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ROLE OF THE CHILDREN IN FOOD WASTE

Devising a gamified solution to avoid food wastage among young kids.

Lappeenranta-Lahti Univeristy of Technology LUT

Software Engineering xxx

Erasmus Mundus Masters in Software Engineers for Green Deal

2024

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ABSTRACT

Lappeenranta-Lahti Univeristy of Technology LUT

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Role of children in Food waste

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Food wastage has seen a significant rise since the 20th century. It has been recorded that over 50% of the waste from households is food waste. This thesis considers children as a main role in this issue. Statistics show that households having young children produce 15% more food waste. Several studies and research have been performed to highlight different reasons behind this issue. Reasons like time-limit pressure, over-purchasing of food in emotions and affiliation by parents, and children not being able to understand their hunger levels, have been the most important among the discussed in the literature review. Following the literature review of the food wastage reasons, we check various games that have been developed to counter the food wastage behavior among children. Games like Feed the Movement, help children understand how to carry out day-to-day activities with parents while keeping minimum food prints, game-on and Tony-Waste help children understand how to manage the kitchen and run restaurants without wasting food whereas Upcycle game teaches children how to be creative in creating recyclable recipes from leftovers, and food waste board game teaches children to be mindful of their decisions in terms of food consumption, storage, and wastage. In addition, Face-the-waste Game provocates children to make them realize how bad it is to waste food when they see the food going into the bin upon answering incorrectly. Exploring the different games developed in this arena gave an idea of what persuasive design principles applied to them. While analyzing the gaps in the games developed, we identify that they lack the element of learning and are also not helping children understand their hunger/fullness cues. As discussed already, one of the important reasons for food wastage among children is the unawareness of their hunger cues, therefore we consider that gap in our game design. With the gaps identified, we formed the basis of our own game. Our game design has been divided into several stages, for each stage, we developed the theoretical gamification framework where we discussed different aspects of the game design fulfilling behavioral change theories. These also incorporate important persuasive design principles. We

discuss the different features of the game and map different quality characteristics with the features and persuasive design principles. After successfully building the game, we delved deeper into the user evaluation study to discover how influential our developed game has proven in changing children's behavior towards food wastage,

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SYMBOLS AND ABBREVIATIONS (may be included, but not relevant for all theses)

Roman characters

p	pressure	[bar, Pa]
qm	mass flow rate	[kg/s]
R	gas constant	[J/kg K]
T	temperature	[ºC, K]
U	voltage	[V]
V	volume	[m3]
v	specific volume	[m3/kg]
x	vapour content	

Greek characters

α	incidence angle	[°]
γ	thermal conductivity	[W/mK]

Constants

g	gravitational acceleration	9,81 m/s

Dimensionless quantities

Re	Reynolds number

Subscripts

1	inflow
2	outflow
kr	critical
mit	mit measured

Superscripts

$'$	stator
$''$	rotor

Abbreviations

CFD Computational Fluid Dynamics

ORC Organic Rankine Cycle

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1

The issue of food waste has impacted the economy, environment, and societies at a global scale in adverse ways according to **su12187401**. As per European Commission 2015 88 million tonnes of food is wasted in Europe which is equal to 173kg of food wasted per person, this indeed is a loss of 143 billion euros for Europe. As per Miljøstyrelsen 2014 Denmark currently throws away 7,00,000 tons of food each year with 260,000 food dumped by households. This itself costs Danes 50% of 11.6 billion DKK. It is also noticeable that 137,683 tons of unprocessed foods are wasted in Danish households, which amounts to 0.96 kilos of food wasted by every Dane each week in a year. Spain wastes 18% of the total food produced which goes up to 2.8 million tonnes of food each year as per *Country Report: Spain* 2016. This wastage amounts to a loss of 11 billion euros. Food wastage is one of the important issues since it affects different aspects of life environmentally, socially, and financially adversely. As per Food and United Nations 2013 producing food requires different resources like heat, water, manpower, and soil therefore wasting food is equivalent to wasting these resources. Not only natural resources, but food production also requires financial resources, therefore wasting food also causes monetary losses for individual and national economies as per Ponis et al. 2017. According to Bravi et al. 2020 when food waste is decomposed, it produces different greenhouse gases which are estimated up to 3.3 million tonnes of carbon dioxide. Food wastage directly impacts food insecurity worldwide, as the food wasted could be redirected to hunger-stricken places. This makes food waste a moral issue since there are 870 million people in the world who are suffering from chronic malnutrition as per FOOD 2016.

According to Herzberg et al. 2020 detailed experimental studies were carried out to lay out the determinants and reasons behind food wastage in Germanic households. They mentioned that smaller households without children wasted 15% less food than the big households with small children. These big households were majorly wasting food due to overpurchasing. As per Graham-Rowe et al. 2014 families with more children waste more quantum of food as compared to the ones without children or with fewer children. According to Parizeau et al. 2015 families with children also produce different kinds of food waste, which consists of spoiled food, unwanted or over-purchased food, and also burnt food. All these studies conclude that children significantly influence household food purchasing and preparation decisions. The preferences and eating habits of children can lead to the purchase of food items that ultimately are not consumed and are wasted. Several studies including Ilić et al. 2022 focused on "plate waste" in both schools and homes have consistently found that

children from age between 2-7 waste a considerable portion of their meals both at schools and in homes due to having peculiar preferences.

Given the significant role children play in contributing to food waste, as highlighted by the aforementioned reasons, it becomes imperative to scrutinize the underlying factors influencing their eating habits. By investigating these factors, we aim to establish a foundational understanding that will guide the identification and analysis of effective strategies to mitigate this issue. This research endeavor is vital not only for pinpointing existing gaps in current solutions but also for crafting innovative approaches that align the insights gained from our study with the practical applications of previously implemented solutions.

1.1 Food Wastage in Schools by Children

According to Derqui et al. 2018 main reason behind food wastage in schools, as identified in the article, was largely attributed to behavioral factors related to individual choices and preferences. These included operational inefficiencies in school catering services and situational factors such as rushed lunch hours and the canteen environment. These factors contributed to significant amounts of plate waste and other forms of food waste in school canteens.

To address this issue, various interventions were suggested. These included educational and awareness campaigns to change student attitudes towards food waste, improve the efficiency of school catering services, and address situational factors to create a more conducive eating environment.

These measures aimed to reduce the amount of food waste generated in school canteens and improve the overall sustainability of school food systems.

1.2 Food Wastage by Children in Households

As per Kansal et al. 2022 children's behaviors and preferences are significant contributors to food waste in households. Key reasons include children's pressure for impulse buying, fussy eating habits, and changing preferences, leading to over-purchasing and over-preparation of food by parents. It also points out that children tend to prefer perfectly shaped food items, making campaigns promoting imperfect produce less effective with them. This emphasizes the need for targeted interventions to change children's food behaviors and the role of parents in reinforcing these changes. The paper also suggested some interventions in this arena that emphasize the need for targeted educational campaigns aimed at both children and parents. These campaigns should focus on changing children's attitudes towards food, including accepting imperfectly shaped produce. Conclusions also focus on parents who play a crucial role in reinforcing these behavioral changes at home. It also sees opportunities for supermar-

kets and government agencies to participate in these educational efforts, helping to reshape marketing strategies towards reducing food waste.

1.3 Food Wastage in Households due to Overpurchasing

The detailed study investigated by Tonini et al. 2023 focussed on factors like socioeconomic characteristics and food-related behaviors. It uses a survey of 806 families, analyzing perishable food items as primary waste contributors. The research identifies two waste patterns: inadequate food management in families with young and middle-aged children, and over-purchasing in others. Key findings include the importance of household type and shopping habits in predicting food waste, with emphasis on policies targeting young families and promoting responsible consumption practices, meal planning, and waste awareness among children.

1.4 Environmental Psychology

The research depicted by Sorokowska et al. 2020 focussed on environmental psychology. It claimed that children's attitudes toward food waste evolve with age. At 6–7, awareness starts forming, by 8–9, a clear attitude against wasting food solidifies, and by 10–12, this attitude is accompanied by actual behavior reflecting their beliefs. This progression suggests that educational programs targeting these age groups could effectively cultivate sustainable habits regarding food consumption and waste. It suggests that to develop sustainable behaviors in children regarding food waste, it's beneficial to introduce targeted educational programs and practical activities during their formative years. Engaging them in discussions about the importance of food, its sources, and the implications of waste can help build a foundation of awareness. Encouraging participation in food preparation, proper portioning, and composting can also foster responsible habits and a deeper understanding of food's value, shaping their attitudes and actions toward minimizing food waste.

1.5 Food and Nutrition Education

As per Balansin Rigon et al. 2022 it has been highlighted that upon observing the food wastage quantity in a couple of Brazilian schools, before and after FNE activities, it was found that, after FNE the proportion of Food wasted in such schools was cut down. A few activities of FNE involved making children understand the size of their hunger and the importance of all foods for a balanced and healthy diet. This understanding was aimed to help them recognize the real size of their appetites to avoid wastage. For example, in one activity, children were asked to gauge how hungry illustrated dolls were and to imagine serving lunch

to these dolls, reflecting on the appropriate food quantity. Another activity of FNE involved educating children about health and sustainability.

1.6 Feeding Patterns and Food Wastage Behavior of Toddlers

The article Swamilaksita et al. 2023 describes The "Shut Mouth Movement" (GTM), a term used to describe behavior in toddlers where they refuse to eat or are extremely selective about what they eat. This behavior often results in the child throwing away food they do not wish to consume, contributing to food wastage. GTM is an indicator of a child's attitude towards food and can impact their nutritional status. Parents and caregivers need to address this behavior effectively to ensure adequate nutrition and minimize food waste.

The article suggests several solutions to address the problem of toddlers' food wastage behavior, including the "Shut Mouth Movement" (GTM). These solutions emphasize the importance of proper feeding practices and parental involvement in managing the food preferences and behaviors of toddlers. The suggested strategies focus on creating a positive and responsive feeding environment, understanding the child's hunger and fullness cues, and offering a variety of healthy food choices. The article underscores the need for educating parents and caregivers about nutrition and effective feeding techniques to improve toddlers' eating habits and reduce food wastage.

1.7 Influence of Picky Food Preferences on Food Wastage

The paper Giboreau et al. 2019 investigates the relationship between children's food preferences and waste in school canteens. It finds a strong correlation between food liking and wastage, with disliked foods being wasted more. The study highlights the significant role of sensory characteristics (taste, texture, appearance) in influencing children's food choices.

To improve attitudes towards food waste, it suggests designing school menus that align with children's preferences, emphasizing the importance of considering sensory aspects of food to enhance consumption and reduce waste.

1.8 Understand Child's Food Preferences

According to Laureati 2022 there are different factors influencing children's food choices rather than directly addressing food wastage. It discusses aspects like sensory properties of food (taste, texture, appearance), psychological factors such as food neophobia (the rejection of unfamiliar food), and environmental influences including family and cultural background.

These factors significantly impact children's preferences and consumption patterns, potentially leading to selective eating and waste, especially of healthy foods like fruits and vegetables. The article emphasizes understanding these determinants to encourage healthier eating habits in children.

1.9 Food Consumption Awareness in Children

The article Grosso and Falasconi 2018 emphasizes the critical role of awareness and education in reducing food waste. It highlights that educating children about the value of food, both in monetary and environmental terms, is essential. To improve children's attitude towards food wastage, education should focus on the environmental impact of food production and waste, the social and ethical implications of food wastage including global hunger and resource distribution, practical steps children can take to minimize food waste, such as understanding 'best before' labels, portion control, and valuing leftovers, and participation in food preparation and gardening activities to foster a deeper appreciation for food. This educational approach aims to influence children's behaviors by making them more conscious consumers and reducing food wastage through informed choices.

Overall the major reasons underlying the children's behavior towards food can be regarded as overbuying/over-purchasing, non-preferred food texture, zero awareness about hunger, and fullness cues. For this purpose, different solutions have been presented out of which the most important role played by persuasive games. Persuasive games have been proven to shape a child's psychology and behavior. Moreover, children are more up for playing constructive games rather than taking advice. In this arena, several games have been developed for children under different age groups which shall be discussed in later sections.

