usually involves mobile apps to detect contexts that may be associated with cue-induced cravings. Sarker et al. [25] observe that mobile apps can be used to prevent smoking lapses by breaking the urge of smoking in certain contexts. Additionally, Naughton [26] confirms the use of mobile apps for smoking cessation by suggesting the use of GPS on mobile cessation apps to know if the user is at places where the user may be triggered to smoke, such as bars, restaurants or outside the buildings. The mobile apps would remind the user to not smoke in a situation or context that he or she usually links to smoking. Furthermore, just-in-time interventions to address regular smoking can use other technologies, such as wearables. For instance, smoking activities can be detected using wrist accelerometers, which sense puffing gestures or hand-to-mouth movements performed while smoking [27]. It can be concluded that JITI can detect the user's smoking contexts by knowing the user's location and smoking gestures.

JITI can not only be used for smoking cessation but also for encouraging healthy diets. Dorsch et al. [28] investigate the effectiveness of LowSalt4Life, which is a mobile app that provides just-in-time tailored messages to promote low sodium intakes when the user enters a grocery store or restaurant. It allows the user to scan or search for food on the app to find options containing lower sodium content. This would facilitate food choice decisions, so the user chooses a healthier food option. Furthermore, mobile apps are created to prevent people from emotional eating, which may lead to an excessive amount of calorie intake. EmoTree is an app that supports the user to avoid overeating associated with his emotional states by using the self-reporting method [29]. Likewise, Chang et al. [30] analyze emotional eating using prosody speech recognition, which detects the user's feelings through linguistic functions, such as intonation, tone, stress, and rhythm. Therefore, JITI facilitates healthy diet practices by giving prompts depending on the user's location and emotional states.

Engaging technologies for healthy diets in physical environments

Technologies involving user engagement provide interesting opportunities to encourage a healthy diet in children. Kadomura et al. [31] acknowledge the importance of user engagement by involving engaging elements in a product called EducaTableware, which is a smart fork that is designed to engage children to eat healthy food by playing child's favorite song when healthy food is eaten (Figure 1). It uses audio feedback to enhance human-food interaction using computer technology to improve dietary education. It also involves gamification to provide the users with a small reward when they can tolerate the food they do not like or have not tasted, which successfully improves children's dietary habits. Similarly, Lo et al. [13] support the presence of engaging technologies to improve children's dietary habits by developing Playful Tray, which displays users' favorite cartoon characters and games to motivate children to eat healthy food. It uses visual cues to not only make the provided healthy food visible but by making it attractive to its users. The purpose of this product is to cut down the amount of time needed to eat for children due to the distraction of social and noneating-related activities. It also involves gamification on the tray, so the users would focus on the tray where healthy food is also located. Children's engagement in using interventions can be achieved by involving gamification, visual and auditory cues.

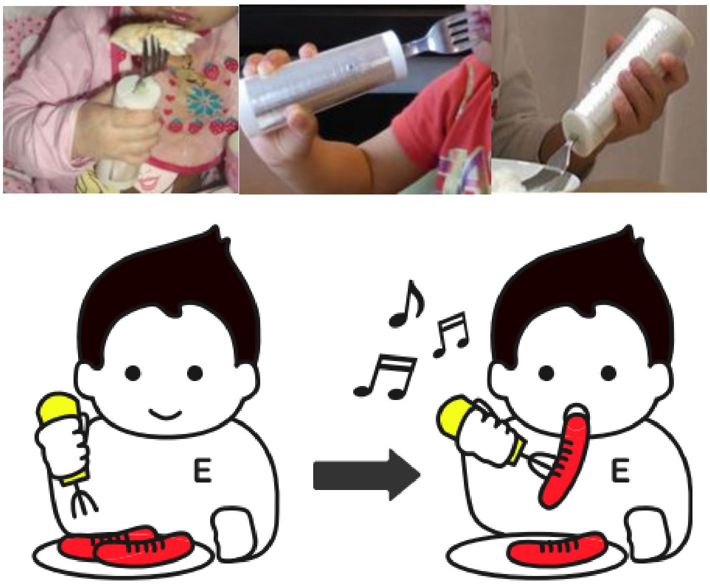


Figure 1: EduTableware engages children using an auditory cue [31].

Engaging technologies in physical environments have not only shown to be beneficial for children, but also for adults to improve their water intake. Chiu et al. [32] evaluate the effectiveness of Playful Bottle, which is made to engage office workers to drink an adequate amount of water involving two hydration games: a single-player TreeGame with a reminder automatically generated by computers and a multi-player ForestGame that involves social reminders by the co-workers (Figure 2). This may allow the workers to not only get reminded by computers but also other workers to stay hydrated. In a similar way, Ko et al. [33] note that Mug-tree successfully encourages working people to drink the amount of water by gamification, connecting water drinking to watering a virtual tree. This involves visual feedback to attract the user to drink a recommended amount of water. According to the two papers, gamification seems useful to improve the water intake for young adults.

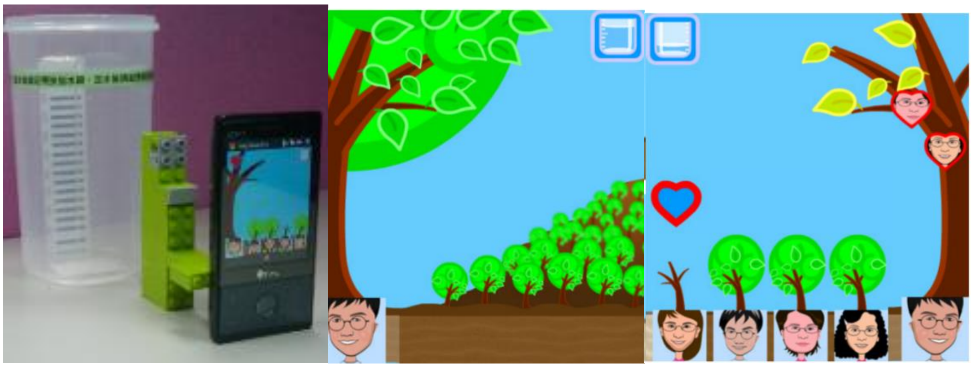


Figure 2: Playful bottle and its gamification [32].

Besides water intakes, engaging technologies can improve young adults' eating habits. Augmented reality has been developed to manipulate the apparent size of food to control user's satiety and food intake through perception [34]. It makes the food looks bigger, so the user feels satiated faster when eating the food. Another technology to encourage healthy eating is an interactive dining table. This dining table display information about the nutritional content contained in the food that is placed on the dining table. It detects foods and their nutritional values using a Kinect and a projector that is mounted above the dining table [35]. The engaging part of this technology is that it has different modes that also allows the user to display a weather widget that is usually utilized by adults and board games like The Settlers of Catan (Figure 3). These flexible and various features could keep the user engaged to use the product.

Figure 3: The features of the Interactive Dining Table [35].

Interventions to increase fruit intake among young adults

Several studies were conducted to improve fruit intake among young adults. One of them is the implementation of email newsletters, computer-based communication, and motivational interviewing to motivate college students aged 18 to 24 years to increase their fruit consumptions [36]. The purpose of this study is to influence college students' decision to eat fruit as recommended by dietary guidelines. This study assessed 4-month intervention, which consists of 4 personalized email newsletters, one session of motivational interviewing, and 2 email contacts during the 4-month period. Next to that, a nutrition website was designed to give guidelines to the students about the fruits' serving size, nutritional value, and preparation tips. To evaluate if this approach works, the questionnaires of fruit consumption frequencies, decisional balance, and self-efficacy were recorded in the initialization and completion of this study. According to this study, email newsletter and motivational interviewing showed a positive skewness on fruit consumption frequencies.

Another study uses general nutritional courses to improve young adults' dietary habits. The courses are done 3 times a week for 50 minutes per session over a 15-week period to increase the nutritional knowledge of students aged from 18-24 years old [38]. The courses covered several topics such as the importance of healthy food, promoting fruits and vegetable consumption, and discouraging the overconsumption of dietary supplements. The participants were interviewed before and after doing the courses to understand the participants' food intake. Additionally, body weight and height were also recorded to know their BMIs. This study reveals that the participants consume more fruits after joining the courses. More than 20% of the participants consumed more than 2 cups of fruit per day at the end of this study.

The last study investigated the effect of physical environment restructuring on fruit consumption. The study examined the influence of fruit's proximity and visibility on fruit consumption in a kitchen setting among college students [12]. The fruits were placed with one of the four conditions: proximate-visible condition (the fruits were served in a see-through bowl within an arm reach of the participant), proximate-invisible condition (the fruits were served in an opaque bowl within an arm reach of the participant), not proximate-visible condition (the fruit were served in a see-through bowl at a 2-meter distance) and not proximate- invisible condition (the fruit were served in an opaque bowl at a 2-meter distance). This study reveals that fruits would be likely consumed if it is proximate (within an arm reach) and visible.

Conclusion

This literature review showed the usefulness of applying just-in-time interventions for health behavior changes in smoking cessation, physical activities, and dietary improvements. It was believed that this intervention design could be used to promote fruit consumption among young adults by offering fruits as a healthy food option in contexts associated with unhealthy food consumption. However, other delivery methods for just-in-time interventions should be explored using other technologies to track the eating context in physical environments.

Additionally, this literature review proved that engaging approaches involving technology in physical environments were not only used for children, but also for young adults. Also, the benefits of these technologies did not differ among these two age groups, because it led to health behavioral changes for both user groups. Therefore, user engagement should be involved in a product that will be created for this graduation project.

This literature review also discussed several studies that address low fruit consumption among young adults. It was discovered that all the listed studies showed fruit intake improvements on the participants. The last study, which investigated the impact of visible and proximate fruits on fruit consumption, could be implemented in this research because restructuring physical environments could be used to facilitate fruit consumption in a home setting.

After just-in-time interventions, engaging technologies, and fruit intake studies were discussed, an appropriate food choice situation needed to be defined. To define an appropriate food choice situation, several contextual factors of unhealthy eating should be investigated because it refers to unhealthy eating situations in which the just-in-time intervention can offer fruits to eat. Hence, the second literature review will discuss the contextual factors of unhealthy eating.

II. Contextual factors related to **food choice situations**

The just-in-time intervention would offer fruits as a healthy alternative in an appropriate food choice situation, which is a situation where people choose the food they want to eat. An additional literature review may be beneficial to give insights about an appropriate food choice situation, which is related to contextual factors. A insights into contextual factors leading to unhealthy diets must be discovered because it tells us in which contexts are associated with unhealthy eating, so we can offer fruit as a healthier food option. Contextual factors can be seen from multiple levels, such as individual, activities, social and physical environments. This leads us to the main question of this literature review *what would be a relevant food choice situation to intervene associated with contextual factors influencing unhealthy diets among young adults in a home setting?*

This review consists of four parts. The first section will discuss the individual factor of unhealthy diet among young adults in a home setting. The second section will focus on the social factor of unhealthy diet at home. The third and the fourth section will give insights into the influence of physical environments and activities, respectively. In the conclusion, all the factors will be summarized, and a relevant food choice situation will be defined.

Individual Factors

An unhealthy diet in a home setting is affected by individuals' negative affect and low self-control. Elliston [42] argues that people with negative affect, such as angry, bored, irritable, restless, sad, and stressed, tend to consume a higher amount of energy-dense snacks as their coping mechanism. Additionally, in a different journal, Elliston [43] mentions that negative affect might lead to self-control failures, which increases the likelihood of eating unhealthy snacks as they are unable to resist food temptations. Low self-control may also lead people towards unhealthy diets. McMinn [44] claims that individuals with weak executive control, eat fewer healthy snacks, such as fruits and vegetables.

Although individuals' negative affect and self-control are relevant, it is still controversial whether they should be considered as the main determinants. Eliston in his research [43] reveals that self-regulation and individuals' negative affect are not significant predictors for low-energy snack intake. Likewise, Schoeppe [11] demonstrates how existing interventions focusing on self-control, such as dietary apps, are unable to show significant changes in unhealthy snack consumption. Therefore, it can be concluded that self-control may not be the main predictor of unhealthy eating according to the literature found in this review.

Social Environments

Social context possibly increases the energy-dense snack intake. Gehrt [45] argues that people that eat alone will be more motivated to eat or snacks healthily. Furthermore, Schoeppe [11] speculates that people who have higher social interactions tend to eat a higher amount of energy-dense snacks. This undesirable behavior occurs because it is considered more appropriate to snack unhealthily on social occasions [45]. Also, the social modeling effect, which is an effect of observing the eating behavior of other people, is the cause of this unhealthy diet [6]. If people eat unhealthy snacks in a social event, others will follow the unhealthy eating pattern. Therefore, social context is believed as one of the factors of an unhealthy diet.

Although the social context is perceived as an unhealthy diet predictor, the idea of social interaction influencing unhealthy eating habits is still debatable. In contrast to Gehrt, Ellison [42] notes that eating alone increases the frequency of unhealthy snacking in a home environment, due to a mood-regulation effect, which is associated with being socially isolated. Besides, Laska [46] refutes the notion of social influence on snacking by revealing an equal number of eating occasion occurrences when people are alone or with friends at home. In other words, snacking behaviors will happen regardless of whether there are social interactions or not. Allan et al. [47] have conducted a survey regarding their social context while snacking unhealthy food. According to his research, it is found that more than 40% of the participants eat unhealthy snacks when they are alone, while only 20% of the participants eat unhealthy snacks with family and friends. Hence, the social context in this study does not seem to be the most important contextual factor that needs to be addressed using the intervention.

Physical Environments

One of the contextual factors of an unhealthy diet is a food environment, which consists of 4 different aspects: the availability, accessibility, visibility, and scent of unhealthy food. Ellison [43] observes that the availability of unhealthy food can increase the likelihood of eating unhealthily, as it increases the temptation to snack. In addition, Mithra [48] reports that easy access to fast-food outlets in a geographical area will increase the fast-food consumption of the inhabitants that live close to it. Thus, not only the availability of food but also the accessibility of food influence unhealthy diets. The visibility and odor of food will also engage people to eat or snack. Elliston [42] outlines that the visibility and the scent of food will attract people to eat it. Therefore, food environments can potentially be modified to facilitate healthy eating habits.

Environmental factors of unhealthy snacking in a home setting not only cover food environments but also eating time. Laska [46] observes that people eat high-sugar snacks mostly in the afternoon from 11 am till 7 pm. Gehrt [45] also agrees that individuals consume more snacks in the afternoon to compensate for irregular eating patterns that most of the time occurs because they miss breakfast. To summarize, by acknowledging the time of snacking occasions, an intervention can be created to offer healthier food to young adults at home.