2 BACKGROUND

In the previous section, the underlying reasons for food wastage by children and different solutions to this problem have been explored. This makes it important to educate children about food waste, as it was constantly stressed in the previous literature review. There are different mechanisms for this purpose e.g.; traditional classroom teaching, parental mentorship, playing games, etc. Under the theory of planned behavior and constructivism, individuals learn more when creating something independently. This means that if children are involved in the process of observation, creation, and its consequences, this can impact their behavior. As per Sinclear et al. 2022, serious games incorporating persuasive elements can result in individuals' emotional reflection, which turns into behavioral change. According to Boyle et al. 2016 there is a 20-30% more enhanced learning outcome in individuals who learn via games, compared to traditional methods. These studies show that persuasive games can prove very effective in changing children's behavior toward food waste. We shall develop our research on the already built game designs in this arena, and the philosophies behind them accompanied by their in-depth analysis.

Before delving into game design discussion, it is crucial to mention the learning models important for the learners to grasp concepts. Understanding these learning models will help define the philosophies behind each game design we study in the proceeding sections. These theories give a first-hand view of how individuals acquire, process, and retain knowledge. This is important to know since it helps inculcate thoughtful elements in the teaching platform, which is a game in our case.

As per Olson and Ramírez 2020 the cognitive theory in depth entails the mental process involved in the learning process, whereas Evolutionary Theory discusses the adaptive importance during learning behavior which is one of the common aspects of persuasive game designing principle.

In another book as per Schunk 2012 several learning theories have been discussed like the theory of behaviorism, the theory of constructivism, social learning theory, and the information processing theory. The external stimuli if designed accordingly, can change the behavior of the learner according to behaviorism. Another theory of social learning, as discussed, stresses how learners can acquire understanding by observing from the educational platform, imitating it, and modeling it. Contrary to it the information processing theory underscores how learners grasp the information and process it as compared to a computer mind. This theory suggests that by understanding the learner's process of retaining and processing information,

the educational platform can be strategized accordingly. The theory of constructivism, on the other hand, mostly emphasizes on enhancing learning via experience. The practical experience can be enhanced via constructing things, and that hands-on experience improves learning. If the educational platform allows the learner to experiment or build something, then this experience helps a lot in learning. The cognitive learning theory in depth discusses the mental model a learner uses while grasping concepts. It entails how learners solve problems while planning, monitoring, and evaluating their learned concepts in parallel.

According to Hale et al. 2002, the theory of reasoned actions is considered important in influencing individuals' behaviors. It suggests that behavioral intention is the key predictor of any behavior toward external stimuli. While designing any persuasive educational strategy, it is important to consider the subjective norms and individuals' attitudes, as they help the individuals in forming their intentions towards any behavior.

An extension of the theory of reasoned actions, according to Ajzen 1985 entails how the theory of planned behavior can be used to predict the goal-oriented behavior of those individuals who have no control over their actions. This theory suggests that most of the behavior of individuals is controlled by the attitude of individuals, norms, and perceived control. This attitude or intention towards carrying out any behavior is shaped by the positive and negative evaluation of their behavioral decisions. To best shape this evaluation, educational media should be helping enough to teach individuals the outcome of their behavior in a fun, meaningful, and interactive way. While designing any intervention to influence behavior, it's important to take into consideration all the factors that shape the intentions of individuals.

As per Tikka and Oinas-Kukkonen 2019, these learning theories can be applied to interventions to make them more persuasive. One of the persuasive principles discussed i.e.; a system of rewards and feedback plays an active role in changing behavior. The system of feedback and rewards makes the individuals do things positively to achieve more rewards and appreciation. On the other hand system of reduction, i.e. dividing complex tasks into simpler challenges helps individuals grasp concepts. The system of reduction is one of the persuasive principles that is built on top of information processing theory. On the contrary, modeling and imitating the acts observed from surroundings while solving any challenge is one of the learning bases that can be utilized by gaming/educational platforms to change attitudes. These platforms can employ real-world scenarios as persuasive principles so that the educator can easily relate to them and imitate the same things he/she has learned from observations. Whereas another aspect of learning i.e. self-determination theory, highly focuses on the user's intrinsic and extrinsic motivation, which can be satisfied using persuasive strategies like competence and autonomy.

After discussing these theories and their relationship with different persuasive strategies, we can say that games carrying persuasive principles geared by learning theories tend to change the behavior of individuals. By analyzing the already-built games in the arena of food waste accompanied by their learning and persuasive strategy drivers, we shall be able to understand what aspects they have addressed, and what laggings they have. These gaps are important to pinpoint so we can develop our game design accompanied by learning frameworks and influence principles.

2.1 Game Designs, their theoretical framework, and applicable Persuasive Design Principles

Several games have been developed to help children stay aware of the food print their activities are causing. In this chapter we shall discuss each game in the light of food waste by children, the theoretical frameworks applicable to them, and the persuasive design principles they follow.

2.1.1 Feed The Movement

The gamified approach as per Titiu 2019 helps children aged 9-12 in a simulated environment with their parents to carry out day-to-day activities like cooking, doing groceries, and eating without causing any food waste. The game presents suggestions to the children related to sustainable activities they can perform to reduce food waste. It creates a social environment where families can compete within the same neighborhood and city for a good cause.

The game is purely based on Social Learning Theory and the Theory of Planned Behavior. The game since incorporates both parents and children in the game, helps children understand the consequence of their actions by learning from their parents, therefore social learning theory best fits here. Secondly, any action taken by children in the game is purely based on their intentions and the norms they have been raised into, therefore Theory of Planned Behavior is suitable as well.

The objective is to educate families about food waste reduction and encourage them to adopt sustainable behaviors through interactive learning and daily practices. It engages parents and children in a collaborative effort to reduce food waste. The core dynamics of this game are Engagement, Education, and Empowerment. The game incorporates Challenges like Assignments and tasks related to food management practices, such as creating efficient grocery lists or learning about food preservation. The Progression depiction is done through Levels and progress bars that reflect the user's journey and achievements in reducing food waste. The Feedback mechanism involves performance graphs for immediate feedback and progress comparisons for long-term feedback, offering positive reinforcement and constructive sug-

gestions. This game includes Virtual rewards (e.g., HERO coins, avatar customizations) and real-life incentives that motivate continuous participation and achievement of goals. The game components include Avatars, Leaderboards, and Educational Content. The game's narrative Incorporates storytelling elements where users feel part of a larger mission to save the planet, making the experience immersive and emotionally engaging. The game involves Social Interaction via:

Collaboration: Encouraging family members to work together on assignments, promoting teamwork and shared learning experiences.

Competition: Optional competitive elements like leaderboards, where families can compare their achievements with others, fostering a sense of community and collective action.

Tasks and challenges designed in the game integrate seamlessly with daily activities, ensuring that the behaviors learned through the game are easily transferable to real-life contexts.

In summary, this game involves different Persuasive design principles like Primary Task Support, Dialogue Support, System Credibility Support, and Social Support. This game simplifies tasks related to food waste reduction, offering tools or information that assist in achieving these goals. It uses praise, reminders, and suggestions to encourage continued engagement and progress in the game. The game design makes it trustworthy in providing accurate information on food waste reduction strategies. It incorporates features that allow for social comparison, normative influence, social learning, and cooperation, encouraging users to change their behavior through community involvement.

2.1.2 Game On

According to Vasconcelos et al. 2023 the paper discusses the game design where Children aged(8 to 12) play with the character Eduardo, illustrated as a lion and chef, who teaches kids how to manage the kitchen while carrying out the cooking tasks of the whole day. Children learn to do appropriate grocery for buying cooking items, what food to keep in the fridge, meal planning, and how much to buy food. Players are rewarded with experience points based on their performance in the kitchen, including how well they store food, select recipes based on needed quantities, use food near expiration dates, and save food by chopping. Players earn coins that can be used to acquire new tools for the kitchen and customize their avatars with accessories.

The game employs Flow theory and Self Determination Theory as the important framework for the design. While managing the kitchen, the player dwells in the actual kitchen scenario where he/she works in a usual flow based on experiences and learns through the consequences of past actions. In addition, the player manages the whole kitchen while staying autonomous

throughout the entire gameplay the player is completely independent and is responsible for his actions.

The story revolves around Tony, a chef striving to minimize food waste. This narrative embeds the game's educational goals within an engaging storyline. Tony and the customers provide a personal touch that enhances player engagement and empathy, making the game's educational messages more impactful. By fulfilling customer pizza orders, players practice managing resources efficiently, directly translating to the game's educational goal of reducing food waste. Immediate feedback on the player's actions (e.g., successfully avoiding waste or failing to do so) reinforces the learning objectives through direct experience. Players learn the importance of reducing food waste by actively participating in the process, making the learning experience more memorable and impactful. Moreover, they must strategize to use ingredients wisely, reflecting real-life decisions on resource management and waste prevention. Instant Feedback: Players receive immediate feedback on their performance, reinforcing correct actions and discouraging wasteful practices. Achievements, high scores, and progress markers serve as rewards that motivate continued play and learning. Consequences for failing (losing scores) to meet the game's waste reduction goals highlight the importance of the issue and encourage players to think critically about their choices. By simulating a real-world task (kitchen management), the game fosters a direct connection between the skills practiced in-game and their applicability to real-life situations regarding food management and waste reduction.

In conclusion, the game employs different persuasive design principles like Reciprocity, Commitment, Consistency, Authority, Personalization, Tailoring, and Feedback. The player receives the reward and penalty for whatever actions he takes. The dwelling into the kitchen and scenario and working with the kitchen tasks in a flow with continuity depicts the consistency, then the autonomous behavior of the player, and being able to customize, dress, and purchase stuff for the kitchen makes the game more persuasive and relatable.

2.1.3 Tony Waste

In the game Ferreira et al. 2019 Children play with the main character Tony. Tony, is a chef who needs help to avoid food waste while preparing pizzas. Customers who order pizzas are also part of the game, providing the assignments (orders) that Tony must fulfill. The player is supposed to be preparing pizzas with specific toppings as requested by customers. The goal is to use the exact amount of ingredients needed to avoid waste.

Tony Waste incorporates the Theory of Constructivism whereby allows the player to cook pizza themself and explore independently what quantities are needed, what to waste, and

what to reuse. This theory is important since it inculcates confidence in the children while creatively discovering what actions are causing more food prints.

The story revolves around Tony, a chef striving to minimize food waste. This narrative embeds the game's educational goals within an engaging storyline. Tony and the customers provide a personal touch that can enhance player engagement and empathy, making the game's educational messages more impactful. By fulfilling customer pizza orders, players practice managing resources efficiently, directly translating to the game's educational goal of reducing food waste. Immediate feedback on the player's actions (e.g., successfully avoiding waste or failing to do so) reinforces the learning objectives through direct experience. Players learn the importance of reducing food waste by actively participating in the process, making the learning experience more memorable and impactful. Players must strategize to use ingredients wisely, reflecting real-life decisions on resource management and waste prevention.

There are several influencing tactics used in this game for example repetitive feedback loops, and freedom to fail. The repetitive feedback loops play an important role, since it gives the player realistic results of their decisions taken in the game, whereas the liberty to fail in the game is not controlling the player. In addition, it uses an attractive narrative and fantasy connected with realworld to make the game more exciting and challenging.

2.1.4 Upcycle

The game design Kanonik and Boudreau 2022 focuses on educating players about environmentally friendly cooking and food waste reduction through engaging gameplay. Players are provided with upcycled recipes that they can cook in-game using ingredients found throughout their journey in burgeon. These recipes, aimed at promoting eco-friendly cooking habits, can also be stored on the Upcycle Phone Companion App for ease of access, allowing players to use them to prepare real meals. The goal is to keep the burgeon food spirit happy who misses the sustainable practices of town from old times.

Several theories like the Transtheoretical Model of Behavior Change and Rhetoric and Persuasion Theory apply to this design. The player is guided throughout the game regarding hints of recyclable meal preparation. This changes the mindset of the player regarding food waste, and the player will probably maintain the consistency of thought. Additionally, the game employs the use of burgeon spirit which conveys logical arguments with emotions. This kind of tactic makes the game more persuasive.

The primary goal of "Upcycle" is to educate players about food waste and its impact on climate change, along with teaching them about upcycled recipes that can be made using leftover ingredients. This educational aspect is seamlessly integrated into the gameplay, making learning an intrinsic part of the experience. The game bridges the gap between virtual and

real-world cooking. Players can use the Upcycle Phone Companion App to access recipes they've unlocked in the game, encouraging them to try these recipes in their kitchens. This direct application of game content to real-life practices reinforces learning and promotes behavior change. By embedding education on food waste within an emotional narrative, the game aims to connect with players on a deeper level. This emotional connection can increase the impact of its message and motivate players to change their habits regarding food waste. This game typically uses rewards (e.g., unlocking new recipes, and earning achievements) to motivate players. Progression through the game involves completing recipes, reducing waste, and meeting other environmental objectives.