Activities

Computer-related tasks are sedentary activities that promote snacking behavior. Allan [47] investigates that watching TV is a typical snacking situation in a home setting. Likewise, McMinn [44] explains that watching TV is detrimental to health because of the lack of physical activities and a higher association with unhealthy snacking. The unhealthy snacking while watching TV is caused by automatic behavior and mindless snacking. To paraphrase, people who regularly snack while watching TV focus more on the subject of TV shows, instead of the portion and the content of snacks. Other computer-related tasks, such as phoning and video gaming, can also potentially influence snacking behaviors. Mithra [48] argues that video gaming and phoning showed a strong association with snack cravings. To conclude, sedentary activities, especially watching TV, can potentially engage people to consume unhealthy snacks.

Cognitive working is related to snacking in home environments. Mithra [48] Argues that energy-dense snacks are usually consumed while studying. Due to insufficient papers that discuss the relationship between cognitive working and snacking, it can be interpreted that cognitive working might have a slight association with unhealthy snacking.

Conclusion

In this literature review, physical environments and activities seemed to be the main determinants of unhealthy diets. The availability and accessibility of unhealthy snacks were most of the time highlighted, so there was a necessity to make healthy food available and accessible, instead of the unhealthy ones. In addition, computer-related activities which are mostly done at home, such as watching TV and working, could engage people to eat unhealthy snacks. Therefore, it is important to give supports in computer-related contexts by providing fruits that are highly accessible and available.

Although the discussion of this literature review seemed limited because it did not explore all possible eating contexts or food choice situations, the findings of this review can be used as a starting point for defining an appropriate food choice situation. For example, an intervention could be placed in the living room to promote fruit consumption, so the intervention would offer fruit while people are watching TV because it is associated with unhealthy eating.

Chapter 3 - Methods and Techniques

This section explains the general methods and techniques to address low fruit consumption among young adults in a home setting. In this graduation project, the Creative Technology Design Process was used as a research method. As illustrated in Figure 7, The Creative Technology Design Process (CTDP) consists of 4 phases: Ideation, Specification, Realization, and evaluation [49].

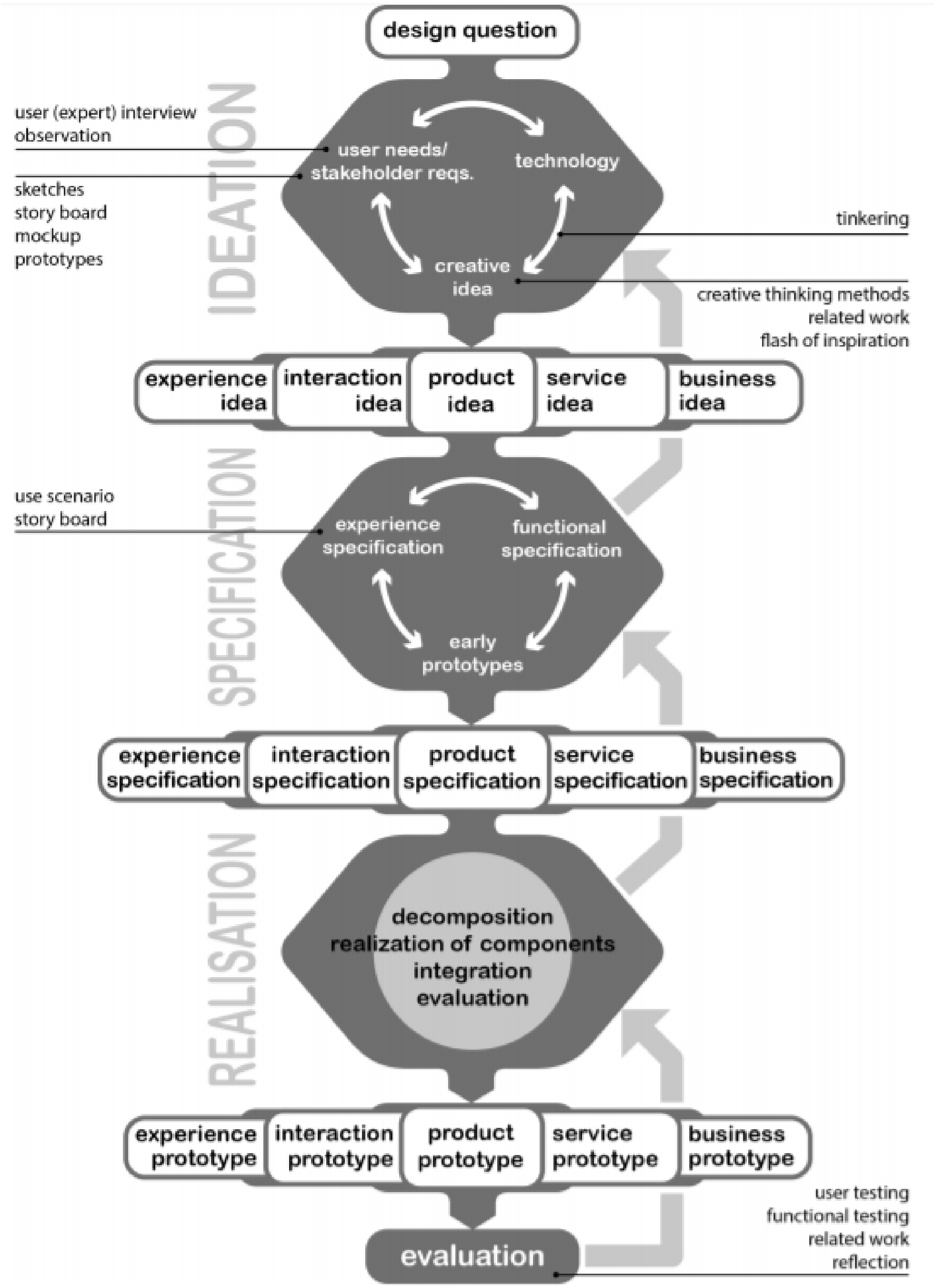


Figure 4: The overview of Creative Technology Design Process [49].

I. Ideation

In the ideation process, brainstorming, tinkering, and mind mapping were used to explore ideas. To understand the problems and needs of the target group, informal interviews as well as the first section of the state of the art were used for inspirations. After a lot of creative ideas were discovered, the best idea was chosen and it was specified in the next section.

II. Specification

The second phase is specification. In this phase, the user scenario was specified by creating personas and a storyboard. The second section of the state of the art, which discussed an appropriate food choice situation, was used as a starting point for determining the specific scenario.

III. Realization

After the idea was chosen and specified, a prototype was made to realize the idea. This involved several electronics, such as Arduino Boards, sensors (ultrasonic sensors) and actuators (LEDs, an LCD screen, and a speaker). Ultrasonic sensors were utilized to detect the food choice situation. The pressure sensor was used to measure the fruit intake. Lastly, the actuators were used to deliver the just-in-time intervention and engage the user to eat fruits.

IV. Evaluation

The user evaluation was conducted at the author’s house. The participants were situated in a living room setting together with the just-in-time intervention. The aim of this evaluation was to investigate whether the fruit facts, visual and auditory cues incorporated in the intervention can engage young adults to consume more fruits. The fruit intake was reported by the participants by means of a messaging app. The participants needed to fill in a questionnaire at the beginning and at the end of the evaluation. Additionally, an interview was conducted to understand their user experience in detail.

Chapter 4 – Ideation

This chapter will explain about the ideation process of this graduation project. The process consists of 3 parts: brainstorming, tinkering and mind mapping. In the brainstorming session, 50 ideas related to a just-in-time intervention and fruit consumption were listed. Then, a few ideas were chosen and combined to create the intervention. In the tinkering session, several existing technologies were listed as inspirations to realize the prototype. The purpose of this process was to find a way to implement the idea using existing technologies and to evaluate whether the idea was technically feasible to create. The mind mapping gave insights about how to incorporate user engagement in the intervention.

I. Brainstorming

Brainstorming is a popular process of generating creative ideas involving 4 rules: a) emphasizing on the quantity of ideas b) welcoming freewheeling c) excluding criticism and d) combining or improving ideas [50]. In this brainstorming process, 50 possible ideas related to fruit consumption among young adults were listed by the researcher. The purpose of this was to generate as many ideas as possible to discover creative approaches to promote fruit consumption among the target group.

The ideas that were discovered in this brainstorming session were inspired by the state of the art (related work) and informal discussions with fellow students. The creative ideas were also discovered by imagining how existing objects or technologies could potentially be used to deliver just-in-time interventions. For example, a fruit bowl that suggests the user to eat fruits in the living room or a fork that detects the user's fruit consumption.

Results

The result of the brainstorming session is shown in Figure 8 (more details are in Appendix A). The ideas that were put on the yellow post-it note involved existing technologies, such as apps, robots, smart appliances, and wearables. The blue and green post-it notes involved uncommon and new technologies, such as holograms, a Tamagotchi, a smart fruit bowl, a smart door, and a smart table. The pink post-it notes involved gamification, such as a fruit ninja game and a harvesting fruits game.

Figure 5: The result of the brainstorming session.

The ideas mostly involved objects or technologies that can be found at home to deliver just-in-time interventions, such as a fruit bowl, a fork, a TV, a speaker, a table, a picture frame, a couch and a pen. Existing JITI delivery methods were also incorporated in generating ideas, such as apps, wearables, and robots. Not only the technologies, but different kinds of user engagements were also explored. The user engagements were gamification, and visual and auditory cues. The gamification was inspired by the existing games related to fruit consumption such as a feeding animal game, a fruit ninja game, and a harvesting fruit game. Other engagement elements were also considered, such as a reward and leaderboard system, quizzes or riddles, a fat avatar of you and a social fruit intake comparison.

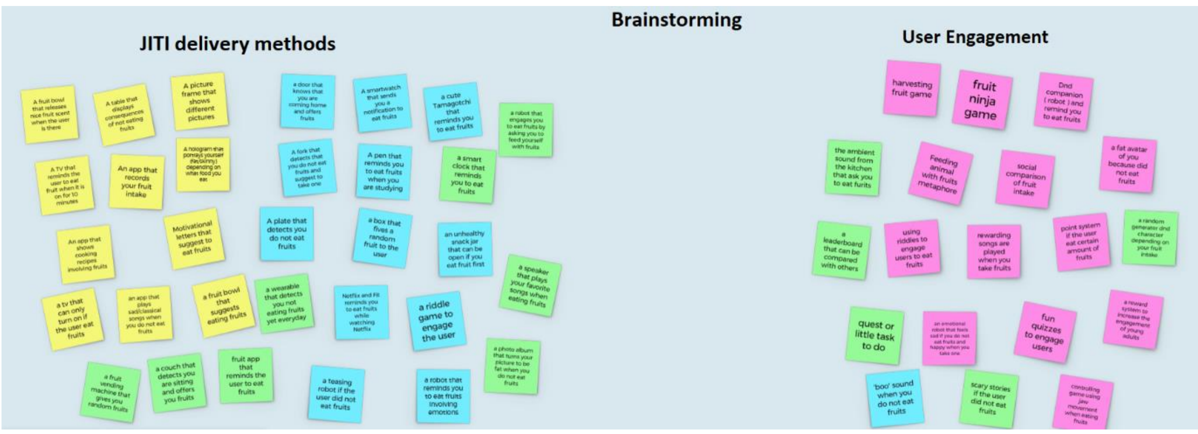


Figure 6 : The categorization of the brainstorming ideas

After the ideas were categorized, the top 12 ideas were chosen from the two categories (6 JITI delivery methods and 6 user engagements). The ideas were chosen by considering the uniqueness and effectiveness of the application and the feasibility to create such just-in-time interventions out of it. The top 12 ideas are listed in Table 1.

Table 1: The top 12 ideas of the brainstorming session

The top 12 ideas	
JITI Delivery Methods	**User Engagement**
1. A photo frame that change the user's photo to be fatter when the user does not eat fruits.	7. Fruit ninja game to increase user engagement.
2. A fruit vending machine that suggests the user to eat fruits and gives random fruits.	8. A fat avatar of the user
3. Netflix&Fit, detects the user watching Netflix.	9. Social media involvement
4. A smart fruit bowl that suggests the user to eat fruits.	10. Riddle games or quizzes to engage the user to eat fruits.
5. A smart unhealthy snack jar that can be opened only if the user eats fruits first.	11. A animal feeding game
6. A smart plate that detects that the user does not eat fruits.	12. Creating a harvesting-fruit game.

Based on the 12 ideas that were found, a smart fruit bowl and Netflix&Fit were chosen and combined to deliver the just-in-time intervention. Additionally, a riddle game was chosen to engage the user. A smart fruit bowl was chosen to deliver a JITI because it is used to store or provide fruits to people living in a house. Netflix&Fit was chosen because watching movies on watching platforms like Netflix, is associated with the consumption of unhealthy snacks, such as ice cream, chips, and soft drinks [47]. Therefore, it would be an appropriate situation to offer fruits while watching Netflix, so the user would eat fruits, instead of unhealthy snacks. Next to that, a riddle game or quiz was chosen for user engagement because the implementation is easy, and it may be fun for young adults. A quiz as a gamification approach has been used to not only enhance learning processes, but also increase young adults' enjoyment and engagement [51].

However, before realizing and going deeper into these three ideas, the technical aspects of the ideas needed to be evaluated to determine if they were either technically feasible to be created and implemented. To understand more about the technical aspects and resources of the chosen ideas, the tinkering process had to be done. In that process, several existing and available technologies, which consist of sensors and actuators, were linked to the ideas, in such a way that they could be utilized to realize the idea. The tinkering process is explained in the next section.

II. Tinkering

Another ideation method was used to link the existing technologies to the chosen ideas to evaluate if they were feasible to implement or not. To do this, the tinkering method was used. Tinkering is a part of the ideation process, which is applied to identify novel applications for existing or new technology [49]. The purpose of the tinkering process was to explore how the existing or new technologies can be used 1) to create a smart fruit bowl that suggest fruits to the user, 2) to detect if someone is watching Netflix, and 3) to make a riddle game.

Results

Several technologies or electronics were listed in order to realize the three ideas. The scheme is shown in figure 10. The arrows represent the transmission of information. The information is usually obtained from software and sensors, and delivered to actuators, such as an LCD screen, an LED strip and a speaker.

As illustrated in figure 10, an LCD screen, an LED strip and a speaker would be used as media to display the riddle game and remind the user to eat fruits. A load cell would be used to measure the fruit intake by weighing the available fruits in the bowl. Buttons would be used to control the game and Processing would be used to create the game itself. However, existing and available technologies to detect if someone is watching Netflix or not could not be identified. Therefore, this intervention might need to be adjusted.

Although it might be difficult to detect if someone is watching Netflix specifically, some technologies, such as LDRs (Light Dependent Resistor), microphones and infrared sensors, can be used to detect if a TV is on. Therefore, the intervention would be created to detect if someone is watching TV, instead of Netflix. The new schematic overview of the intervention is illustrated in figure 11.