The most important aspect of this game is a credible support system. The guidance provided in the game related to recyclable recipes using food leftovers is something that user needs to rely on. Therefore game provides authentic and right suggestions after analyzing the collected food leftovers. Moreover, dialog support is an important aspect of this game, where players shall be continuously reminded, guided, and notified about where to search for leftovers in the town, which tools to use for food preparation, what recipes to make, etc.

2.1.5 No Food Wasted Board Game

The paper *The No Food Waste Game* 2020 discusses the educational pack designed by WWF in the form of a board game, to teach children about how to deal with food leftovers. The game aims to promote responsible behavior regarding food consumption and waste management through engaging gameplay.

Social learning theory forms the basis of the game, where players while observing other's actions and consequences learn about food waste. Since the game is played collectively, therefore cross-learning across the team, makes the gameplay more fun and exciting.

The game focuses on educating players about the consequences of food waste and encouraging thoughtful decision-making regarding leftover food. It is played in teams of 5-6 players using a complete game pack. The game includes garbage and recycling/composting cards, a sachet with snack cards, and a set of two tompola cards per player, which depict different choices for managing uneaten snacks. Players take turns drawing snack cards from a central sachet, each card representing a snack that was not completely eaten. After drawing a card, each player decides what to do with the uneaten snack. They can either place it on their tompola cards, which represent different future uses of the snack, or dispose of it in the designated bins for garbage, recycling, or composting. The game ends when a player successfully fills all the squares on their tompola cards and declares "bingo," signifying their win. The game pack includes points for discussion to further engage the players and deepen their understanding of food waste issues.

Social learning and competition are some important applicable design principles important for influencing children behavior. Players learn across the team players, by observing the rewards and consequences of their actions, also the game engages the players in a healthy competitive environment where there is a race to get bingoed first.

2.1.6 Face-the-Waste Game

The game Sinclear et al. 2022 uses a multiple choice question-based design that educates individuals not only about food sustainability but also uses provocative means to convince users how bad it is to waste food.

The theoretical framework this game mainly uses the Behavioral Change Theory and the Provocative Design Theory. The game focuses on changing children's behavior through a provocative persuasion strategy so that children can realize how bad this deed could be.

This game is a physical installation and mimics a quiz show with multiple-choice questions. Children are asked the questions, and if they answer questions incorrectly, they have to see food going on the conveyor belt and waste in the bin. This strikes an emotional realization within the player, that makes him/her understand it is not a good thing.

Emotional Engagement, Feedback, and Simulation are the only persuasive strategies employed in this game. Since provocative design is used it also gives feedback when the player is making a mistake and this whole environment is simulated to mimic the quiz show.

2.2 Comparative Study of Game Designs

While discussing different game designs we will present a comparative study from different perspectives like PSDs and Theoretical frameworks.

2.2.1 Comparative Study of Theoretical Frameworks with Games

Table 1 shows that only the theory of planned behavior and self-determination theory applies to 3 games, whereas other theories are only applicable to 2 out of 5 games. in addition to that it is evident that narrative persuasion theory is only applicable to the Upcycle game which means that the Upcycleable game has a more emotional aspect than other games. Among the 5 games studied, two of them, Tony Waste and Upcycle employ the most theoretical gamification frameworks which are 3 in number, the rest of them employ two theories.

2.2.2 Comparative Study of PSDs applicable to Games

As per 2 the Reward and Feedback mechanic applies to almost all the game designs except for the board game, where feedback is not possible, since players will only lose or win and

Theoretical Frameworks	Feed the Movement	Game ON	Tony Waste	Upcycle	No Food Waste Board Game	Face-the-Waste
Social Learning Theory	Yes	No	No	No	Yes	No
Theory of Constructivism	No	No	Yes	Yes	No	No
Theory of Planned Behavior	Yes	Yes	Yes	No	Yes	No
Self Determination Theory	No	Yes	Yes	Yes	No	No
Narrative Persuasion Theory	No	No	No	Yes	No	No
Provocative Design Theory	No	No	No	Yes	No	Yes

Table 1: Theoretical Frameworks applicable

Applicable Design Strategies	Game Designs
Reduction, Social Competition, Self Monitoring, Rewards, Feedback, Real World Feel	Feed the Movement Titiu 2019
Real-world Feel, Freedom To Fail, Self Monitoring, System Credibility Support, Tailoring, and Personalization	Game ON Vasconcelos et al. 2023
Real-world feel, Clear Goals and Mission, Self Monitoring, System Credibility, Rewards, and Feedback	Tony Waste Ferreira et al. 2019
Emotional Engagement, System Credibility Support, Self-monitoring, Clear Goals, and Missions	Upcycle Kanonik and Boudreau 2022
Social Competition, Rewards	No Food Waste Board Game *The No Food Waste Game* 2020
Feedback, Simulation, Emotional Engagement	Face-the-Waste Sinclear et al. 2022

Table 2: Comparison of PSDs applicable to different Game Designs

won't get any hints. Self-monitoring which applies to up to 4 out of 5 games suggests that depicting a player's progress is important as it helps in self-evaluation of performance. Real World Feel is an important phenomenon taking place in 3 out of the 5 game designs since it increases easy learning by social relevancy. In addition to that 2 out of 5 games encourage healthy competition through leadership boards in Feed the Movement and through snack cards in No Food Waste Board Game. Two important games i.e. Upcycle and Face-the-Waste game employ emotional persuasion tactics among the other games studied. Besides that Clear Goals and Missions applies to 2 out of 5 games, where pizza has to be prepared and burgeon spirit should be satisfied.

2.2.3   Comparison of type, age group of game designs

When it comes to game categorization, we took different genres and classified them. As per 3 games belonging to the Simulation category are more in number since the element of real-world feel exists in them therefore 4 out of 5 games belong to the Simulation genre. The trivia genre is a puzzle-like game where the solution has to be provided by exhausting resources within the time limit, just like Tony Waste where pizza has to be prepared while taking care of time. Whereas there is only 1 board game among all i.e. No Food Waste Board game. The RTS category (Real-time strategy applies to all the game categories except for Upcycle. In all the games real-time strategy has to be made to do appropriate actions, whereas, in Upcycle, real-time strategy and time bounding do not exist.

As per 4 it is evident that games that are pure simulation, are mostly applicable to Desktop platforms, whereas puzzle games like Tony Waste and Game On are more compatible with Mobile and tablet-like platforms. The board game like No Food Waste Board Game is compatible with all the platforms. Moreover, adventure games like Upcycle are tablet and mobile-dependent since it has a dedicated app for unlocking recyclable recipes. The only physical game which does not have a digital version is the Face-the-Waste Game.

Game Types	Feed The Move-ment	Game On	Tony Waste	Upcycle	No Food Waste Board Game	Face-the-Waste Game
Simulation	Yes	Yes	Yes -	-	Yes	
Trivia	-	-	Yes	-	-	-
Board Game	-	-	-	-	Yes	-
RTS	-	Yes	Yes	-	Yes	-
Adventure	-	-	-	Yes	-	-

Table 3: Game Genre classification

Platform	Feed The Movement	Game On	Tony Waste	Upcycle	No Food Waste Board Game	Face-the-Waste Game
Desktop	Yes	-	-	-	Yes	-
Mobile	-	Yes	Yes	Yes	Yes	-
Tablet	-	Yes	Yes	Yes	Yes	-
Physical Installation	-	-	-	-	-	Yes

Table 4: Game Platform Comparison

Type of player	Feed The Movement	Game On	Tony Waste	Upcycle	No Food Waste Board Game	Face-the-Waste Game
Multiplayer	Yes	-	-	-	Yes	Yes
Single Player	-	Yes	Yes	Yes	-	-

Table 5: Game Player Type Comparison

As per the table 5 it is evident that games that encourage social learning and social competition like Feed the Movement, Face-the-Waste Game, and No Food Waste Board Game involve multiplayer, since Feed the Movement include families with children and parents and engage them in competition among same neighbor and cities. Whereas for playing Board games, at least 5-6 players are needed, moreover for face-the-waste games at least 2 people are required to play. The rest have been categorized in the single-player category.

As per table 6 only 2 out of 5 games have specified the age group for children and parents, the rest of them do not have any such mention in their game strategy.

Age Group Identification	Feed The Movement	Game On	Tony Waste	Upcycle	No Food Waste Board Game	Face-the-Waste Game
Mentioned Age Groups	9-15 (children) 30-40(parents)	8-12 (children)	undetermined	undetermined	undetermined	undetermined

Table 6: Game Comparison with age groups

3   OUR APPROACH

Our approach tries to bridge the gap between the major causes of food waste in children and the absence of those aspects in the studied game design. To address these concerns, we first lay out our research questions.

3.1   Research Methodology

This research shall focus on designing the game mechanics to influence children's behavior in reducing food waste. We shall form the game mechanics by answering these research questions while inculcating persuasive principles and learning theories.

3.1.1   RQ1:

What strategy can be followed to teach children about managing their food consumption through the serious game while maximizing engagement?

3.1.2   RQ2:

How to ensure that children are encouraged to learn in the game design.

3.1.3   RQ3:

How is the game design maintaining relevancy while ensuring relatability for easier learning?

3.1.4   Research Rationale:

The purpose of these questions is to underscore the main features of game design that shall prove useful for influencing children's attitudes and intentions towards food wastage. Moreover, answering these research questions shall depict how learning theories and PSDs have been employed to improve children's behavior.

3.2   Requirements Specification and their Relationship with Persuasive Design Principles

To set the design process we shall first define the usage scenario. Usage scenario is a list of scenarios that answer the 1st research question. Moreover, the usage scenario also lays the foundation for the business domain model. Based on the scenario game's functional and

quality requirements shall be defined. From non-functional requirements, we shall extract the persuasive design principles.

3.2.1 Usage scenarios

Scenario 1: The child playing the game

User: Child

Goal: Learn about food sustainability concepts and earn rewards.

Select Language:

- The kid launches the game and is prompted to select a language.

- The kid chooses their preferred language from the options provided.

Choose User Type:

- The kid is asked if they are a kid or a parent.

- The kid selects ”Kid”.

Take the Food Sustainability Quiz:

- The kid begins a quiz on food sustainability.

- They answer multiple-choice questions about food waste, expiration dates, and sustainable practices.

- The kid earns badges for correct answers.

Experience Hunger Management:

- During the quiz, the kid's hunger level increases.

- The game takes the child on a hunger quest where they discover they can see two options, checking the fridge or going to the grocery, if the fridge is empty the child has to land at the grocery.

Grocery Shopping:

- The kid enters the grocery store module.

- They select items to purchase, keeping an eye on expiration dates and avoiding expired items.

- The game warns the kid if their cart is overweight.

Cooking and Eating:

- The kid uses the purchased items to cook a meal.

- They follow a recipe to prepare the meal and then "eat" it in the game.

- If the kid selects the correct recipe steps in sequence, then rewards are awarded.

Sort Leftovers Through Puzzle:

- After eating, the kid is taken to a labyrinth puzzle to sort the leftovers.

- They select the leftovers and collide with the correct destination.

- The kid earns coins for correctly sorted items.

Cook Recyclable Meal:

- Using the earned coins, the kid cooks a meal using recyclable ingredients.

- The game provides feedback on their choices and rewards.

Scenario 2: A Parent Monitoring Progress

User: Parent

Goal: Monitor the child's progress and make informed decisions.

Select Language:

- The parent launches the game and selects their preferred language.

Choose User Type:

- The parent is asked if they are a kid or a parent.

- The parent selects "Parent".

Enter PIN:

- The parent is prompted to enter a secure PIN to access the monitoring features.

View Performance Reports:

- The parent accesses a dashboard showing the child's performance in different stages of the game.

- They see detailed graphs and reports on:
    - Preferred grocery items
    - Preferred meals prepared
    - Time spent eating
    - Number of morsels eaten
    - Amount of food left
    - Decisions made in sorting leftovers

Analyze Data:

- The parent reviews bar graphs and other visual data representations.
- They analyze the child's progress and learning outcomes.

Make Informed Decisions:

- Based on the analysis, the parent may decide to discuss certain aspects of food sustainability with the child.
- They can also encourage the child to focus on areas where they need improvement.