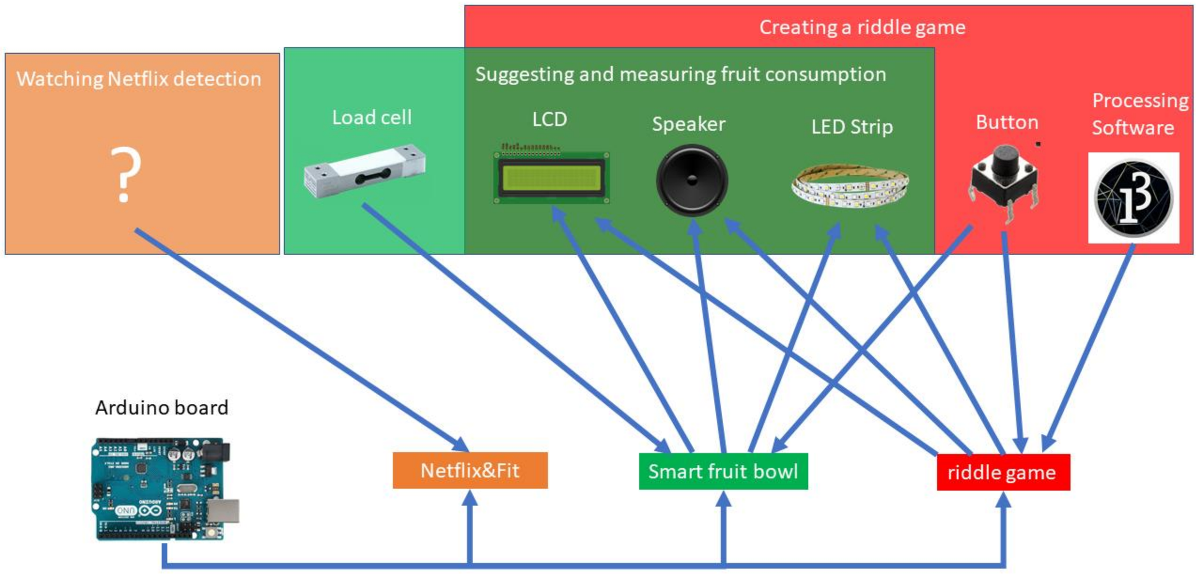


Figure 7 : The schematic overview of existing technologies that can be used to implement the chosen ideas.

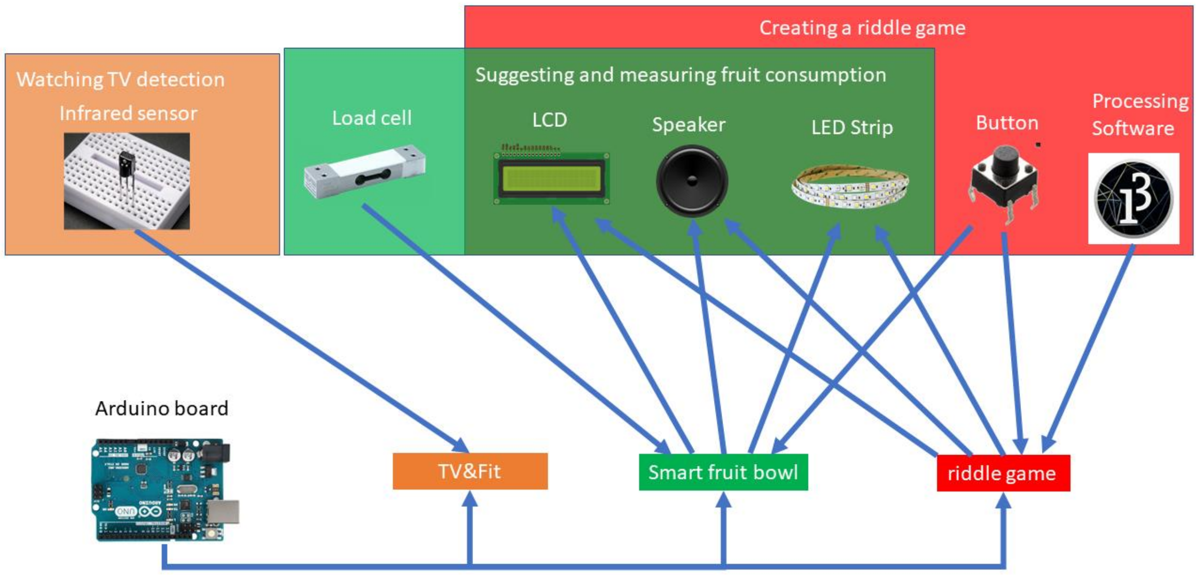


Figure 8: The schematic overview of the existing technologies to implement the improved ideas.

An Infrared sensor was used because it is more reliable than an LDR. An LDR detects the intensity of light that is emitted from the TV. The light detection could be interfered by the lights from the environment, such as a lamp and sunlight. Similarly, using a microphone to detect the sound of a TV might not be optimal because it may capture other sounds from its surroundings. The infrared sensor would be utilized in the intervention because it could only be triggered once the user uses a TV remote control, which also uses infrared. In other words, when the user turns on the TV using a remote control, the sensor will detect that someone is going to watch TV and send a signal to the smart fruit bowl to promote fruit consumption in that particular situation.

After all the technical aspects have been considered, it is important to understand what to do with the riddle game and what other engagement aspects must be involved to engage the user eating fruits. To explore the engagement aspects, mind mapping will be used as an ideation method in the next section to find the engagement aspects for the intervention.

III. Mind mapping

The implementation of the riddle game in this intervention was not only to sustain the use of the intervention by the users, but also to engage the user to eat fruits. Therefore, the user engagement that would be involved in this game was identified. Mind mapping is defined as a 'visual and non-linear representations of ideas and their relationship' (p.3) to find creative associations between ideas [52]. This approach may be useful to explore the engagement aspects for this project because it has an unconstrained structure that allows the researcher to search deeper into the user engagement for young adults.

Results

The mind map of the user engagement is illustrated in figure 12. There were 5 approaches that could be incorporated in the riddle game: a narrative, social aspects, a progress measurement, a reward system, and teasing the user if he cannot answer the question correctly in a fun and playful way. First, an interesting narrative aspect in the riddle game may motivate people to keep playing the game or to reach the goal of the game, which could engage people to eat fruits. Second, the social aspects of the game could be done by doing social competition and collaboration. Additionally, social pressure and status may also intrigue the use of the game. Third, the measurement of progress could be involved in the riddle game to show what the user has achieved. This could be done in several ways, such as displaying points, leaderboards, badges and levels. Fourth, rewards could be given depending on certain milestones, for example, saying "Congratulations" or giving an incentive like the actual provided fruits to the user, if he solves the riddle correctly. The last approach is teasing the user if he loses the game. It should not be delivered in a harmful, insulting or punishing way, but rather in a humorous, playful, or fun way.

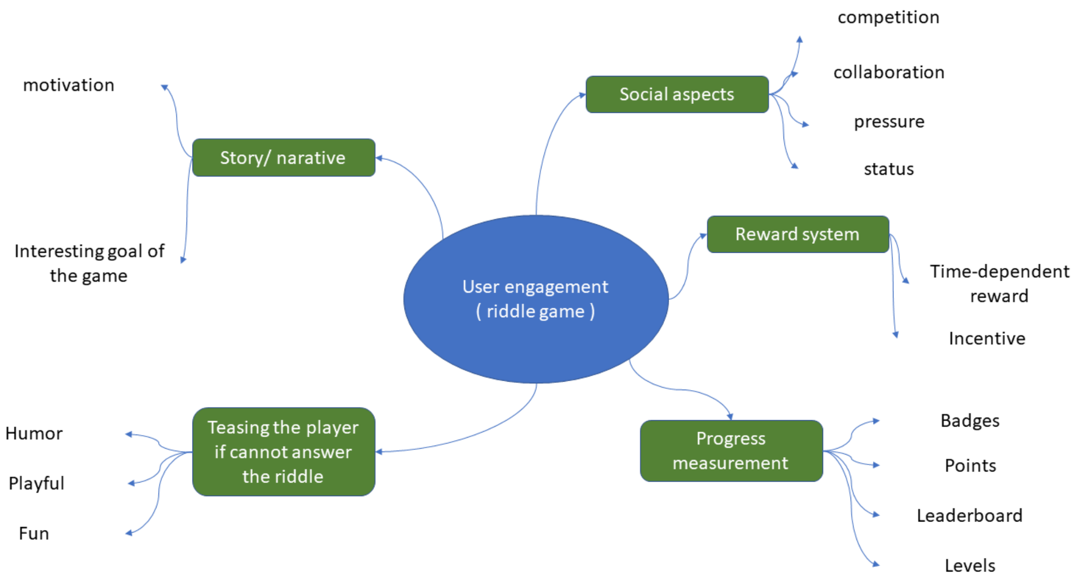


Figure 9: The mind map of user engagement.

Only 2 out of 5 approaches were chosen and used in the riddle game. The reward system and teasing approach were chosen because it is easy to implement, and it may effectively engage people to eat more fruits. This is how the riddle game works with its engaging approaches. The intervention will ask the user to play the riddle game. If the user could solve the riddle correctly, it would give fruits as a reward. Otherwise, it would tease the user in a humorous way and suggest the user to eat fruits.

IV. Conclusion

By combining and refining ideas using brainstorming, tinkering and mind mapping methods, a final idea was chosen. The final idea was a smart fruit bowl that reminds the user to eat fruits in an engaging way using riddle games when the user watches TV. The scheme of TV&fit is shown in figure 13.

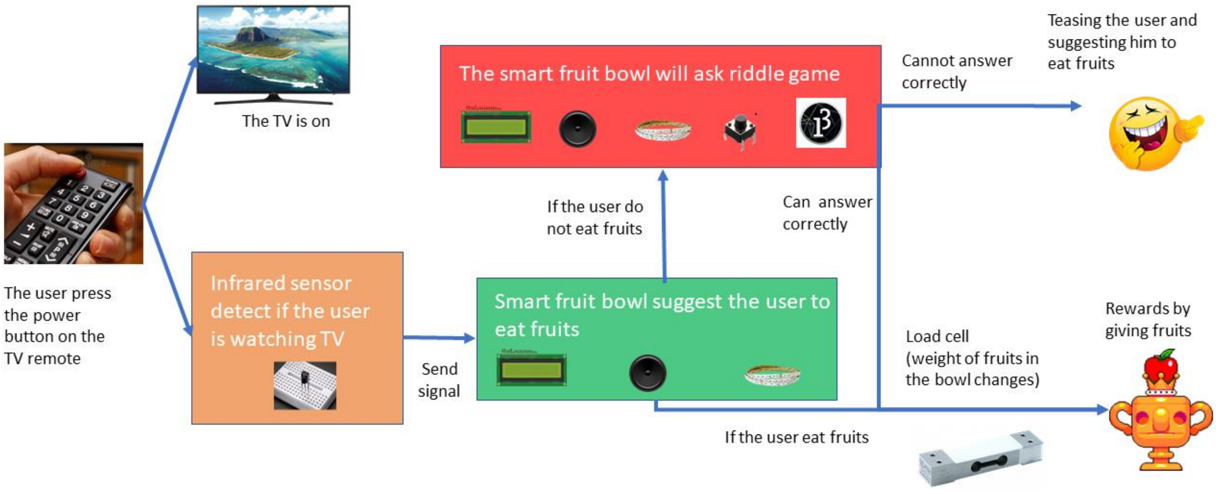


Figure 10 : The scheme of the final idea.

In this concept, the infrared sensor would detect if someone is using a TV remote control. Then, the sensor would give a signal to the smart fruit bowl to give a notification that recommends the user to eat fruits. If the user takes the fruits provided in a smart fruit bowl and the load cell detects the weight changes on the fruit bowl, the user would get rewards (saying "good job" or "congratulations"). If the user ignores the notification, the smart fruit bowl would display the riddle game on the screen that is attached to the front part of the fruit bowl. If the user can answer it correctly, the user would be given fruits as a reward through communication, for example, "Please have some fruits, you deserve it.". Otherwise, it would tease the user and suggest the user to eat fruit for increasing their cognitive performance.

In the next chapter, this concept will be specified using personas and a storyboard to determine the user scenario and functionality of this concept.

Chapter 5 – Specification

After deciding on the idea of the smart fruit bowl, the user experience and functionality of this fruit bowl were further specified. A story board was created to understand the user experience and scenario of the interaction using the smart fruit bowl. Subsequently, to achieve the corresponding user experience and interaction of the smart fruit bowl, the functionalities of the smart fruit bowl were specified. The functionalities were specified using the MoSCoW analysis. Finally, the 3D design of the smart fruit bowl was shown to visualize the functionality specification that was identified.

I. User Experience

The smart fruit bowl was specifically made for the researcher's housemates. To get insights on the user experience of the smart fruit bowl, a story board was created as illustrated in figure 14. The story board illustrated the interaction between the user and the smart fruit bowl and how this interaction could lead to an increasing fruit intake. The smart fruit bowl gives a just-in-time reminder or notification to eat fruit when the user is watching TV in the living room. If the user does not respond to this by taking a piece of fruit, the smart fruit bowl would ask the user to play a riddle game, which may engage the user to eat fruits.

Figure 11: The story board of the smart fruit bowl.

II. Functional specification

The smart fruit bowl should have a number of features to provide the user experience described above. To analyze the most important features to create in this project, the MoSCoW method was used. In the MoSCoW method, several features were grouped into 5 categories according to its priority and relevance [53]. The categories are must have, should have, could have, won't have (but would like in the future) items. The result of MoSCoW analysis, its rationale and relevant technology are shown in table 2.

Table 2 : The listed features and its design priorities.

Design Priorities	Features	Rationale	Technologies
Must have	Just-in-time reminder	The purpose of this project is to create a just-in-time intervention, which involves a reminder.	Using LED Strips for visual cues and speakers for auditory cues.
	Food choice situation detection	To notice the appropriate situation (watching TV) where just-in-time reminders are given.	Using Infrared sensors to detect the use of TV remote control.
	Riddle game	The riddle game must be created to engage the user to eat fruits. User engagement is also part of the main research question in this project	The riddle game can be created using Processing software and displayed on an LCD screen
Should have	Speech recognition	This feature would help the user to interact with the smart fruit bowl.	Using microphone and speech recognition program.
	Fruit intake tracking	Although the fruit intake tracking is not a vital feature, it can add a significant value to notice if the user takes a piece	Using a load cell to detect if a fruit taken from the smart fruit bowl.

		of fruit from the smart fruit bowl.	
Could have	Different emotions of the smart fruit bowl	The different emotions of the smart fruit bowl can be used to attract the user or make the user guilty.	The emotions can be displayed on an LCD screen.
Won't have (But would like in the future)	Fruit recognition	The fruit recognition feature is not a priority for this graduation project because it does not have any added values in answering the research questions of this project. However, it would be nice to implement for future research.	Using a camera integrated with object or color recognition program.
	Personalized fruit intake tracking	It may also be nice if the smart fruit bowl involves personalization, meaning that the fruit bowl notices which person takes fruits from the fruit bowl. However, this feature is not related to the research questions in this project.	Using RFID tags or facial recognition program.
	Reminder to refill the fruit bowl	This feature is nice to have. However, it is not important and relevant in this project.	Using a load cell to detect how much fruits in the bowl and a voice prompt to remind the user to refill the smart fruit bowl.

To summarize the result of the MoSCoW method, this project will prioritize the 'must have items', namely just-in-time reminder, food choice situation detection and riddle game. These features are chosen because it is in line with the research questions that need to be answer in this project. If the ‘must have items’ have been created, other features will gradually be built according to the design priorities.

III. 3D design of the prototype

The 3D design of early prototype was created by considering the user experience, design priority and behavioral change technique, as showed in figure 15. This 3D design was used to visualize the concept of the smart fruit bowl in detail and more specific. In this 3D design, a touch screen was attached in front of the fruit bowl, which display different expressions and the riddle game. An LED strip was placed on the circumference of smart fruit bowl. A load cell was put inside the smart fruit bowl to measure the weight of fruit on top of it. Two speakers were attached on the front part of the smart fruit bowl. This 3D design was shown during lo-fi prototype testing with the target group to help the participants visualize and understand the concept of the smart fruit bowl.

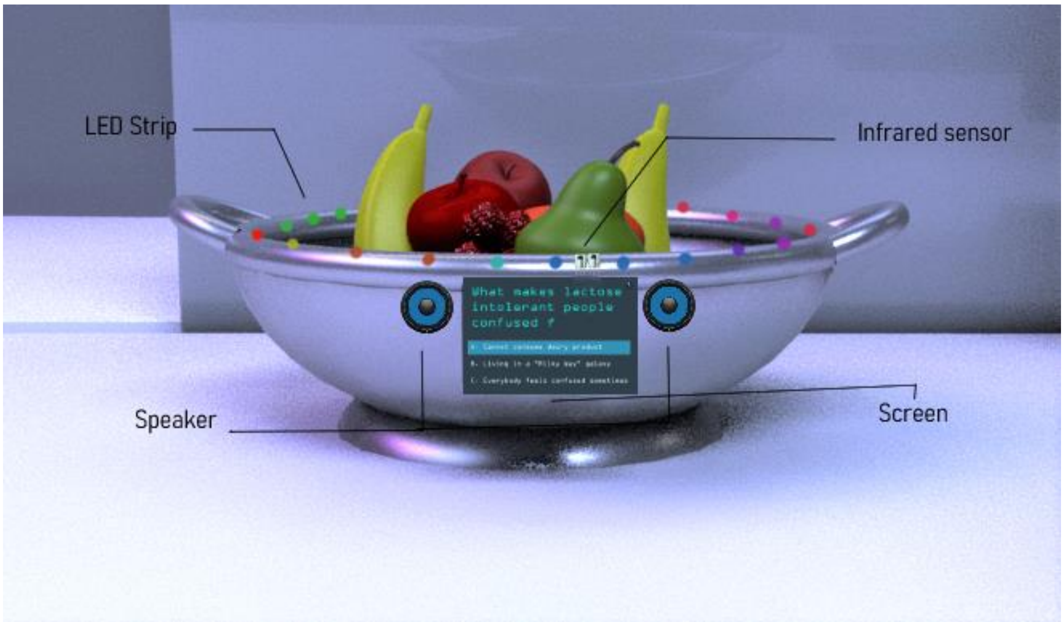


Figure 12 : The 3D model of smart fruit bowl with different emotions.

Chapter 6 - Lo-fi Prototype Testing

In the lo-fi prototype testing, a pen-and-paper prototype, which is a prototype that is drawn on paper, was confronted with the participants, who are young adults. The purpose of this testing was to validate the concept and improve the features of the smart fruit bowl. The participant was situated in a living room where they usually watch TV, together with the prototype. The participants were asked to do several tasks related to the usability and features of the prototype, such as activating the just-in-time reminder and playing the riddle game. After the participants finished the tasks, they were interviewed and asked to fill in a questionnaire to understand what they thought about the concept and how it could be improved. The participants' feedback was incorporated in to the hi-fi prototype of the smart fruit bowl.

I. Participants

Two participants were involved in this user study. The participants are young adults (19-30 years old), who do not have fruit allergies, dietary restrictions and eating disorders. They were recruited among the researcher's housemates. The participants were approached by asking them in person to participate and by explaining what the study is about, both spoken and written using the information brochure (see Appendix B). Then, they were asked to sign the consent form (see Appendix B) if everything is clear and they agree to participate.

II. Methods

After the participants read the information brochure and filled in the consent form, the researcher explained the purpose of the study and the tasks verbally, so the participants could understand and test the prototype. Subsequently, they were confronted with the lo-fi prototype. The lo-fi prototype consisted of a regular fruit bowl and paper to display the interface. The lo-fi prototype is illustrated in figure 16. Each participant would test the smart fruit bowl. The participant could touch the paper to show the interaction with the prototype. The interaction was operated manually by the researcher.

Figure 13: The lo-fi prototype and the user-interface interaction.

The lo-fi prototype was situated in the living room together with the participant. The participant sat on the couch facing a small table and a TV. On the small table, the prototype and a TV remote were placed. The living room setting is illustrated in a 3d model in Figure 17. The participant was first asked to fill in a pre-event questionnaire to obtain their personal information, such as initials, age, and to understand their eating habits and fruit intake (see Appendix C).

Figure 14: The 3d design of the setting of the lo-fi prototype testing.

After the pre-event questionnaire was filled in, the participant was asked to do several tasks related to the usability and usefulness of the prototype to engage young adults to increase their fruit intake. The tasks are:

- Figure out how to activate the just-in-time reminder
- Interact with the smart fruit bowl by playing the riddle game on the interface

- Choose to take fruit from the smart fruit bowl

After the tasks were completed, the participants were asked to fill in the post-event questionnaire (see Appendix C). The questionnaire contains questions about the effectiveness of the just-in-time reminder, the appropriate food choice situation, and the user engagement involving the riddle game to engage young adults to eat fruits. An interview was also conducted to understand the user's need and experience deeper.

III. Results

The results of the pre-event questionnaire showed that both participants have different fruit consumption behaviors. It was found that one of the participants believed that eating a recommended amount (200 grams) of fruits is important to stay healthy, but Participant 1 did not eat the recommended amount of fruits nor were actions taken to increase fruit consumption. On the other hand, Participant 2 thought that eating the recommended amount of fruits is not important, because vitamins could be obtained from other food sources. Additionally, Participant 2 mentioned that eating one piece of fruit per week was good enough. Participant 2 did not eat the recommended amount of fruit nor took actions in increasing fruit intake.

When testing the lo-fi prototype, the participants completed the tasks relatively quick. They thought that the just-in-time reminder activation, which was by turning on the TV using a remote control, was straight forward. They understood the use of the just-in-time reminder to eat fruits while watching TV. They also thought that this approach might lead young adults towards a higher fruit consumption.

Additionally, the participants gave insightful feedback related to the concept of the smart fruit bowl. Participant 2 said that the just-in-time reminder and riddle game were good, but it should make the user feel guilty so they would consume more fruits. On the other hand, the Participant 1 mentioned that the just-in-time reminder would be better if the reminder was prompted on certain times to create a habit or routine of eating fruits (for example, the reminder is given between breakfast and lunch time, and between lunch and dinner time).

Regarding the food choice situation (watching tv), both participant argued that placing the smart fruit bowl in the kitchen or on the dining table would be better, because they barely went to the living room and went to the kitchen more often to get food.

Both participants argued that the riddle game was not engaging in the long term because it would get boring over time. Participant 2 said that it would work for children but not young adults. It should contain funny riddles and sarcastic jokes to engage young adults to eat fruits. Participant 1 suggested to include fruit fun facts as the user engagement. Participant 1 also thought that the interface could contain emotions and more audio cues, rather than just a screen that has text that suggests to the user to eat fruits.

The participants gave additional recommendations for the concept of the smart fruit bowl. Participant 2 recommended that the fruit bowl could be placed in the bedroom, because the ideal place to give reminders to eat fruits is where the participants spend their time the most. Participant 1 gave a further recommendation of using color recognition to detect what fruits are available or if the smart fruit bowl is empty. If there are no fruits available, the smart fruit bowl could remind the user to buy fruits. Furthermore, Participant 1 said that by implementing this, the participant could get reminded to buy more or different fruits.

IV. Conclusion

Some of the feedback from the participants in this testing was incorporated in the design of the smart fruit bowl to engage young adults to eat fruits. According to the feedback, it would be more effective if the smart fruit bowl detects the people's presence around the dining room, instead of detecting if someone is watching TV in the living room, because the participants usually go to the dining room, instead of going to the living room. Furthermore, the dining room is also a place for the users to get and eat any kinds of food, so the fruit bowl can prevent or remind the user to eat fruits, instead of unhealthy food.

The riddle game in the smart fruit bowl will be replaced with fruit facts because it may have a direct impact towards fruit consumption. The fruit facts could give the user reasons to eat fruits, which may increase the user engagement and motivation to consume more fruits.

There were two additional features that would be implemented in the smart fruit bowl based on the testing. First, to reduce the redundancy of the just-in-time reminder that is prompted every time the user passes by the dining room, the just-in-time reminder could be given at certain times to help the user creating a habit or routine of eating fruits. Second, fruit recognition would be a valuable addition to detect if the user takes the fruits from the smart fruit bowl.

The hi-fi prototype of the smart fruit bowl was built by incorporating the users' feedback from the lo-fi prototype testing. Instead of placing the smart fruit bowl in the living room to detect if someone is watching tv and to offer fruits or to display a riddle game, the smart fruit bowl was placed on the dining table to detect the user's presence and to give a notification as well as a fruit nutritional fact to the user. These changes were made because the riddle game was not that engaging and the user barely watches tv in the living room, which means that it might not be the most appropriate situation to intervene.

Chapter 7 - Realization

In this chapter, the steps of creating the hi-fi prototype are explained. The materials needed were first explained. Then, just-in-time reminder were created by involving visual and audio cues. After that, the food choice situation detection was creating by involving an ultrasonic sensor. Fruit color recognition was also explained but not used in the final design because it might not be reliable to detect fruits color which could be easily influenced by the ambient light. Finally, all the functional components were integrated to create the smart fruit bowl.

I. Materials

The electrical components that were used to create the smart fruit bowl are:

- 2 Arduino boards.
- A mini MP3 player module.
- A speaker.
- A programmable LED strip.
- 2 ultrasonic sensors.
- A TFT LCD shield.
- Wires.
- 2 power banks.
- A breadboard.
- A laptop.

Other components are also needed, such as:

- A fruit bowl.
- A piece of ring-shaped wood to attach the led strips.
- A stick to attach the ultrasonic sensor.
- A cardboard.
- Tapes.
- A wooden plate to cover the electrical components in the smart fruit bowl.

II. Just-in-time reminder

The just-in-time reminder was made by involving visual and auditory cues. The visual cues were created using an LED strip and an LCD screen. The auditory cues were prompted using A mini MP3 player shield.

Visual cues

a) LED Strips

An LED strip was used to remind the user to eat fruits. The LED strip must be prompted once the user passes by the smart fruit bowl. the LED strip was placed around the smart fruit bowl. To do that, a piece of ring-shaped wood was needed to attach the LED strips. Because the ring-shaped wood was not available, a 3D printer was used to create the ring. Then, it was put on top of the smart fruit bowl. The figure of the LED strip is shown in figure 18.

The LED strip program was made using an Arduino library called "FastLED" (source see Appendix D). By using this library, different LED colors can be displayed.

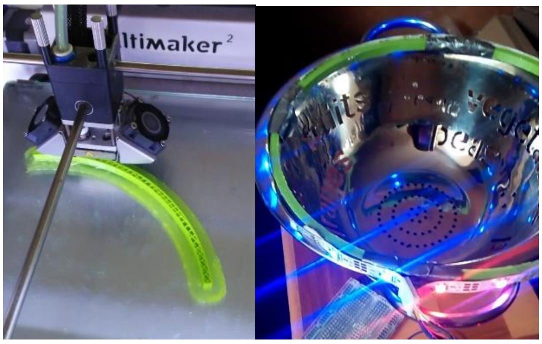


Figure 15: The 3D printed ring and an LED strip.

b) LCD screen

Similar with the LED strip, a TFT LCD screen was used to give a visual cue to the user to eat fruits. The TFT LCD screen was meant to be triggered once the user passes by the smart fruit bowl. This means that the LCD screen should be connected to the food choice situation detection. Because the LCD screen is a shield, another Arduino board was needed, and it should communicate with the other Arduino. This could be done by using I2C communication (Inter-Integrated Circuit) by connecting the ground, pin A4 (the data or SDA pin) and A5 (the clock or SCL pin) of one Arduino to the other one (https://www.arduino.cc/en/Tutorial/MasterWriter). However, pin A4 was used as display pins for the LCD shield, thus could not be used to communicate data with the other Arduino. So, the LCD shield ran its program independently without being triggered by the food choice situation detection program.

The LCD displays a text and robot face to the user as a reminder to eat fruits. The display that was used during the user testing is static and was improved after the testing. To program the LCD screen, an Arduino library "MCUFRIEND_kbv" was used to facilitate the programming process (source see Appendix D). The picture of the LCD display is shown in figure 19.

Figure 16: The LCD display of the smart fruit bowl.

Audio cues

a) Sound

There are 10 different sounds that are prompted by the smart fruit bowl. One of the sounds is a victorious sound effect that is given when the user takes the fruit from the fruit bowl as a reward. The other sounds (voice messages) contain fruit facts and reminders to eat fruits that are prompted every time the user passes by the smart fruit bowl. The voice messages are prompted in a random order. The list of the voice messages is shown in table 3 (source see Appendix D).

Table 3: The list of voice messages corporates in the smart fruit bowl.

	Voice Messages
0	Victorious sound effect
1	"Did you know that oranges contain lots of Vitamin C which keeps your teeth and gum healthy? To stay healthy, do not forget to grab an orange."
2	"Did you know that oranges contain a lot of fibers?