Functional Requirements:

The functional requirements are necessary to obtain as they provide a glance at the basic functionalities and the workings of the system. Moreover, it forms the basis of our major design and architecture decisions, since the services associated with every functional requirement tell a different story of data exchange and functionality. Some services associated with a functional requirement may have complex data structures to share with other services. The demands of all the service candidates under a functional requirement shall help shape our technical decision records.

FR-1==> Perform Food Sustainability Quiz.
FR-2==> Purchase Grocery.
FR-3==> Perform Cooking.
FR-4==> Manage Food Consumption and the Leftovers.
FR-5==> Child Performance Analysis.

The main idea behind our game design is to make sure that the child goes through all the phases that project important concepts of food wastage. Performing Food Sustainability Quiz

shall asses the child's know-how of important food sustainability concepts with story anima-
tions. These concepts include over-purchasing, expiry data awareness, food storage, over-
cooking, and recycling food leftovers. FR-2 which deals with grocery purchases takes the
child to an interface where children can do groceries, while carefully looking at the weight
and expiry of every item, so they get to purchase them wisely using coins. Analyzing the
grocery takes the child to the kitchen, which suggests to the kid items they can cook for a
one-time meal. The child picks the steps randomly from the recipe to cook the meal. Once
this is done, the child gets to manage his eating, and the cooking/eating leftovers by going
through a puzzle and taking the leftovers to their accurate destination. The results of all the
activities are analyzed, and a visual representation of all these activity results is displayed in
the parent's interface.

3.2.2   Quality Requirements:

The quality requirements are important to identify as they describe the qualities of the over-
all system. Moreover, they lay out important concerns for the technical decision records,
where each quality requirement must be fulfilled by our chosen decision option. The quality
requirements that fit best into our game design are enlisted as follows:

==> Efficiency

==> Usability

==> Accessibility

==> Functional appropriateness

The efficiency of the system is an important concern, as the game should be able to complete
all the functionalities smoothly, without lagging time, and without using additional resources.
Usability is yet another important concern, as it lays out how easy-to-use the system is, as
the target audience is children and their guardians, and the game must be easy to understand
by children specifically. Accessibility is important to be satisfied in the game, as it should
be easily available to children of all kinds. Functional appropriateness is yet another crucial
requirement since the game shall be dispensing important information that should be reliable,
moreover, the consequences attached to the game functionality need to be accurate, as it shall
be an important source of learning. To make the game persuasive, it is important to make the
requirements relevant to influence strategies. Therefore the quality requirements identified
above shall be mapped to the significant persuasive design principles applicable to them.

As per the table 7, different quality requirements can correspond to persuasive principles in
the game. Efficiency being one of the important quality requirements makes sure that the

Quality Requirements	Persuasive Design Principles
Efficiency	1- Reduction. 2- Tailoring 3-Feedback and Rewards. 4- Consistency
Usability	4- Tunnelling. 5- Suggestions. 6- Self-monitoring. 3- Feedback and Rewards. 7- User engagement.
Accessibility	2- Tailoring. 8- Facilitation. 7- User engagement.
Functional Appropriateness	8- TrustWorthiness. 9- Authority

Table 7: Mapping Quality Requirements to Persuasive Design Principles

system efficiently does the processes without wasting computational resources. Reduction as one of the PSD, makes sure that the complex challenges are divided into smaller tasks. This way it's also easier for the system to process the performance data of players efficiently. Tailoring is an important aspect as it ensures that player data is processed efficiently for each user. This makes it easier for the system to manage and store the data. With the Feedback and Reward strategy, the user can make more informed decisions, which makes it easier for the system to analyze the user's performance. With more consistency, the user shall complete the game-play in one go, which is easier for the system to keep the data and analyze it without losses. On the other hand, the user engagement principle is important to add, as it makes sure children are captivated by the game idea and are moved by the game's narrative to avoid food wastage.

For sustainability, the Tunneling principle works best as it ensures that the player is well aware of the game levels, and challenges, and how to do them. Using the Suggestions strategy, the player can stay informed of more sustainable practices, that reduce food wastage. With the Self-Monitoring aspect, the player can stay well aware of their energy, hunger, fullness level, and the food remaining to eat, which makes sure that food consumption has sustainably taken place. With a Feedback and Reward system, players shall feel appreciated for good performance which increases motivation and, hence better for individual sustainability.

When it comes to Accessibility, it means the game should be easily approachable to all the players out there. Tailoring strategy best fits this requirement as it allows the player to play the game in the language of their choice. Moreover, the facilitation strategy allows the children to understand the game levels and challenges with an easy-to-use interface. This makes sure

that the game is accessible to all kinds of children. The user engagement strategy is always there to maximize user attention from all categories of children.

3.3 Design and Architecture

To design the system and its architecture, we first categorize our functional requirements into business services and their respective service candidates. This will help in giving a holistic view of how different services are working internally, and communicating amongst each other.

3.3.1 Service Oriented Analysis

In this section we shall discuss the business domain model, extracting business services from functional requirements, and identifying the service candidates that satisfy the business process.

Business Domain Model

Before delving into the business services, it is crucial to first identify the business domain model. This business domain model shall give an overview of all kinds of stakeholders (both primary and secondary) and users involved in the system.

In the food waste fiasco business domain model, the crucial stakeholders and users are identified as follows:

- Kids

- Parents

- Food Waste Management Authorities

- Grocery Retailers

- Language Provider

- Recipe Provider

- Dishes Provider
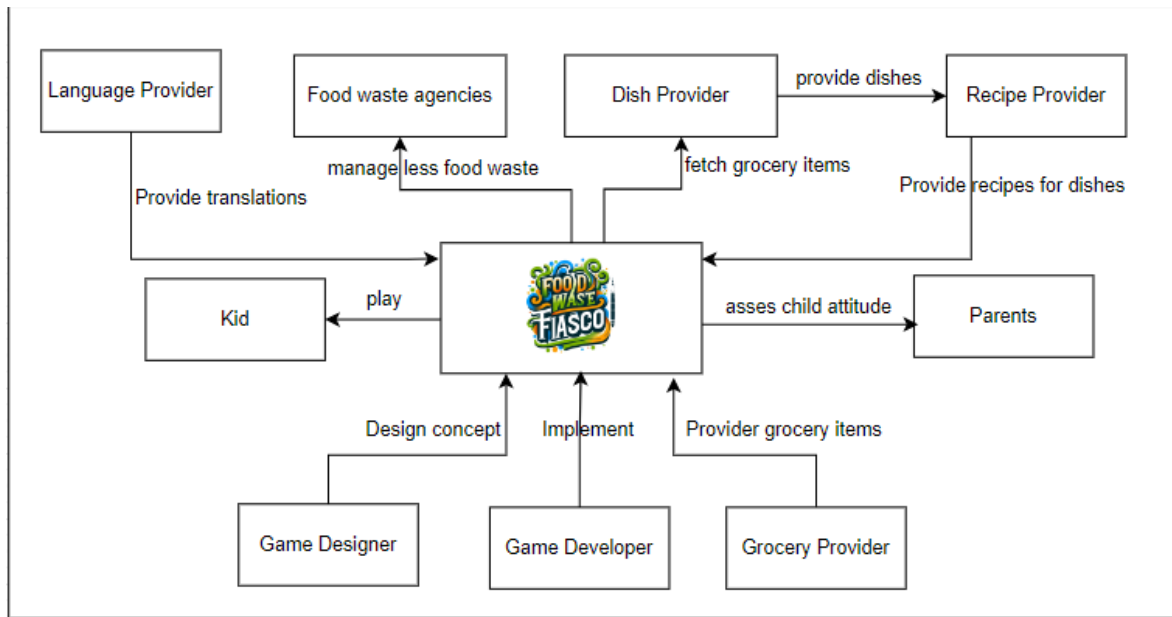
- Game Designers

- Game Developers

Figure 1: Business Domain Model of Food Waste Fiasco

As per figure 1 it is evident that kids will get the important educational output from the Food Waste Fiasco whereas Parents shall be able to monitor the kids' attitude towards food waste from their performance in the system. The game since persuasive to change the child's attitude, shall enable them to reduce wasting food. Due to this behavior, food waste authorities shall significantly observe that food is being wasted less. The grocery provider provides the catalog of groceries in the system, whereas the language provider provides translation support for localization in the system. The dish provider retrieves the list of groceries from the system and generates a list of dishes that can be prepared from the groceries. The recipe provider takes the dishes from the Dishes provider and supplies the recipe steps to the system for the dishes. The game designer shall design the system storyboard and the developer shall implement the mechanics of the system.

Identifying Business Services

In this section, we shall identify the business services for each functional requirement. These business services shall form the basis of the service candidates' extraction process.

- **FR-1: Perform Food Sustainability Quiz**

    BS-FR1-1: Quiz Service.

- **FR-2: Purchase Grocery**

    BS-FR2-1: Grocery Shopping Service

- **FR-3: Perform Cooking**

  BS-FR3-1: Cooking Service

- **FR-4: Manage Food Consumption and Sorting Leftovers**

  – BS-FR4-1: Consumption Service.

  – BS-FR4-2: Food Waste Management Service

- **FR-5: Child Performance Analysis**

  – BS-FR5-1: Quiz Analysis Service.

  – BS-FR5-2: Grocery and Cart Analysis Service

  – BS-FR5-3: Meal Preparation Analysis Service

  – BS-FR5-4: Food Consumption Analysis Service.

  – BS-FR5-5: Food Leftovers Decision Analysis Service

The quiz service provides a set of randomly arranged quizzes with different concepts of food sustainability and their corresponding options, answers, and animation. Whereas grocery shopping service allows the child to shop from a grocery catalog. The Food Consumption and Waste Management Service shall enable the child to make their character eat food, and sort out their cooking and eating leftovers. Child performance analysis shall enable analytics on different through different services like quiz analysis, grocery analysis, cooking analysis, eating analysis, and wasting sorting analysis.

Identifying Service Operation Candidates and Service Candidates

- **BS-FR1-1 Quiz Service**

  The business service Quiz Service has been classified into the following service candidates:

  – SC-1 Language Service

  – SC-2 Treasure Chest Hunt Service

  – SC-3 Tutorial Service

  – SC-4 Quiz Question Service

  – SC-5 Score Calculation Service

– SC-6 Reward Management Service
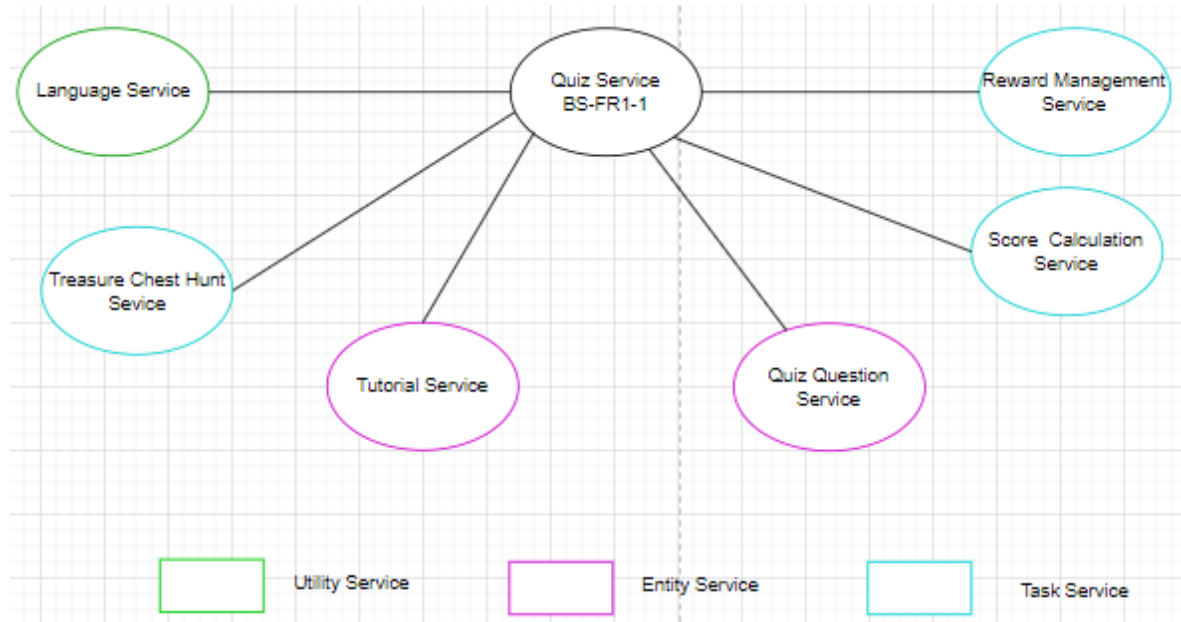
Their classification has been done as follows:

Figure 2: BS-FR1-1 Quiz Service

As per figure 2 The language service candidate is the translation support in the food waste fiasco. It is an external module that provides localization services. therefore it is a utility service. All the services that are responsible for bringing data from the repo have been marked as entity services. Contrary to this the services that are supposed to analyze quiz scores, and awarding badges have been marked as task services, as their responsibility is to provide functionality.