3	"Did you know that apples contain more energy than coffee due to high carbohydrate, vitamin and mineral content? To stay energized, do not forget to eat apples!"
4	"Did you know that the skin of apples contains a lot of lot of fibers? So, do not peel the nutrition away and do not forget to eat apples now!"
5	"Did you know that bananas help you maintain your digestion system? So, eat a banana a day and say goodbye to digestive diseases!"
6	"Did you know that grapes can boost your brain power? Resveratrol contained in grapes can help you speed up your mental response and prevent you from brain diseases. To stay smart, do not forget to eat grapes!"
7	"Did you know that grapes contain lots of antioxidant which helps in preventing cancer and heart diseases? To stay healthy do not forget to eat grapes today!"
8	"Did you know that apples can maintain your weight? To stay slim, do not forget to eat apples!"
9	"Did you know that oranges contain vitamin B6 which helps your mind and body relax? So, what are you waiting for, grab some oranges!"

b) Audio shield & Speaker

To prompt the voice messages, a mini MP3 player module and a speaker were needed. The mini MP3 player module attached to a breadboard read the voice message from a micro SD card that was placed in it. A library called "DFRobotPlayerMini" was also required to play the sounds and to control the volume of the sounds. The connection between the mini MP3 player and speaker is shown in figure 20.

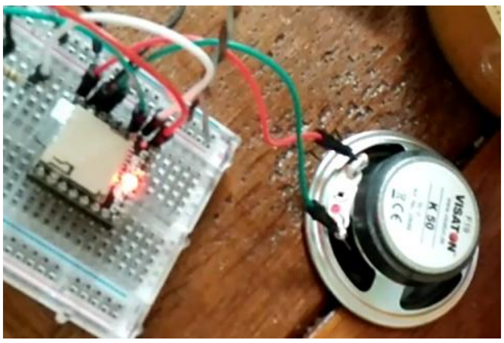


Figure 17: The connection between the mini MP3 player and speaker.

III. Food choice situation detection

To detect the food choice situation, an ultrasonic sensor was used. This sensor detected if someone is passing by the smart fruit bowl or dining room. The sensor calculated its distance with the nearest object in front of it (a cupboard was in front of it at around 110 cm distance) using ultrasonic waves. The principle of distance calculation using an ultrasonic sensor is that it emits ultrasonic waves, which are triggered by a trigger pin, that then receives the reflected waves from the nearest object, which is detected by an echo pin. It measures the travelled distance of the ultrasonic wave. To change the sensor values into a meaningful distance unit (cm), equation 1 should be incorporated in the program.

$$Distance\ (cm) = \frac{Duration\ (\mu s) * Speed\ of\ sound\ (\frac{cm}{\mu s})}{2} \qquad (1)$$

The duration can be obtained by using an Arduino function = pulseIn (echo pin, High), which calculates the time for the echo pin to receive the reflected waves in microseconds (μs). The speed of sound is 0.034 cm/ μs. The distance is divided by 2, because the wave travelled back and forth from the ultrasonic sensor. In the smart fruit bowl program, the just-in-time reminder was triggered if the calculated distance is smaller than 90 cm (due to fluctuated calculations), which could indicate that a person is in front of or passing by the smart fruit bowl.

IV. Fruit Recognition*

A fruit recognition program was created to detect if fruits are taken from the smart fruit bowl. To do this, a Processing software and OpenCV library were involved (see Appendix D). Color recognition was used to recognize different colors which correspond to the available fruits (banana=yellow, orange=orange, grape=purple, and apple=red). A laptop camera was used to take real-time images and the program would filter its hue depending on assigned thresholds. There were 2 color categories that were analyzed, yellow-orange and red-purple color. The 2 colors were combined because their hue values are close to each other (yellow-orange hue range= 37-53 and red-purple hue range=278-340). The program is shown in figure 21 (more details see Appendix E).

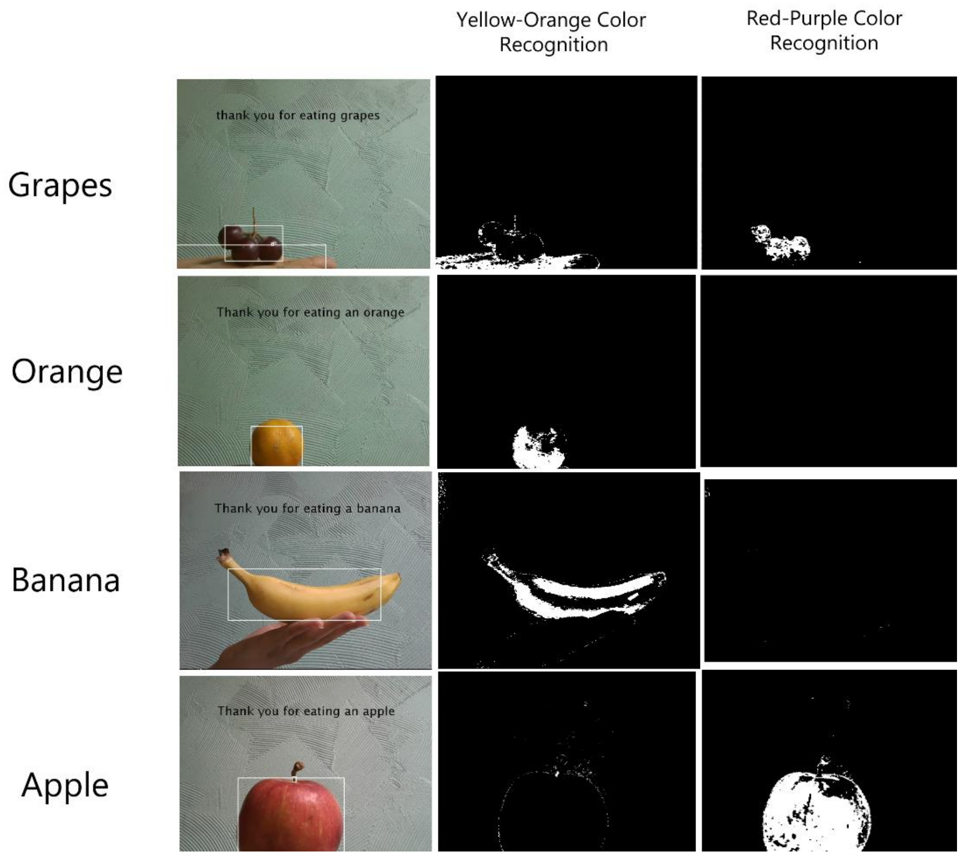


Figure 18: Color recognition to distinguish detected fruit.

However, the color recognition was easily influenced by ambient light, thus was not stable. The ambient light would change the thresholds to capture the fruit colors. Furthermore, the color recognition would detect other objects that have similar colors as the fruits and recognize it as a fruit although it is not. Also, a green screen or background was needed to make the color recognition slightly stable, but there was no a green screen or background where the testing was conducted. Therefore, the fruit color recognition was not incorporated in the smart fruit bowl prototype due to the instability and technical difficulties of the fruit color recognition.

Instead of using fruit color recognition, an ultrasonic sensor was used to detect if the user took the fruits from the fruit bowl. Using an ultrasonic sensor is more stable and accurate to sense hand movement. The sensor was put on a stick, which was placed on top of the smart fruit bowl.

V. Component Integration

After the individual electrical components were built and programmed, they were all combined. The schematic of the combined electrical components is shown in figure 22. Two Arduino boards were used, one for the LCD Shield and the other one for the food choice detection, prompting audio cues and activating the LED strip. The red lines represent the flow of 5V power and black lines represent the connection of the ground. For the ultrasonic sensors, the yellow and green lines represent the connection to trigger and echo pins, respectively. The pink and dark blue lines represent the connection to amplify the sound using an amplifier. The grey line represents the connection to the LED strip. The brown and light blue lines were used to communicate with the mini MP3 player module. The LCD shield used a separate Arduino board and was unable to communicate with the other Arduino because one of the necessary pins were used for the shield.

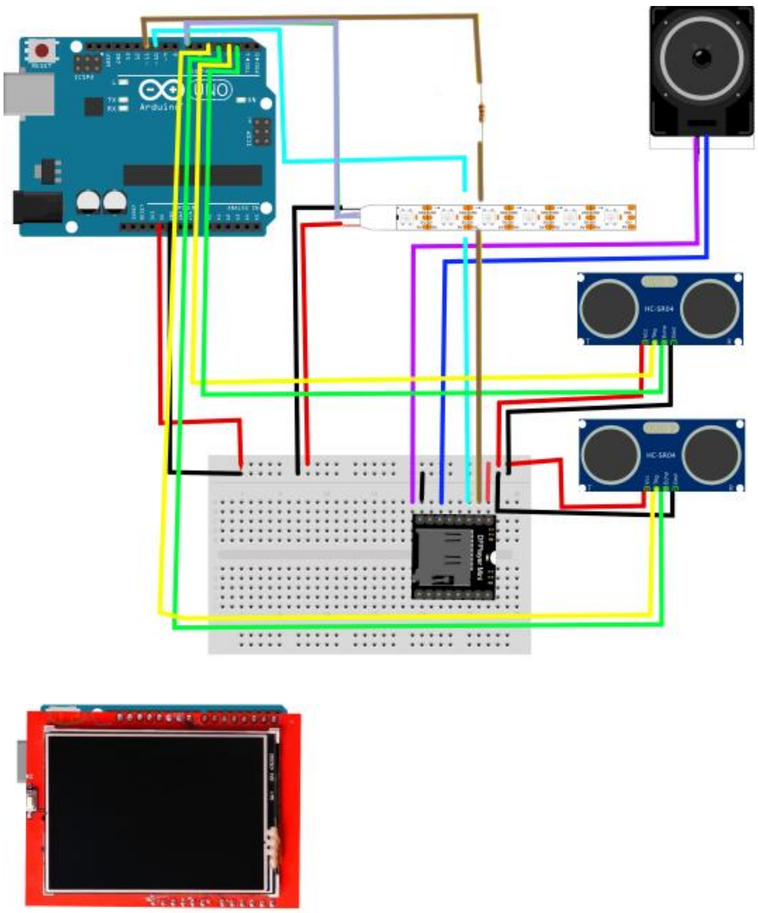


Figure 19: The overview of electrical schematic.

All the electrical components were placed in the smart fruit bowl and covered by a wooden plate, where the fruits were placed. The hi-fi prototype is shown in figure 23 (see code in Appendix E). the smart fruit bowl prototype was placed on top of a cardboard to elevate the smart fruit bowl, so it would not detect surrounding objects placed on the dining table instead.

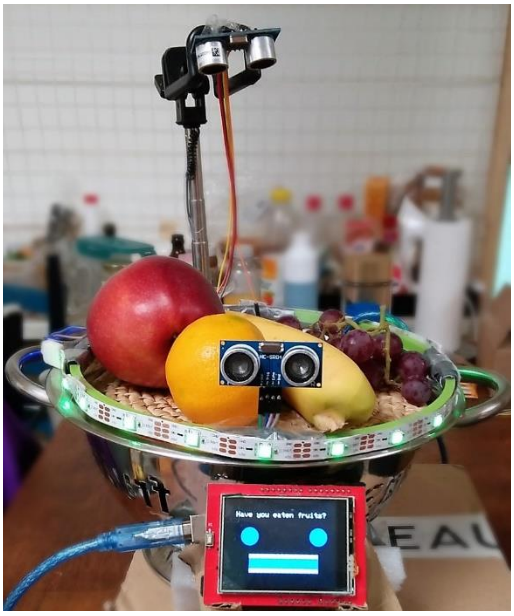


Figure 20: The hi-fi prototype of smart fruit bowl.

Chapter 8 – Hi-fi Prototype Testing

In this testing, a regular fruit bowl and smart fruit bowl were used by the participants for 7 days. The participants first used the regular fruit bowl for 7 days. After two weeks of smart fruit bowl development, the participants were asked to use the smart fruit bowl for another 7 days. The participants reported their fruit consumption every day in a 7 days via a messaging app. At the end of this testing, a questionnaire was given to the participants to obtain the level of user satisfaction towards the smart fruit bowl in general. Subsequently, an interview was conducted to understand the user experience or technical difficulties using the smart fruit bowl in depth.

I. Participants

The participants, who participated in the lo-fi prototype testing, were asked to participate again in the hi-fi prototype testing. The participants are young adults (18-25 years old), who do not have fruit allergies, dietary restrictions, and/or eating disorders. They were recruited among the researcher's housemates. In this research, two specific users were tested the smart fruit bowl to have a deep investigation of the functionality and user experience of the smart fruit bowl.

II. Method

To evaluate the impact of the smart fruit bowl in increasing young adults' fruit intake, the regular fruit bowl was tested for 7 days and the smart fruit bowl was tested for another 7 days. The regular fruit bowl was tested by both participants simultaneously. In contrast, the smart fruit bowl was tested 2 days earlier by one participant than the other because of their different availability in their participation in this testing. The user evaluation was conducted in the researcher's house. The floor plan of the dining room setting is portrayed in figure 24. The regular fruit bowl was situated on the dining table. Similarly, the smart fruit bowl was situated at the same place to detect the users' presence when accessing the kitchen from the living room or the refrigerator from the aisle.

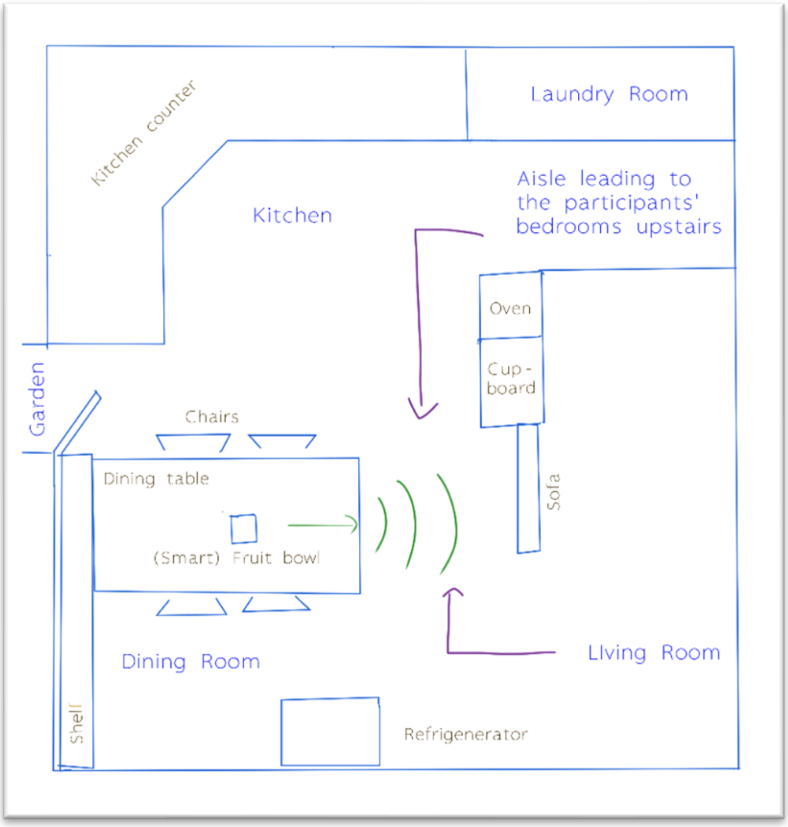


Figure 21:The floor plan and location of the kitchen counter, appliances, and furniture in the dining room setting.