The flow of these service candidates is illustrated in the diagram as follows:
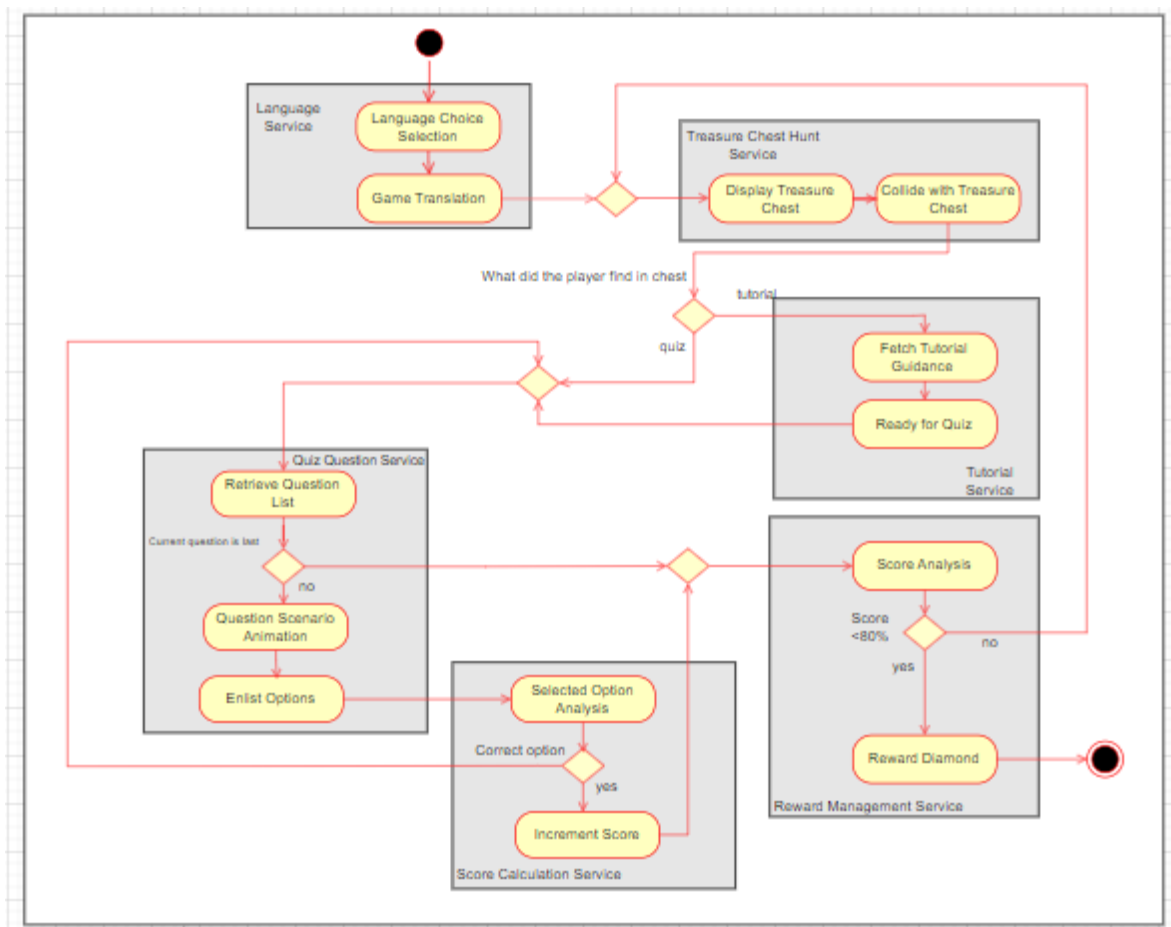
Figure 3: Quiz Service Activity Diagram

As per figure 3, the start shall take place by selecting the language and since this business service belongs to children, therefore selecting a kid is mandatory during role choice. Upon hitting the treasure chest, the player shall be exposed to 2 options either they can play a quiz or check out the tutorial to attempt the quiz. If the player selects the quiz starts, they can see one question at a time with quiz question scenario animation being played, then the player makes the right options to get the rewards.

- **BS-FR2-1 Grocery Purchase Service:**

The identified service candidates for this business service are as follows:

- SC-1 Catalog Service

- SC-2 Cart Management Service

- SOC-3 Expiry Management Service

- SOC-4 Over-weight Management Service

– SC-5 Push Notification Service

– SC-6 Checkout Service

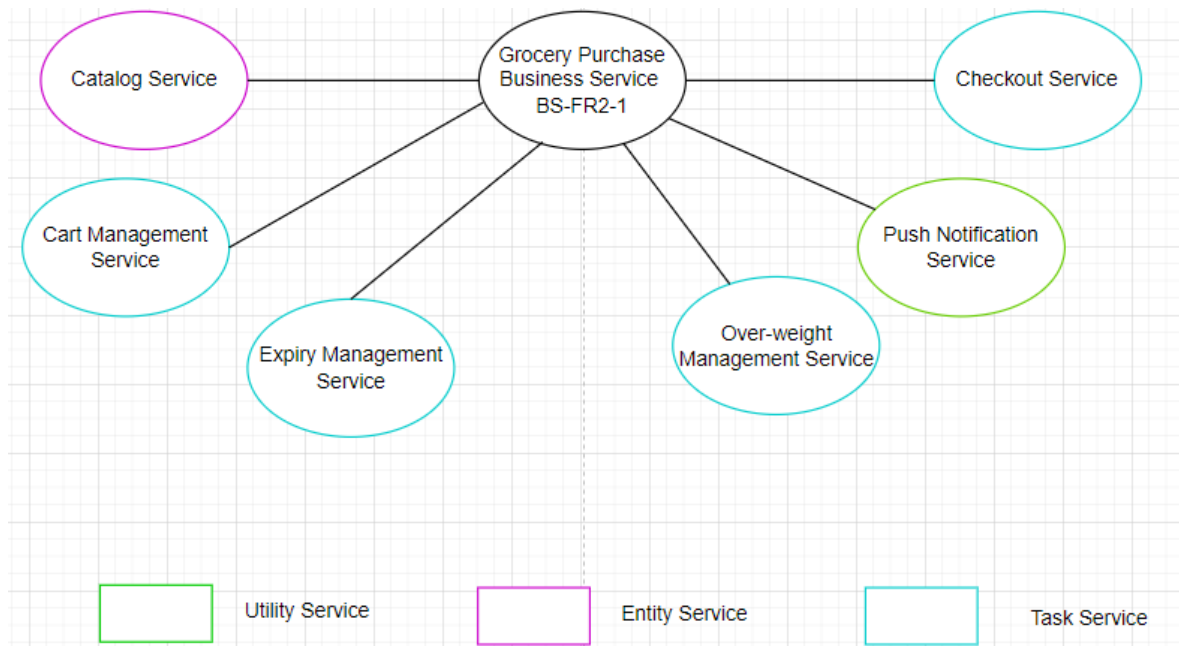The categorization of these candidates is as follows:

Figure 4: BS-FR2-1 Grocery Purchase Business Service Candidates

As per figure 4 tasks like grocery catalog browsing have been marked as entity service candidates, whereas all the other service candidates that provide functionalities have been marked as task services. The external integration of the push notification mechanism has been labeled as a utility service, as it is an independent service.
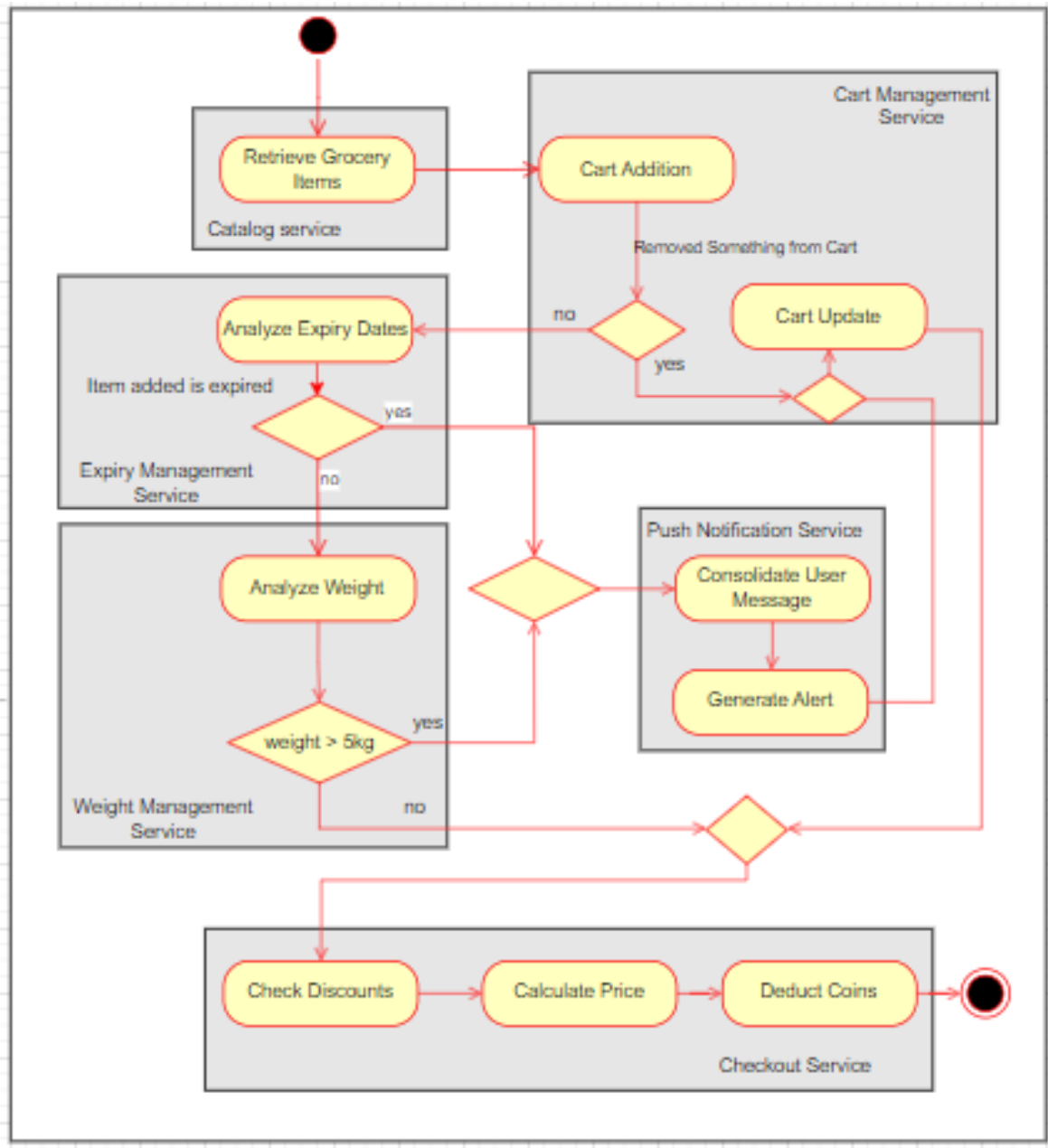
Figure 5: BS-FR2-1 Grocery Purchase Business Service Activity Diagram

As per figure 5 the conditionals apply on the system when the player purchases the catalog items that are expired and when the cart weight is beyond 5kg. This shall help players purchase groceries wisely for one-time meals.

- **BS-FR3-1 Cooking Business Service**

The identified service candidates for cooking service relevant to Food Waste Fiasco are as follows:

    – SC-1 Dishes Suggestion Service

– SC-2 Recipes Suggestion Service

  – SC-3 Cooking Analysis Service
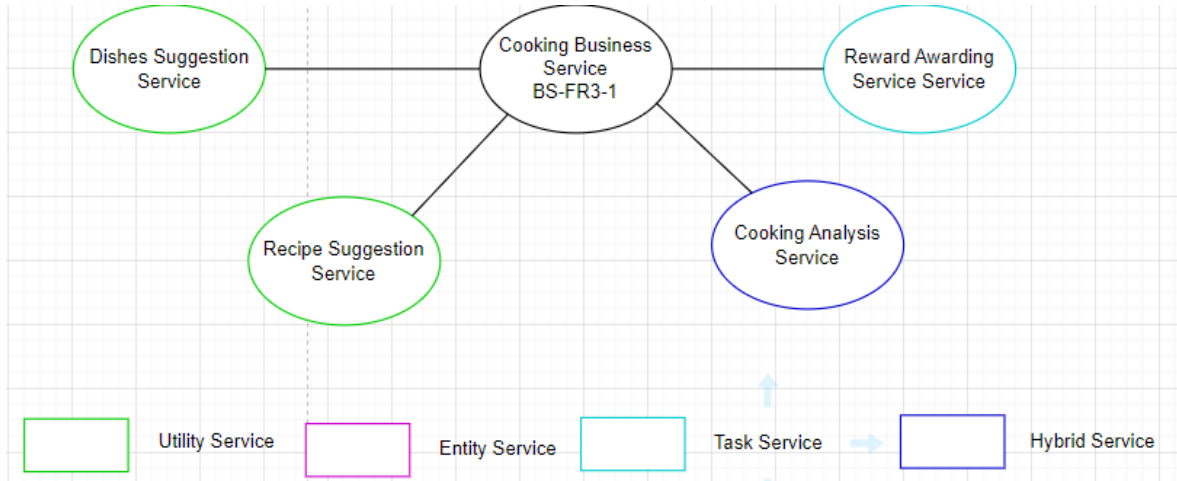
  – SC-4 Reward Awarding Service

Figure 6: BS-FR3-1 Cooking Business Service

As per figure 6, the tasks like recipe generation and dish suggestions are coming from external independent services and, therefore have been marked utility, other service candidates have been marked task service, as they give out functionality, whereas the animation management service can be marked as hybrid service, as it can not only generate the animation from the game resources, but it can also do from external sources.
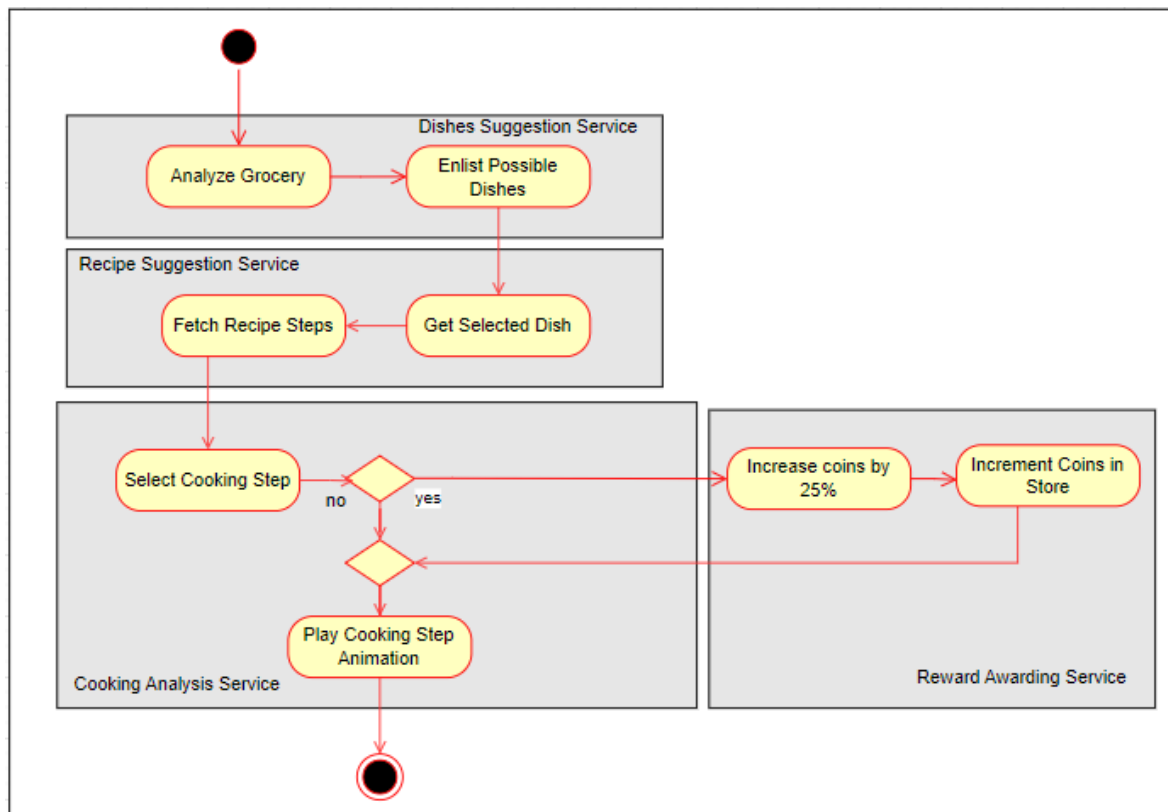
Figure 7: BS-FR3-1 Cooking Business Service Activity Diagram

According to figure 7, when recipe step selection is made by the user, then the answer is verified whether the selected step is right or not if that is the case, the player earns a reward, otherwise, they don't earn anything. Moreover, whenever the player selects the recipe step from the list, regardless of whether it is wrong or right, the respective cooking animation of the character shall be played.

- **BS-FR4-1 Food Consumption Business Service:**

The service candidates for food consumption service are as follows:

- – SC-1 Portion Management Service

- – SC-2 Hunger Management Service

- – SC-3 Food Intake Tracking

For food consumption business service, the hunger bar, and food spirit are supposed to keep track of food intake. In addition, the food intake tracking also increments the amount of morsels eaten in the animation. In contrast, the remaining food calculation keeps decreasing the food portion with the rate of increase in morsel number.
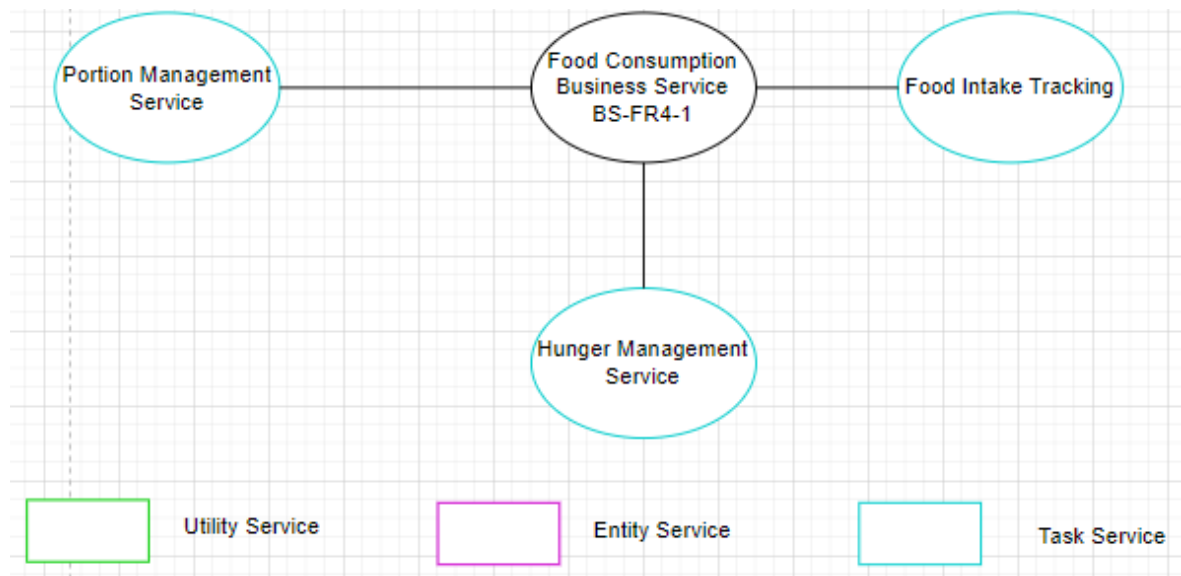
Figure 8: BS-FR4-1 Food Consumption Business Service

As per figure 8 almost all the service candidates of this business service, are tasks since they are performing calculations, and making comparisons, whereas the animation management service candidate can be labeled as a hybrid since it can either come from the game repo or the external independent source.
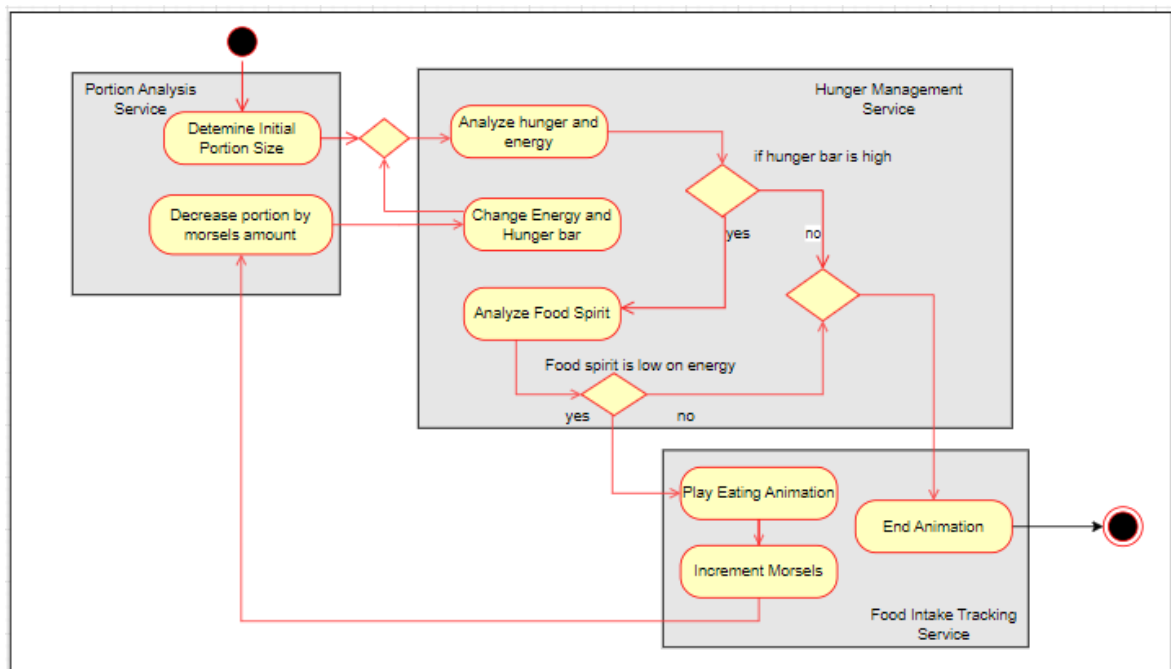

Figure 9: BS-FR4-1 Food Consumption Business Service Activity Diagram

As per figure 9 the hunger levels and food-to-eat portion weight are calculated before the player starts eating. The hunger bars and energy bars represent the hunger level

and the Food spirit is there to illustrate the fullness level. If the hunger bar is high, the player can stop eating, and in the end, the remaining food that the player has left is calculated and analyzed.