There were 4 different types of fruits provided in the (smart) fruit bowl: grapes, orange(s), banana(s), and apple(s). In the regular fruit bowl, multiple pieces of fruits were placed. On the contrary, only one piece of each fruit (except grapes) was placed in the smart fruit bowl, because the foundation of the smart fruit bowl was not strong enough to handle the weight of multiple pieces of fruits. When a piece of fruits was taken from the (smart) fruit bowl, it would be refilled by the researcher, so the fruits were always provided for the participants.

The participants needed to record and report the type and number of fruits they ate every day via a messaging app to the researcher in both conditions. The researcher was not around the dining room most of the time to reduce the influence towards the participants' fruit consumption. After the regular fruit bowl and smart fruit bowl were individually tested, a questionnaire was given and an interview was conducted to understand the usability, user experience, satisfaction, technical difficulties, and flaws of the smart fruit bowl implementation. The questionnaire and interview sessions took 20 minutes. The questionnaire and interview questions can be found in Appendix F.

III. Results

Fruit consumption

The graph of fruit consumption using a regular fruit bowl in 7 days is shown in figure 25. Participant 2 ate 1.28 servings of fruits every day on average, which met the fruit intake recommendation by WHO (200 grams of fruits per day) [1]. On the contrary, participant 1 only ate 1.14 serving of fruit per day on average. Both participants on average ate bananas every day and did not eat oranges. Participant 1 ate a few pieces of grapes and apples. Participant 2 ate plenty of apples but did not eat grapes. The result of this testing will be used as a baseline.

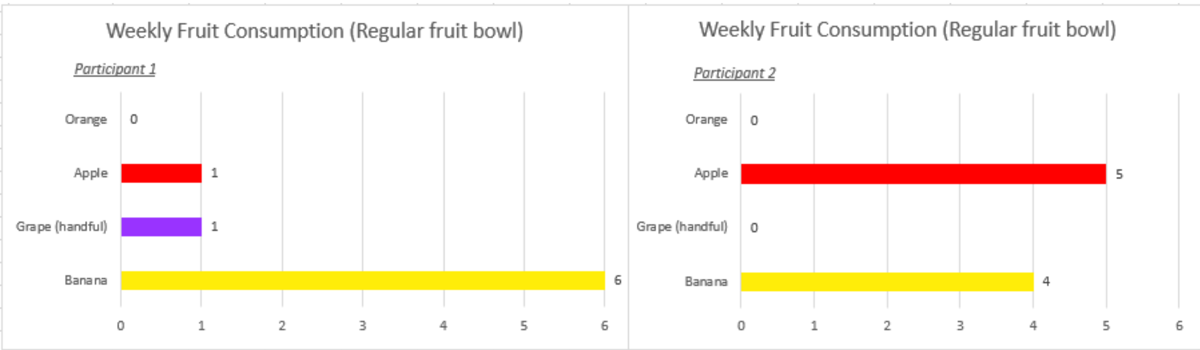


Figure 22: The graph of the participants' weekly fruit consumption using a regular fruit bowl.

After the regular fruit bowl testing was conducted, the smart fruit bowl was tested by the participants for another 7 days. It was discovered that there was a positive relationship between the use of the smart fruit bowl and the grape consumption of participant 2. The orange consumption of both participants using the smart fruit bowl was similar to the prior consumption using the regular fruit bowl, which is 0. The consumption of apples decreased when using the smart fruit bowl, from 6 pieces to 0 in total. The consumption of bananas slightly decreased compared to using the regular fruit bowl. The overview of the participants' weekly fruit consumption using the smart fruit bowl is shown in figure 26. The fruit consumption using the smart fruit bowl was relatively lower than using a regular fruit bowl.

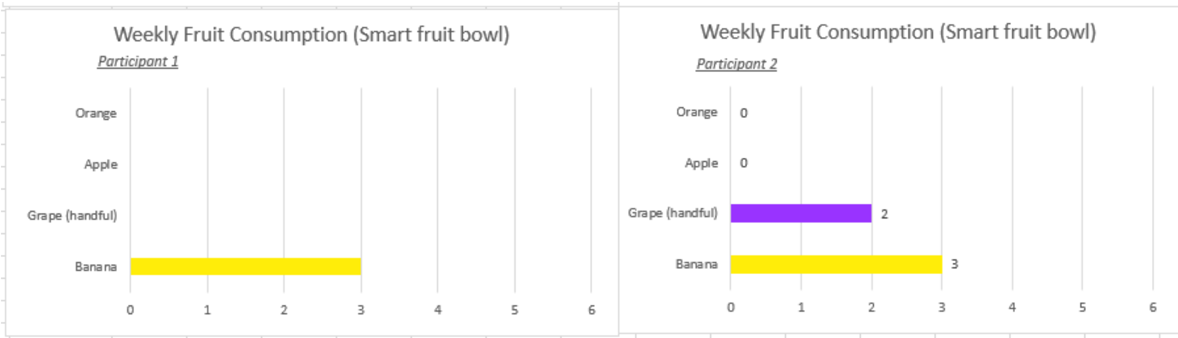


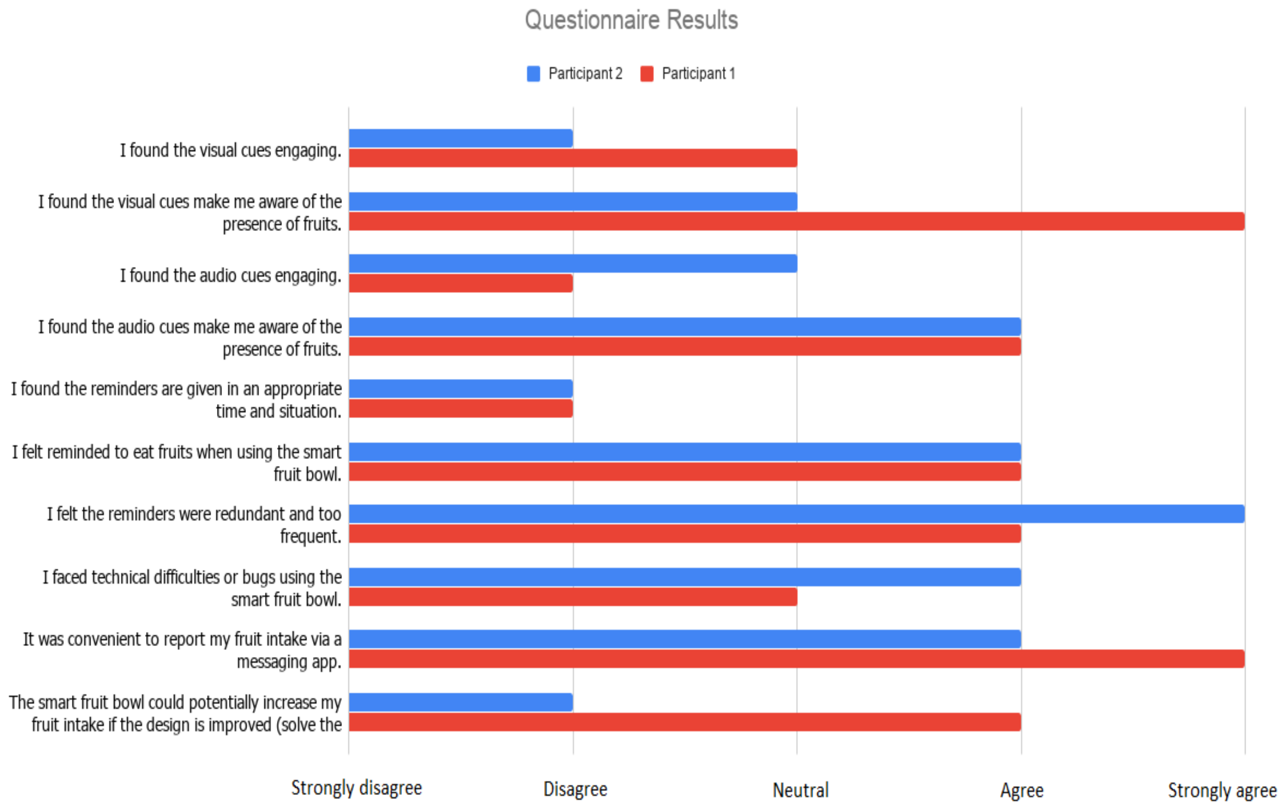
Figure 23: The participants' weekly fruit consumption using the smart fruit bowl.

Questionnaire

A questionnaire was used as one of the tools to obtain the participants' feedback on the smart fruit bowl. There were 9 questions related to user satisfaction in the questionnaire. A Likert scale was involved in the questionnaire to allow the participants to express how much they agree or disagree with the user satisfaction statements (1= strongly disagree, 5=strongly agree)[54]. The list of questions can be seen in table 4. The graph of questionnaire results is shown in figure 27.

Table 4: The overview of the questionnaire questions.

	Questionnaire Questions
1.	I found the visual cues engaging.
2.	I found the visual cues make me aware of the presence of fruits.
3.	I found the audio cues engaging.
4.	I found the audio cues make me aware of the presence of fruits.
5.	I found the reminders are given in an appropriate time and situation.
6.	I felt reminded to eat fruits when using the smart fruit bowl.
7.	I felt the reminders were redundant and too frequent.
8.	I faced technical difficulties or bugs using the smart fruit bowl.
9.	It was convenient to report my fruit intake via a messaging app.
10.	The smart fruit bowl could potentially increase my fruit intake if the design is improved (solve the technical issues, make it more engaging, less redundant, and frequent)



It was revealed that both participants thought that the visual and audio cues made them aware of the presence of fruits but comparatively not engaging. Furthermore, they thought that they felt reminded to eat fruits but the reminders itself were not given in an appropriate situation and were redundant. One of the participants experienced technical difficulties when using the smart fruit bowl. Both participants found it convenient to report their fruit intake using a messaging app. One of the participants was optimistic that the smart fruit bowl could potentially increase their fruit intake if the product were improved by considering the participants' feedback.

Interview

Referring to Appendix F, some questions were asked to the participants in this interview session. The questions were about the participants' general experience, what elements that the participants liked or disliked from the smart fruit bowl, and how the product could be improved. Participant 1 liked several aspects of the smart fruit bowl, such as the visual cues and the sound effect when the user took the fruits from the smart fruit bowl. Furthermore, Participant 2 liked to use the smart fruit bowl because it facilitated the availability, visibility, and accessibility of fruits. Both participants also explained some aspects they did not like about the smart fruit bowl, for example, the reminders were a bit too frequent, redundant, and annoying.

In terms of different effects using the regular fruit bowl and the smart fruit bowl, Participant 1 thought that the smart fruit bowl increased the awareness of provided fruits. In contrast, Participant 2 did not experience different effects between using the regular fruit bowl and the smart fruit bowl. Furthermore, the researcher asked the participants if their routine in consuming fruits was the same before participating in this research. Participant 1 said that he ate fruits just like he normally does, but he was aware of being part of an experiment and had to report his fruit intake, thus making him more conscious to eat fruits. Similarly, Participant 2 explained that “self-reporting did not change my actual eating behavior, but eating fruits was facilitated by the regular or smart fruit bowl, so I ate more fruits than usual”.

Both participants did not experience technical difficulties when using the smart fruit bowl. Participant 1 did not experience technical difficulties when using the smart fruit bowl. Participant 2 mentioned that “I was actually impressed with the durability of the prototype because it gave me reminders to eat fruits and fruit facts every time I am in the dining room throughout the 7-day period”. Additionally, Participant 2 mentioned that the smart fruit bowl system could be manipulated by placing a hand on top of the smart fruit bowl, so the smart fruit bowl assumed that some fruits were taken, thus not prompting the reminder.

Subsequently, both participants gave suggestions on how to improve the smart fruit bowl. Participant 1 mentioned that it would be better if the just-in-time reminder was less frequent, did not have a voice message, but subtle music instead. Participant 2 suggested that a research on predicting when someone wants to eat should be done, so the just-in-time reminder could be prompted in an appropriate situation. Also, Participant 2 ought that “the smart fruit bowl would be more effective to increase fruit intake if it was placed in our bedroom because we spend our time the most”.

Lastly, their preference for using the regular fruit bowl or smart fruit bowl was asked. Participant 1 mentioned that “If someone bought the smart fruit bowl for me, I would like to use it and I believe it can improve my fruit intake”. On the other hand, Participant 2 preferred the regular fruit bowl compared to the smart fruit bowl.

Chapter 9 – General Discussion

This research focused on creating a just-in-time intervention involving technology to engage young adults and to increase their fruit intake. A negative relationship was discovered between the participants' fruit intake and the use of the smart fruit bowl, which is a just-in-time intervention involving user engagement. The fruit consumption using the smart fruit bowl was generally lower compared to the fruit consumption using a regular fruit bowl, which was set as a baseline. However, the grape consumption was slightly higher when using the smart fruit bowl, which was assumed as the impact of fruit facts that encouraged the participants to taste a variety of fruits.

The results of the smart fruit bowl research deviated from the previous studies. Inconsistent with the result of a similar study conducted by Privitera [12], the use of the smart fruit bowl did not lead to a higher fruit intake regardless of its higher visibility compared to the regular fruit bowl. The visual cues displayed by the smart fruit bowl might increase its visibility, but it did not always guarantee that the user would take the fruits from the smart fruit bowl. Furthermore, the just-in-time reminder prompted by the smart fruit bowl was not effective to increase fruit intake as opposed to the results of the LowSalt4Life app experiment, which showed that its just-in-time reminders were effective to slightly reduce adults' sodium intake [56]. The audio and visual cues (fruit facts and colorful lights) did not engage the participants and did not produce similar outcomes as a smart fork (EducaTableware) or interactive dining table, which engaged its users to improve their eating behavior [31, 35].

Several factors were found as causes of the unexpected results. The redundancy and frequency of the just-in-time reminders were considered as the major reason why the smart fruit bowl did not increase fruit intake as expected. It was assumed that the just-in-time reminders were disruptive resulting in unsustainable use of the smart fruit bowl. Moreover, a lack of user engagement from the smart fruit bowl might decrease the user's interest in using the smart fruit bowl, resulting in low fruit consumption. The redundancy of reminders and lack of user engagement were also the major problems reflected by other health-related interventions, such as the Cell Phone Intervention for You (CITY) app as a weight loss intervention. The CITY app trial was tested for 24 months and only showed weight loss in the first 6 months because the user engagement dropped substantially after the first months. Furthermore, the prompts were slightly intrusive [57].

Implementing less intrusive and other favorable user engagements, such as gamification and social media might improve the functionality of the smart fruit bowl. Flexible and less intrusive reminders could be created by implementing a timer for the reminders to be prompted. This was expected to sustain the use of the smart fruit bowl and potentially lead to an increased fruit intake. Implementing gamification and social media might increase the user engagement of young adults. This was proven by the implementation of the Hydration game that could increase employees' water intake [33]. Moreover, social media involvement could engage young adults in improving health behaviors. A study on the impact of social media to improve physical activity, which was conducted for 13 weeks and tested by 217 university students, showed that promotional messages for improving physical activity shared on social media were successful in improving physical activity [58].

Besides the undesirable aspects in the design of the smart fruit bowl, the negative results might be caused by external factors, such as the availability of the participants attending to the just-in-time intervention, self-regulation, and ambient temperature. Saker (2014) asserts that the success of a JITI depends on the timing of the JITI delivery when the users are available physically, cognitively, and socially to attend to the intervention. It was assumed that the participants were not fully available in attending and committing to the just-in-time intervention. As a consequence, the reminders got ignored and the participants consumed less fruits. Moreover, self-regulation plays an important role in health-protective behavior engagement [43]. It was speculated that the participants had higher self-regulation when using a regular fruit bowl because they independently steered themselves to eat fruits without any technological interference. Using the smart fruit bowl might reduce the participants' self-regulation since they might rely on the smart fruit bowl itself to remind them to eat fruits. The combination of the participants' unavailability to attend to the just-in-time intervention and lack of self-regulation could produce a substantial reduction in fruit consumption. Another speculation of low fruit consumption when using the smart fruit bowl was due to the ambient temperature that influenced the participants eating behavior. People tend to eat more when exposed to cold than hot temperatures due to a higher metabolic rate [59]. When testing the smart fruit bowl, the ambient temperature got higher, thus this might influence the participants and cause them to eat less fruits.

Referring to the research questions, the smart fruit bowl, which is a just-in-time intervention integrated with technology, could not engage young adults, and increase their fruit consumption in a home setting. Being in or passing by the dining room might be an appropriate situation to intervene but might not always be associated with a food choice situation. Hence, another food choice situation, which has a more direct association with eating behavior, should be defined. An ultrasonic sensor was discovered as a suitable sensor to detect a food choice situation. Moreover, fruit facts (audio cues) and colorful lights (visual cues) as responses to engage young adults to eat fruits were not effective in increasing their fruit intake. Although the smart fruit bowl was not effective in increasing young adults' fruit consumption, the researcher believes that the smart fruit bowl can accomplish its goal to increase young adults' fruit intake by improving its user engagement and redefining the fruit choice situation.

I. Limitations

The limitation of this research is that the fruit intake results were obtained from self-reported data, which might influence the participants’ natural eating behavior. The participants might manipulate their fruit intake because they were aware that their fruit intake was recorded, thus not consuming as many pieces of fruits as they normally eat. This effect is called a novelty effect, where the participants behave differently from what they would do in the normal real world due to participating in research [60]. Another approach to know the participants’ fruit intake might need to be addressed in future research, for example, fruit intake tracking using technology.

The just-in-time reminders were also constrained by the ambient sound, which was sometimes louder than the reminders. This might interrupt the delivery of reminders to eat fruits, thus the participants might not hear the reminders.

II. Implications

Although the smart fruit bowl could not increase the young adults’ fruit intake, the smart fruit bowl was successful to make them aware of the presence of fruits. The visual and audio cues might bring their attention to the smart fruit bowl. This finding could have an implication for canteen settings in universities. Creating appealing visuals and subtle sounds on healthy food buffets might influence students to be more aware of the presence of healthy food. Additionally, this finding might have an implication in improving the prototype of the smart fruit bowl to increase young adults’ fruit intake for future research. The use of fruit facts and colorful lightning in the smart fruit bowl might need to be avoided or improved because it did not contribute to a higher fruit consumption among young adults and only increased young adults’ awareness of available fruits. An approach to engage young adults to consume healthy food, especially fruits, still needs to be investigated in future research.

Also, some potential classes of users have been found that might get helped by the smart fruit bowl and would be interested in it. For example, people with impulsive eating behavior might get facilitated to eat more fruits when using the smart fruit bowl because they might be triggered or urged to eat fruits that are highly visible and available in a home setting [55]. Children might be engaged to eat fruit because the smart fruit bowl looks child-friendly and playful. Moreover, families might be in favor of using the smart fruit bowl to increase the family members’ fruit intake, because families spend most of their time at home where the smart fruit bowl was meant to be used.

Chapter 9 - Conclusion

Less than a quarter of European young adults follow the WHO fruit intake recommendation. Through iterative ideation, specification, realization, and user evaluation processes, a smart fruit bowl, which embodies a just-in-time intervention involving technology and fruit facts as user engagement, was created to address young adults' low fruit consumption.

In this research, it was revealed that the smart fruit bowl could not contribute to an increased fruit intake compared to a regular fruit bowl. The reason for this is because the just-in-time reminders to eat fruits were redundant and too frequent. Moreover, the fruit facts were relatively not engaging, thus resulting in unsustainable use of the smart fruit bowl, and lower fruit consumption. Several external factors were assumed to have an influence on the low fruit consumption, such as the availability of the users to attend to the JITI, self-regulation, and the ambient temperature.

Although the smart fruit bowl could not increase the participants' fruit intake, it increased the participants' awareness of available fruits. This study provides new insight into the relationships between the use of visual and audio cues and the high awareness of available fruits. To improve the smart fruit bowl, flexible and less intrusive reminders should be created to eliminate the redundancy and frequency of the just-in-time reminders. Additionally, implementing other user engagements, such as gamification and social media might engage young adults to consume more fruits.

By improving the just-in-time reminder and user engagement, the smart fruit bowl could potentially increase young adults' fruit intake in the future. The purpose of the smart fruit bowl could also be expanded to improve the fruit intake of other potential users, such as people with impulsive eating, children, and families.

Chapter 10 – Future Work

This research provides a good starting point to create a just-in-time intervention that can increase young adults' fruit intake. The results of this research showed that technology in the just-in-time intervention could increase the awareness of available fruits. In future work, technology can be involved not only to increase the awareness of available fruits, but also the awareness of the user's fruit intake. This way is seen as a more promising direction because the users can reflect on their fruit intake, thus motivating them to consume more fruits. Fruit consumption tracking mechanisms should be investigated using different kinds of technology in future work.

Furthermore, the appropriate timing of JITI delivery should also be discovered. This refers to a food choice situation, where the user encounters food choice and is available physically and mentally to attend to the just-in-time intervention. Moreover, flexible and less intrusive JITI deliveries can also be addressed in future work.

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Appendix A – The 50 Ideas

Just-in-time intervention delivery methods

1. A smart fruit bowl that releases nice scents
2. A smart table that displays the consequences of not eating fruits
3. A smart picture frame that shows different fruit pictures
4. A TV that reminds the user to eat fruits
5. An app that records your fruit intake
6. A hologram that portrays a fat version of you
7. An app that shows cooking recipes containing fruits
8. A motivational letter generator that suggests eating fruits
9. A tv that can be turned on if the user eats fruits
10. An app that plays sad songs if you do not eat fruits
11. A fruit bowl that suggest the user to eat fruits
12. A door reminds you to eat fruits when you enter the room
13. A smart watch that sends you a notification to eat fruits
14. A cute Tamagotchi that reminds you to eat fruits
15. A fork that detects you do not eat fruits and suggest eating fruits
16. A pen that reminds you to eat fruits when you are studying
17. A plate that detects you do not eat fruits
18. A box that give you random fruits
19. An unhealthy snack jar that can only be open if the user eats fruits first
20. Netflix and Fit, reminds you to eat fruits when you watch Netflix
21. Object recognition to see if the user eats fruits or not
22. A fruit app that reminds the user to eat fruits
23. A speaker that plays the user' favorite songs when eating fruits
24. A robot that teases you when you do not eat fruits
25. A robot that reminds you to eat fruits involving emotions
26. A couch that detects that you are sitting and offers you fruits
27. D&D companion robot that suggest the user to eat fruits
28. A smart clock that reminds you to eat fruits
29. A photo album that makes you look fat
30. A wearable that encourage you to eat fruits
31. A fruit vending machine

User Engagement

32. "boo" sound when you do not eat fruits
33. A leaderboard that can be compared with others
34. Scary stories if you have not eaten fruits
35. Harvesting fruit game
36. Fruit ninja game
37. The ambient sound from the kitchen that ask you to eat fruits
38. Quest or little task to do
39. A random generator D&D character depending you fruit intake
40. Feeding animal game
41. Social comparison of fruit intake
42. A fat avatar of you
43. Riddle games
44. Rewarding system
45. Points collection system
46. Fun puzzles
47. Colorful LEDs
48. Relaxing smells
49. Social media involvement
50. Vibrating objects

Appendix B – Information Brochure and Consent Form

Information Brochure Department Biomedical Signals and Systems (Promoting fruit consumption)

In this brochure, we would like to inform you about the research you have applied to participate in. The experiment will take place between May and July 2020, in the researcher's house, in Enschede. The aim of the research is to investigate whether a just-in-time intervention that is delivered in an engaging way can promote fruit consumption among young adults. The proposed research, entitled "increasing fruit intake in an engaging way", consists of a lo-fi and hi-fi prototype testing.

Lo-fi prototype testing

In the lo-fi prototype testing, the participant will try to use a lo-fi prototype, which is a prototype that is drawn on papers to display the concept of the smart fruit bowl, will be tested. The participants need to do several tasks related to the usability and features of the concept, for example playing the riddle game and activating the just-in-time intervention. In the end of the lo-fi prototype testing, there will be an interview session, which will take around 20 minutes, to understand what the participants think of the concept and how it can be improved. The participants' feedback will be incorporated in creating a hi-fi prototype of the smart fruit bowl.

Hi-fi prototype testing

In the beginning of the hi-fi prototype testing, the amount of fruits and the type of fruits taken from an ordinary fruit bowl will be observed over 7 days. A fruit bowl containing various fruits will be placed in the living room. The participants can take the provided fruits from it in a 7-day period. After the 7-day period, the participants are asked to report on their consumption by means of a brief questionnaire.

After that, a hi-fi prototype, which is a working and fully functional prototype, will be tested. The hi-fi prototype of a smart fruit bowl will replace the ordinary fruit bowl that is placed on the table between a TV and cough in the living room. The smart fruit bowl will be placed there for the next 7 days. The participants can take any fruits from the smart fruit bowl and they should report the type and the amount of fruit they consumed over the last 7 days by means of a questionnaire. Also, the questionnaire contains several questions regarding their experiences with the smart fruit bowl.

More information

If you request further information about the research, now or in the future, you may contact Giuseppina Pinky Kathlea Diatmiko, Creative Technology student (Tel: +31 (6)17 132 014, Email: pinkykathleadiamtiko@student.utwente.nl)'

If you have any complaints about this research, please direct them to the secretary of the Ethics Committee of the Faculty of Electrical Engineering, Mathematics and Computer Science at the University of Twente, P.O. Box 217, 7500 AE Enschede (NL), email: ethics-comm-ewi@utwente.nl).

The Consent Form

Please tick the appropriate boxes	Yes	No
Taking part in the study		
I have read and understood the information brochure. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	O	O
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.	O	O
I understand that this study involves a lo-fi and hi-fi prototype testing. The study will use interviews and questionnaires to obtain my data.	O	O
Use of the information in the study		
I understand that information I provide will be used for Creative Technology graduation project.	O	O
I understand that my personal information and the research results about me will not be shared beyond the study and be made completely anonymous.	O	O
My personal data will not be disclosed to third parties without my express permission	O	O

Signatures

______________________ ______________________ ________

Name of participant Signature Date

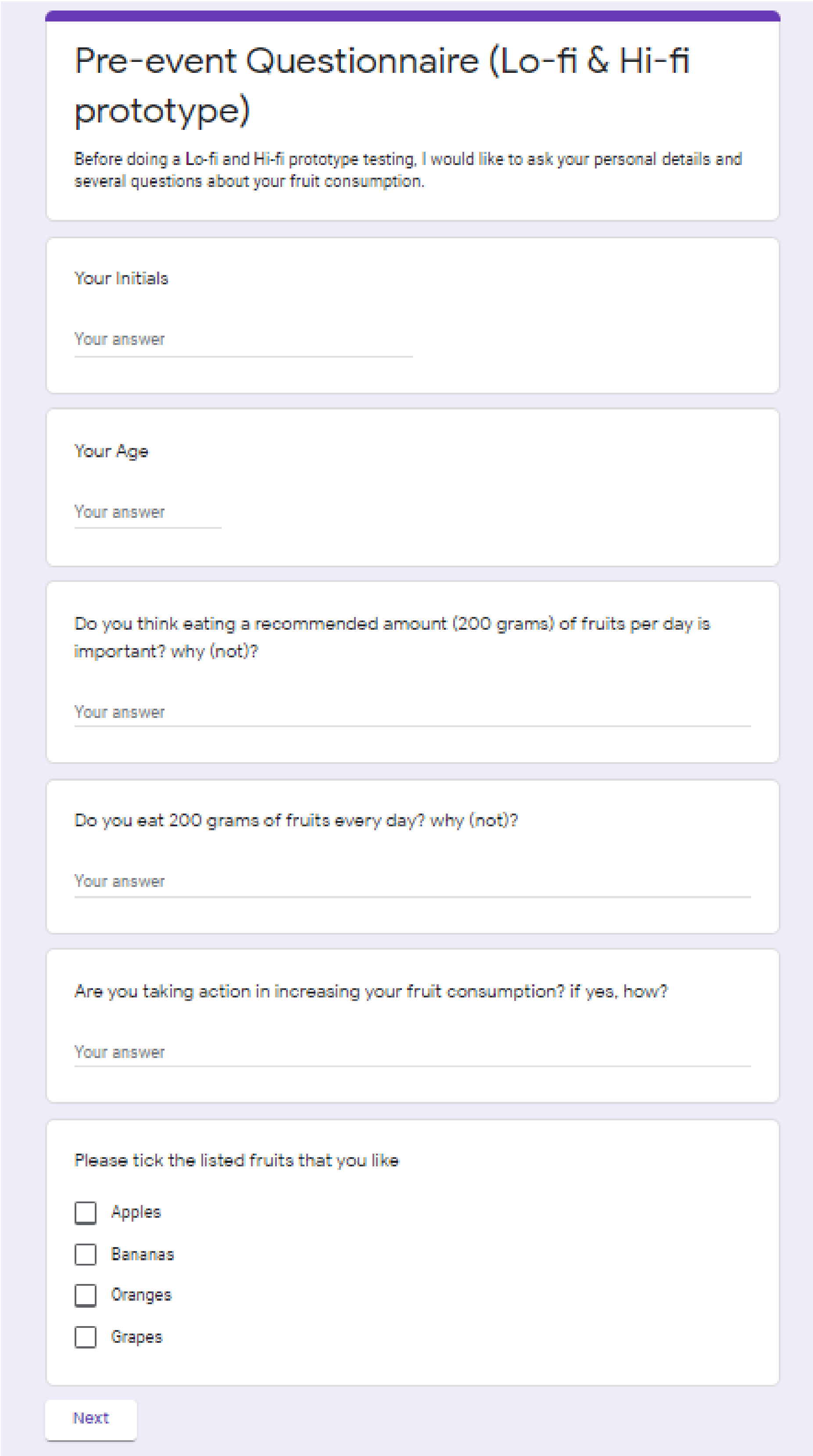
To be completed by the researcher

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.