Modelling Service Candidates While Keeping Business Domain in Context

Use-Case Modelling:

The use cases are modeled by keeping in context the business domain and identifying service candidates. We include those stakeholders or users in our use cases accordingly to depict which use case belongs to which stakeholder/user.
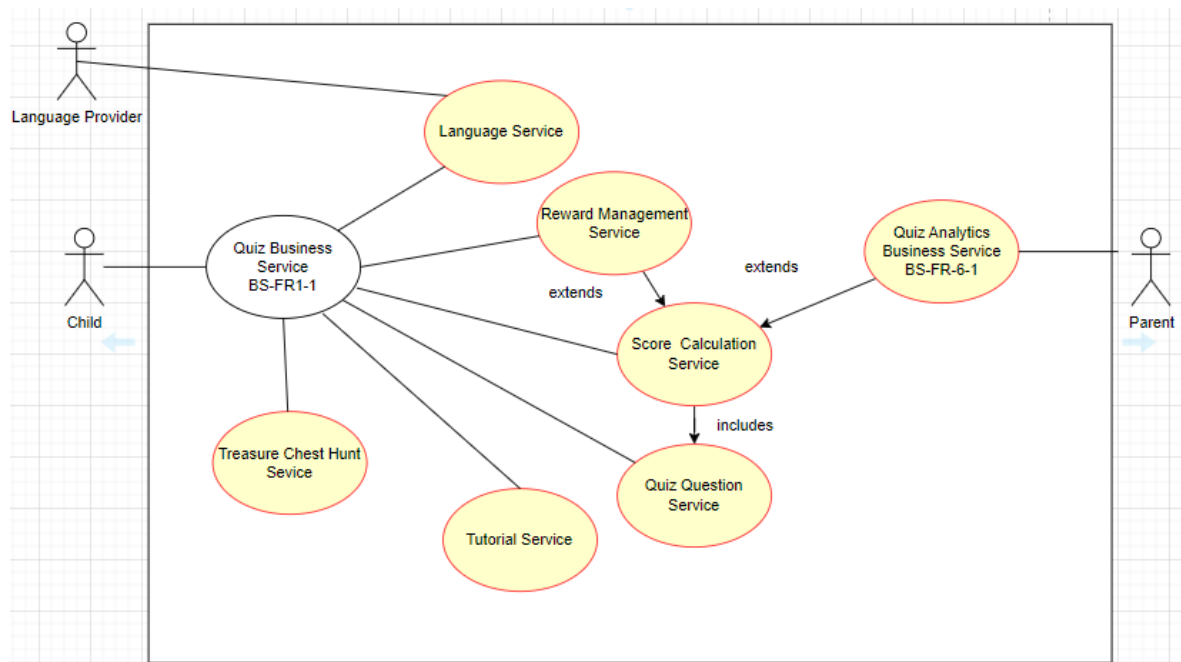
- **BS-FR1-1 Quiz Business Service:**

Figure 10: BS-FR1-1 UC-Quiz Business Service

As per figure 10 the use-case of quiz business service is utilized by Quiz Analytics Business Service which is consumed by Parents. Children shall consume Quiz Business Service. The questions list having the record of correct answers and options shall be included by the score calculation service to verify answers. The scores calculated by Score Calculation Service shall be in turn used by Reward Management Service. The language provider shall be providing language support to the food waste fiasco.

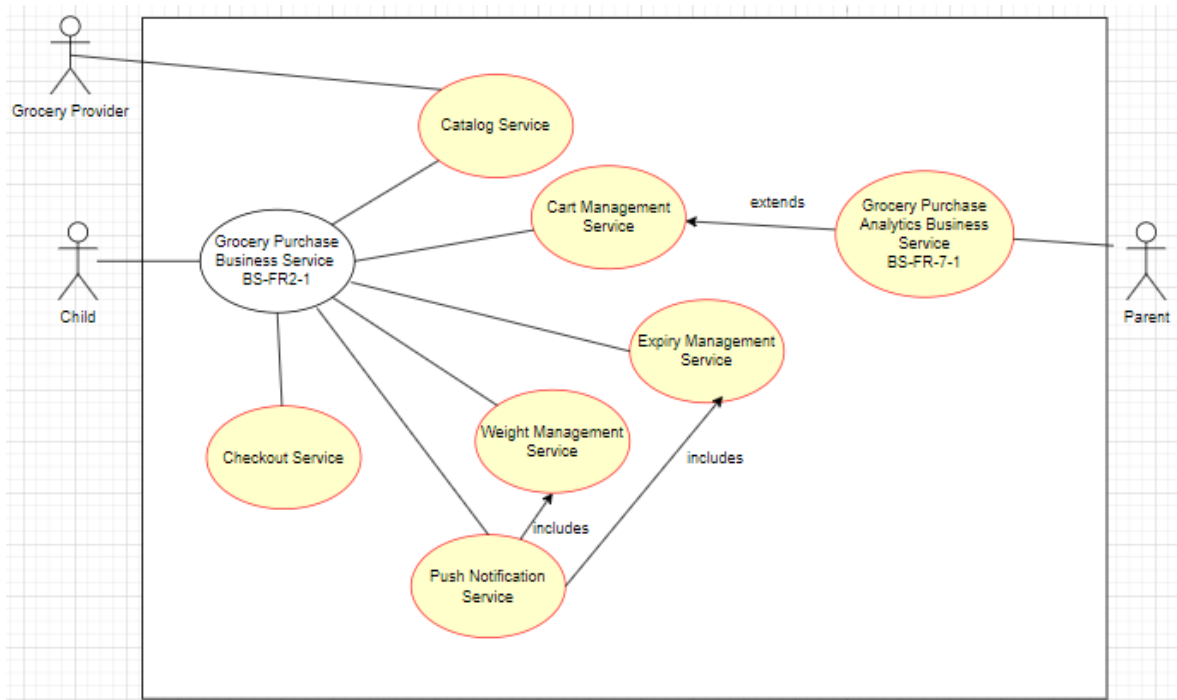- **BS-FR2-1 Grocery Purchase Business Service**

Figure 11: BS-FR2-1 UC-Grocery Purchase Business Service

As per figure 11 the grocery items shall be provided by the grocery provider and the items added to the cart shall be used to manage the weight, expiry of the food items, and the analytics of the purchase.
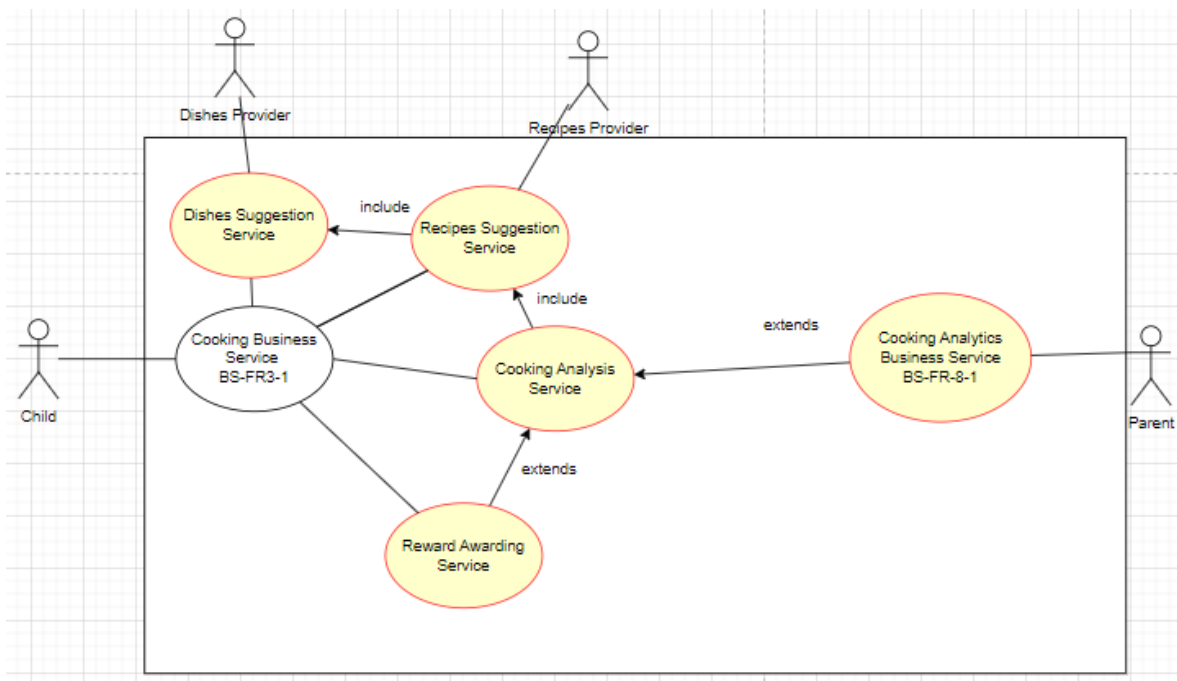
- **BS-FR3-1 Cooking Business Service:**

Figure 12: BS-FR3-1 UC-Cooking Business Service

As per figure 12 the dishes list shall be provided by the dish provider, and using the selected dish, the recipe provider shall generate the list of methods to cook food. The cooking Analysis service shall take into account the list of steps and generate animation accordingly. This service shall be usable by Cooking Analytics Service as well.

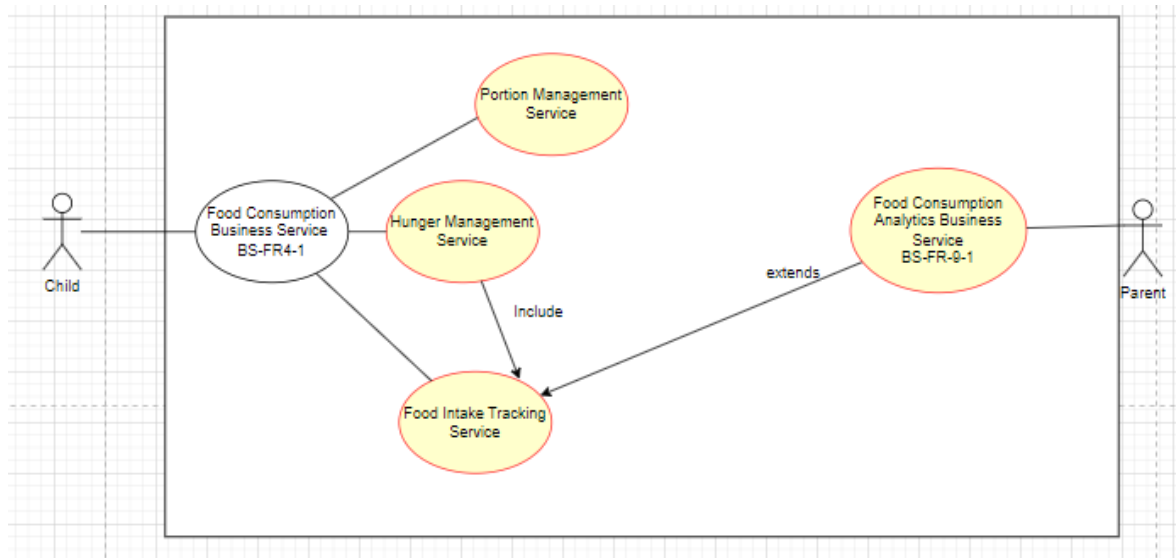- **BS-FR4-1 Food Consumption Business Service:**

Figure 13: Bs-FR4-1 UC-Food Consumption Business Service

As per figure 13 the food intake process will be affecting the hunger management, as the hunger management consists of illustrations like food spirit, and hunger meter. These will only change when food intake is tracked. This food intake is also used to produce analytics of children eating food.