__________________________ ____________________ _________

Researcher name Signature Date

Appendix C – Lo-fi Prototype Testing Questionnaire



Pre-event Questionnaire (Lo-fi & Hi-fi prototype)

Before doing a Lo-fi and Hi-fi prototype testing, I would like to ask your personal details and several questions about your fruit consumption.

Your Initials

Your answer

Your Age

Your answer

Do you think eating a recommended amount (200 grams) of fruits per day is important? why (not)?

Your answer

Do you eat 200 grams of fruits every day? why (not)?

Your answer

Are you taking action in increasing your fruit consumption? if yes, how?

Your answer

Please tick the listed fruits that you like

- [ ] Apples
- [ ] Bananas
- [ ] Oranges
- [ ] Grapes

Next

Post-event Questionnaire (Lo-fi prototype)

After testing the lo-fi prototype, I would like to ask you about your experience using the smart fruit bowl.

Do you think the just-in-time notification to eat fruit is given at the appropriate time? why (not)

Your answer

Do you think the food choice situation is appropriate to give a just-in-time intervention? why (not)?

Your answer

Do you think the riddle game is engaging? why (not) ?

Your answer

Do you think this product can lead to an increased fruit intake?

Your answer

Do you like the interface?

Your answer

How can this product be improved?

Your answer

Back Submit

Appendix D – Arduino Libraries, Fruit Facts, Sound Effect Sources

I. Arduino Libraries Sources:

- FastLed : https://github.com/FastLED/FastLED
- MCUFRIEND_kbv : https://github.com/prenticedavid/MCUFRIEND_kbv
- Ultrasonic Sensor code Inspiration: https://create.arduino.cc/projecthub/abdularbi17/ultrasonic-sensor-hc-sr04-with-arduino-tutorial-327ff6
- DFRobotPlayerMini: https://wiki.dfrobot.com/DFPlayer_Mini_SKU_DFR0299
- OpenCV: https://github.com/atduskgreg/opencv-processing-book/blob/master/code/hsv_color_tracking/HSVColorTracking/HSVColorTracking.pde

II. Fruit Facts Sources:

- Apple : https://www.healthline.com/nutrition/10-health-benefits-of-apples#section10
- Orange: https://timesofindia.indiatimes.com/life-style/health-fitness/diet/why-you-should-eat-oranges/articleshow/4662391.cms
- Grape: https://food.ndtv.com/food-drinks/benefits-of-grapes-from-being-a-powerful-antioxidant-to-preventing-signs-of-ageing-1223636
- Banana: https://www.everydayhealth.com/diet-nutrition/11-banana-health-benefits-you-might-not-know-about/
- General fruits: https://www.lifehack.org/articles/lifestyle/20-incredible-facts-about-eating-fruits-and-vegetables-that-you-probably-didnt-know.html

III. Sound effect:

- https://freesound.org/search/?q=nylon+guitar

Appendix E- Arduino and Processing codes

I. Fruit recognition

```
import gab.opencv.*;
import processing.video.*;
import java.awt.Rectangle;
import org.opencv.imgproc.Imgproc;

Capture video;
OpenCV opencv;
PImage src, colorFilteredImage;
ArrayList<Contour> contours;
fruitRecognition frYellow;
fruitRecognition frRed;
fruitRecognition frPurple;

// <1> Set the range of Hue values for our filter
int rangeLow;
int rangeHigh;

boolean detected= false;
int counter= 0;

void setup() {
  video = new Capture(this, 640, 480);
  video.start();

  opencv = new OpenCV(this, video.width, video.height);
  contours = new ArrayList<Contour>();
  frYellow = new fruitRecognition (0, 480); // fruit recognition of yellow-orange fruits
  frRed= new fruitRecognition (640, 0);// fruit recognition of red-purple fruits
  frPurple= new fruitRecognition (640,480);
  size(1280, 960, P2D);
}
void draw() {
  // Read last captured frame
  if (video.available()) {
    video.read();
  }

  // <2> Load the new frame of our movie in to OpenCV
  opencv.loadImage(video);

  // Tell OpenCV to use color information
  opencv.useColor();
  src = opencv.getSnapshot();

  image (src, 0, 0);
```

```
  frYellow.initializing(14,17);
  frYellow.update(50, 100, 200, 500, "Thank you for eating an orange", "Thank you for eating a
banana");
  frRed.initializing(2,8);
  frRed.update(175,250, 20,50, "Thank you for eating an apple", "thank you for eating grapes");
}

class fruitRecognition {
  int xPos, yPos;
  fruitRecognition (int x, int y) {
    xPos=x;
    yPos=y;
  }
  void initializing(int rangeL, int rangeH) {

    // <2> Load the new frame of our movie in to OpenCV
    opencv.loadImage(video);

    // Tell OpenCV to use color information
    opencv.useColor();
    src = opencv.getSnapshot();

    // <3> Tell OpenCV to work in HSV color space.
    opencv.useColor(HSB);

    // <4> Copy the Hue channel of our image into
    //     the gray channel, which we process.
    opencv.setGray(opencv.getH().clone());

    // <5> Filter the image based on the range of
    //     hue values that match the object we want to track.
    opencv.inRange(rangeL, rangeH);

    // <6> Get the processed image for reference.
    colorFilteredImage = opencv.getSnapshot();

    // <7> Find contours in our range image.
    //     Passing 'true' sorts them by descending area.
    contours = opencv.findContours(true, true);

    // <8> Display background images

    image(colorFilteredImage, xPos, yPos);
  }

  void update(int minContour, int maxContour, int minContour2, int maxContour2, String message,
String message2 ) {

    if (contours.size() != 0) {
      // <9> Get the first contour, which will be the largest one
```

```
    Contour biggestContour = contours.get(0);
    Rectangle r = biggestContour.getBoundingBox();

    // <11> Draw the bounding box of our object
    noFill();
    strokeWeight(2);
    stroke(255, 255, 255);
    rect(r.x, r.y, r.width, r.height);
    //fill(255, 255, 255);
    //rect(100, 70, 470, 35);
    textAlign(LEFT);
    fill (0, 0, 0);
    textSize (30);

    // <9> Check to make sure we've found any contours
    if (contours.size() > minContour && contours.size() < maxContour) {
     detected = true;
     text (message, 100, 100);
    }

    if (contours.size()> minContour2 && contours.size()< maxContour2 ) {

     detected = true;
     text (message2, 100, 100);
    }
   }
  }
}
```

II. LCD Screen code

```
#include <MCUFRIEND_kbv.h>
MCUFRIEND_kbv tft;       // hard-wired for UNO shields anyway.
#include <TouchScreen.h>
#include "rsz_21fruits_arduino.c"

uint16_t ID;
uint8_t Orientation = 1;    //PORTRAIT

int xPos = 70;
int yPos = 100;
int rad = 25;

// Assign human-readable names to some common 16-bit color values:
#define BLACK   0x0000
#define BLUE    0x001F
#define WHITE   0xFFFF

void show_tft1(void)
{
```

```
  tft.setTextSize(2);
  tft.setTextColor(WHITE);
  tft.setCursor( 30 , 30);
  tft.println("Have you eaten fruits?");
  tft.setTextSize(2);
  tft.fillCircle(xPos, yPos, rad, BLUE);
  tft.fillCircle(xPos + 200, yPos, rad, BLUE);
  tft.fillRect (xPos, tft.height() - 80, 200, 30, BLUE);

  for (int i = 0; i < 200; i = i + 10) {
    tft.fillRect (xPos + i, tft.height() - 90, 9, 10, WHITE);
    tft.fillRect (xPos + i, tft.height() - 50, 9, 10, WHITE);
  }
}
void setup(void)
{
  tft.reset();
  ID = tft.readID();
  tft.begin(ID);
  Serial.begin(9600);
  tft.setRotation(Orientation);
  tft.fillScreen(BLACK);
  delay(1000);
}

void loop()
{
  show_tft1();
}
```

III. Food choice situation detection and just-in-time reminder code

```
#include <FastLED.h>
#include "Arduino.h"
#include "SoftwareSerial.h"
#include "DFRobotDFPlayerMini.h"

#define echoPin2 2 // attach pin D2 Arduino to pin Echo of HC-SR04
#define trigPin2 3 //attach pin D3 Arduino to pin Trig of HC-SR04
#define echoPin 4 // attach pin D2 Arduino to pin Echo of HC-SR04
#define trigPin 5 //attach pin D3 Arduino to pin Trig of HC-SR04
#define BRIGHTNESS 70
#define LED_PIN     7
#define NUM_LEDS    29


// defines variables
long duration2; // variable for the duration of sound wave travel of the ultrasonic sensor mounted
on top of the smart fruit bowl
int distance2; // variable for the distance
long distance; // variable for the distance to detect the user's presence
int duration;// variable for the duration to detect the user's presence


CRGB leds[NUM_LEDS];

boolean toggle = false;
boolean toggle2 = false;
SoftwareSerial mySoftwareSerial (10, 11);
DFRobotDFPlayerMini myDFPlayer;


void setup() {

 pinMode (trigPin, OUTPUT);
 pinMode (echoPin, INPUT);
 pinMode(trigPin2, OUTPUT); // Sets the trigPin as an OUTPUT
 pinMode(echoPin2, INPUT); // Sets the echoPin as an INPUT
 Serial.begin(9600);
 FastLED.addLeds<WS2812, LED_PIN, GRB>(leds, NUM_LEDS);
 FastLED.setBrightness (BRIGHTNESS);

 mySoftwareSerial.begin (9600);

 Serial.println();
 Serial.println(F("DFRobot DFPlayer Mini Demo"));
 Serial.println(F("Initializing DFPlayer ... (May take 3~5 seconds)"));

 if (!myDFPlayer.begin(mySoftwareSerial)) {  //Use softwareSerial to communicate with mp3.
  Serial.println(F("Unable to begin:"));
  Serial.println(F("1.Please recheck the connection!"));
```

```
    Serial.println(F("2.Please insert the SD card!"));
    while (true) {
      delay(0);
    }
  }

}

void loop() {
  // put your main code here, to run repeatedly:
  // Clears the trigPin condition
  digitalWrite(trigPin2, LOW);
  delayMicroseconds(2);
  // Sets the trigPin HIGH (ACTIVE) for 10 microseconds
  digitalWrite(trigPin2, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin2, LOW);
  // Reads the echoPin, returns the sound wave travel time in microseconds
  duration2 = pulseIn(echoPin2, HIGH);
  // Calculating the distance
  distance2 = duration2 * 0.034 / 2; // Speed of sound wave divided by 2 (go and back)


  // put your main code here, to run repeatedly:
  // Clears the trigPin condition
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin HIGH (ACTIVE) for 10 microseconds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  // Reads the echoPin, returns the sound wave travel time in microseconds
  duration = pulseIn(echoPin, HIGH);
  // Calculating the distance
  distance = duration * 0.034 / 2; // Speed of sound wave divided by 2 (go and back)
  // Displays the distance on the Serial Monitor
  //Serial.println(distance);
  //Serial.write (6);
    Serial.println (distance);

  if (distance2 <= 90 && distance2 != 0 ) {
      toggle2 = true;
      myDFPlayer.volume(28);
      myDFPlayer.play(random(2, 10));
  } else {
    toggle2 = false;
  }


  if (distance <= 10 && distance2 != 0) {
    toggle = true;
```

```
    myDFPlayer.volume(25);
    myDFPlayer.play(1);
  } else {
    toggle = false;
  }
  if (toggle == true || toggle2 == true) {
    for (int i = 0; i <= 29; i++) {
      leds[i] = CRGB ( 0, 0, 255);
      FastLED.show();
      delay(20);
    }
    for (int i = 29; i >= 0; i--) {
      leds[i] = CRGB ( 255, 0, 0);
      FastLED.show();
      delay(20);
    }
    for (int i = 0; i <= 29; i++) {
      leds[i] = CRGB ( 0, 255, 0);
      FastLED.show();
      delay(20);
    }
    for (int i = 29; i >= 0; i--) {
      leds[i] = CRGB ( 0, 0, 255);
      FastLED.show();
      delay(20);
    }
    for (int i = 0; i <= 29; i++) {
      leds[i] = CRGB ( 255, 0, 0);
      FastLED.show();
      delay(20);
    }
    for (int i = 29; i >= 0; i--) {
      leds[i] = CRGB ( 0, 255, 0);
      FastLED.show();
      delay(20);
    }
  } else {
    for (int i = 29; i >= 0; i--) {
      leds[i] = CRGB ( 0, 0, 0);
      FastLED.show();
      delay(20);
    }

  }
}
```

Appendix F – Hi-fi Prototype Questionnaire and Interview Questions

Questionnaire:

1. I found the visual cues engaging.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

2. I found the visual cues make me aware of the presence of fruits.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3. I found the audio cues engaging.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

4. I found the audio cues make me aware of the presence of fruits.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

5. I found the reminders are given in an appropriate time and situation.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

6. I felt reminded to eat fruits when using the smart fruit bowl.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

7. I felt the reminders were redundant and too frequent.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

8. I faced technical difficulties or bugs using the smart fruit bowl.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

9. It was convenient to report my fruit intake via a messaging app.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

10. The smart fruit bowl could potentially increase my fruit intake if the design is improved (solve the technical issues, make it more engaging, less redundant, and frequent)

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Interview questions:

1. What was your general experience using the smart bowl?
2. What do you like about the smart fruit bowl?
3. What do you dislike about the smart fruit bowl?
4. Did you feel any differences between using the smart fruit bowl and the regular fruit bowl?
5. Can you explain the technical issues or bug you experienced when using the smart fruit bowl?
6. How can the features in the smart fruit bowl be improved?
7. Would you like to use the smart fruit bowl in a regular basis, if it is improved (the technical issues are solved, the smart fruit bowl is more engaging, less redundant, and frequent)?