- **BS-FR4-2 Food Waste Management Business Service:**

_____

Modelling Data Model

Modeling Data Model is essential, as it lays out all the components involved in the system, the local attributes they hold, and how they do data exchange among each other to make the system up and running.
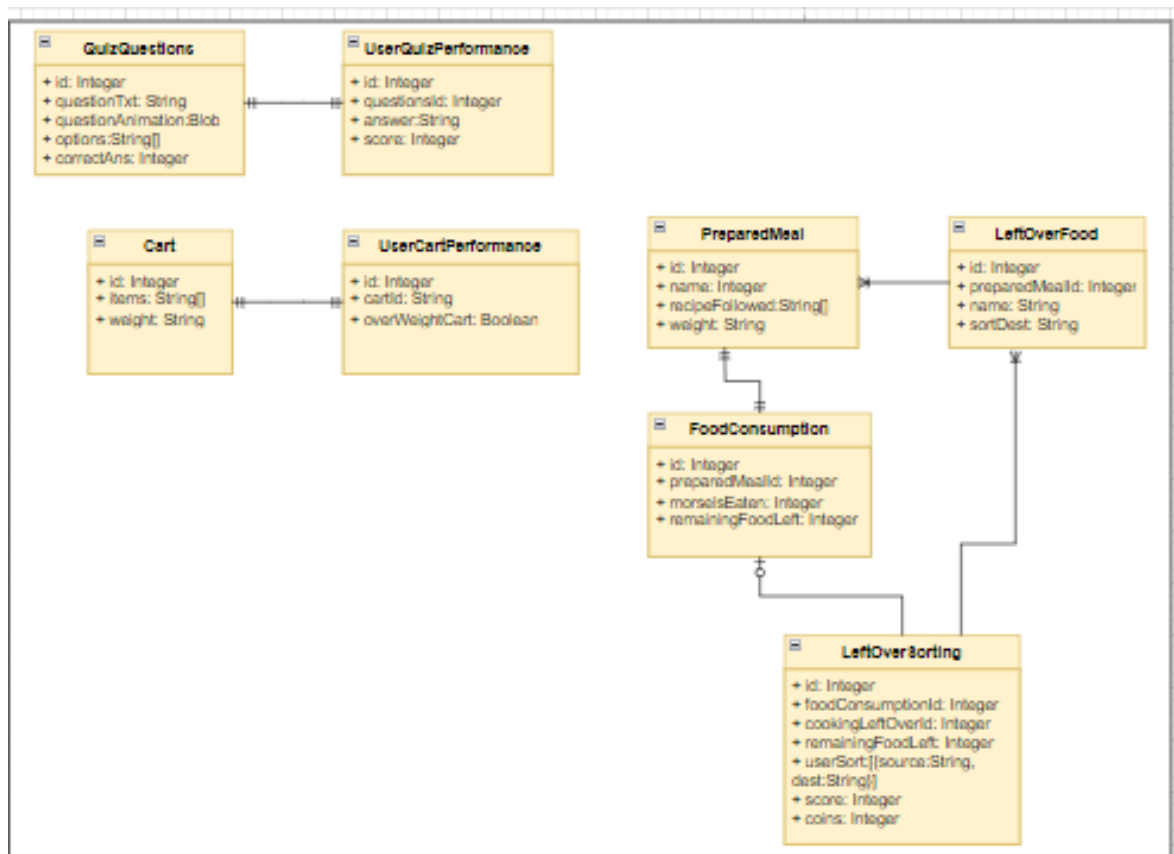
Figure 14: Data Model

As per figure 14, the data model depicts that there is a clear record of quiz questions with their defined answers and animations. In order to analyze how the player performs in the quiz, its necessary to hold what answer did the player give for any specific question. There shall be the answer recorded for one question at a time therefore one to one relation. Cart items need to be kept in check, as they determine the overall weight and cost. To maintain the user cart performance report, it is not only essential to have a record of cart items, but also whether the cart is overweight or not. Each cart will have one report at a time. Prepared Meal is a report of cooking performance, which checks if the player followed the recipe steps correctly or not. This also leads to leftovers. Therefore it's also important to have a record of what type of food leftovers can be, and where should they be placed. One prepared meal can have multiple leftovers, therefore relation is one to many. There will be one record of food consumption for a certain prepared meal. The food consumption data holds the data for morsels eaten and the remaining food left. This food consumption data and leftover data are used by leftover sorting. This leftover sorting is supposed to hold the data of player performance in sorting food waste. The waste generated from food consumption can be non-existent, because it might be possible that player eats the whole food, therefore 0 to 1. Since there are multiple

leftover records out of one prepared meal, therefore one to many relationship between leftover records and sorting reports.

4   CONCLUSIONS

The conclusions explain how well your research achieved its objectives, what its findings were and what they mean in a wider perspective and for the future. The conclusions should examine how your findings differ from or coincide with those of previous studies. Analyze the impact of your research: its theoretical or practical contribution and wider societal importance. In addition, mention possible limitations of your study and research topics that should be dealt with in the future.

Remember that if or when someone other than your supervisor reads your thesis, they will most likely read the introduction and conclusions first.

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Note: More information on referencing is available in Appendix B

A APPENDIX: TEXT PROCESSING AND LAYOUT IN A THESIS

Good text processing skills make writing your final thesis and using this template easier. Therefore, you should make sure you have the sufficient basic skills to edit long documents with text processing software before you start. This involves applying the styles, understanding automatic referencing and knowing how to divide your text into sections.

The essential thing is to understand the following basics of Word:

- Do not modify your layout by adding consecutive spaces or line breaks. If you need to press Enter or the space bar more than once, you are probably doing something wrong. When you want to start a new paragraph, press Enter once at the end of the sentence and use styles to create a space between the paragraphs.
- Do not do numbering manually. Word has efficient automatised tools for this. Section numbering and page numbering are applied in this template but also automatised numbering of figures/tables is possible. They keep the numbers in the right order even if you modify, add or remove information.
- Do not add hyphenation at the end of a line manually. Word's automatic hyphenation tool can be used in this template. If you need to add more hyphens, select manual hyphenation in Word. The automatic hyphenation is usually turned off, but you can activate it yourself.

Line spacing, font, margins, alignment, page numbering and headings

Official layout guidelines state that the line spacing should be 1.5 except for the abstract and possible direct citations, where the spacing is 1. You can choose from two fonts: Times New Roman (12 pt) or Arial (11 pt). This template has been written in Times New Roman 12 pt (Style LUT Normal). Leave an empty line before and after tables and figures.

Leave the following margins:

- top and left 35 mm
- bottom and right 20 mm.

The page number of the title page is 1, but the page numbering should not be visible before the first page of the table of contents. Place the page numbers at the top of the page, either centred or in the right-hand corner. Page numbering ends on the final page of the reference list: appendices do not have page numbers unless the appendix is multiple pages.

Always use heading styles in your headings (LUT Heading 1, LUT Heading 2, LUT Heading 3). Always place chapter headings (LUT Heading 1) on a fresh page. If you add large figures or tables, remember to check that the empty space after the figure or image covers no more than 20% of the page.

Always use heading styles in your headings (LUT Heading 1, LUT Heading 2, LUT Heading 3). Always place chapter headings (LUT Heading 1) on a fresh page. If you add large figures or tables, remember to check that the empty space after the figure or image covers no more than 20% of the page.

The thesis should include no more than three heading levels, and the headings should progress in a logical order (first LUT Heading 1, then LUT Heading 2, etc.). If you need even more detailed subheadings, do not number them, and leave them out of the table of contents. Concise headings that describe the text sufficiently are the best. You can use question marks or exclamation marks, but do not add a period if the heading is a regular sentence.

A heading cannot be followed by a heading. Always write something between them. For instance, there must be text between headings 1 and 1.1.

Lists are a good way to express things clearly. Use the same type of bullet or symbol in lists throughout your thesis. A section should never end in a list. There should always be two or three sentences after a list.

B   APPENDIX: REFERENCES

The text must include references to the sources you use. LUT University applies the Harvard referencing style, also called the author-date style with in-text referencing and a detailed reference list at the end.

The purpose of a reference is to provide sufficient information on a source used in the study, allowing the reader to consult the original source for further information. The reference enables the reader to find detailed information on the source easily in the list of references. You should refer to the original and most recent sources. If no new studies have been published on the topic in question, also older ones may be used.

Referring to a source means that you explain the contents of the source material in your own words. Direct citations, on the other hand, are placed in parentheses (" "). Plagiarism or using another person's original material without appropriate referencing is not allowed.

Referencing technique

In the Harvard system, the citation is placed in parentheses directly in the text to indicate the passage that has been cited from another source. Place the citation before the period that ends the sentence when it refers only to the sentence in question (Kaasinen et al. 2020, 173–174). If you are referring to more than that one sentence, introduce the source you are summarizing or paraphrasing at the beginning of the paragraph. Then, refer back to the source when needed to ensure your reader understands you are still using the same source.

Typically, the citation mentions the author (the last name is sufficient, unless authors of several sources have the same last name), the publication year and the page number. Please note that the author does not always have to be a person, but it may also be an organisation, for instance. If the source does not mention who the author is, the reference should include the name of the publication instead of the author. (Nykänen 2002, 77.) The author (or the title of the work) is very commonly mentioned as a part of a sentence: "According to a study conducted by Möttönen (2007, 68), a pike is a fish".

If the source has more than one author, they are all mentioned in the reference by their last name and separated with the word 'and' or the symbol '&'. Make later references to the same work with the first author's last name and "et al." If you reference several works published by the same author in the same year, add lower-case letters (a, b, c…) after the publication year to distinguish the sources. Use the same alphabetical organisation also in the list of references.

There are several referencing and citation styles. It is essential to consistently use the same style throughout the thesis. Examples and detailed instructions on referencing:

LUT Academic Library's instructions on how to cite electronic documents

Aalto University citation guide

Harvard referencing, University of Sheffield

C   APPENDIX: TABLES, FIGURES, EQUATION, NUMBERS. SYMBOLS AND ABBREVIATIONS

It is a good idea to illustrate your text with figures and tables. Figures and tables must have captions and consecutive numbering. The captions of tables are placed above the table and those of figures below the figure. Refer to the figures and tables in the text body, preferably before you introduce them, and align them with the text body.

Remember to add alt text (alternative text) to your figures and tables to ensure accessibility. Alt text is read with a designated reader and can be viewed even when the image cannot be displayed on the page. The MS Word text processing software creates alt text automatically, but you should make sure it describes the object sufficiently and understandably. You can modify the alt text by right-clicking on the figure or table.

Tables

Remember to add alt text (alternative text) to your figures and tables to ensure accessibility. Alt text is read with a designated reader and can be viewed even when the image cannot be displayed on the page. The MS Word text processing software creates alt text automatically, but you should make sure it describes the object sufficiently and understandably. You can modify the alt text by right-clicking on the figure or table.

Table 8: Sensor measurements

Voltage U [V]	Pressure p [Pa]
0.984	0
2.252	150
2.772	300
3.181	450
3.615	600
3.817	750
4.088	900

Figures, charts, graphic elements

Images help illustrate your text. The text should contain a reference to the image Figure 15. Number your figures and place a caption underneath – not inside the figure.

You should use a software programme such as Excel or Matlab to draw charts. Charts should be clear and easy to understand. Use a white background. A background grid is allowed if it

does not make the figure difficult to interpret. Variables and measurement points should be clearly visible. Name the axes and their units.

Create as much of the figures yourself as you can. Use the same font as in the text body and equations. If you use images created by someone else, remember to cite them correctly. Remember that images are copyrighted works, the use of which must always be authorized by the author. Captions need to be in the same language as the text body.
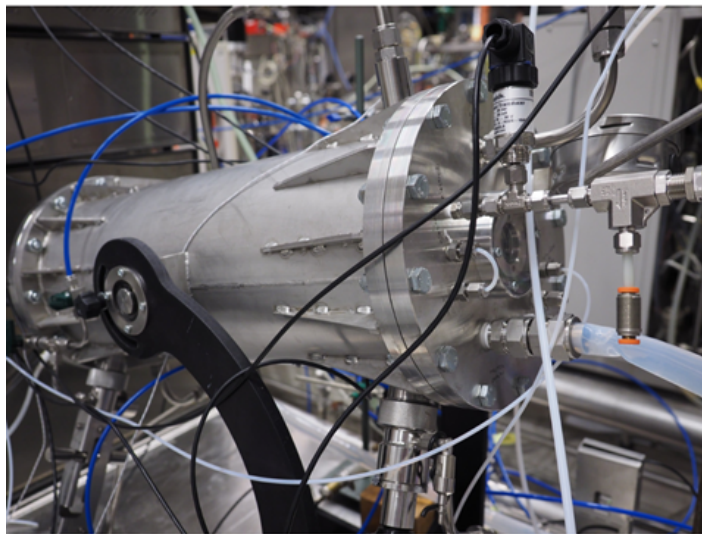

Figure 15: Gas fermentor (VTT 2020, LUT image bank)

Do not end a paragraph in a figure or table. Add text underneath, such as comments on the figure. Large figures, tables, long equations and other supporting material can be appended, if needed.

Numbers, symbols and equations

Numbers in the text are usually approximations. Their accuracy depends on the observational error. Include only significant figures in the results. Interim results should include at least two figures more to avoid round-off errors. Present large and small figures in powers of ten 10^n, where n should preferably be divisible by three.

Equations and other mathematical expressions must consist of standardised symbols if ones exist. You may use other symbols only if there are no applicable standardised or established ones.

Explain the symbols in an equation when you use them for the first time. Write each equation clearly on its own line and indent it. Number your equations consecutively or by paragraphs so that the number is in parentheses on the right side of the equation and aligned to the right.

You can refer to an equation only after you have presented it, with certain exceptions, such as if the object you are referring to is far ahead. Example:

$$pv = RT \qquad (C.1)$$

where p is pressure [Pa], v is specific volume [m³/kg], R is the gas constant [J/kgK] and T is temperature [K].

When writing symbols for your thesis, it is recommended to check the spelling with the MS Word equation editor. It follows general rules for the writing of symbols, e.g.

- Write scalars in italics and vectors in bold, not in italics. Don't write dimensionless quantities in italics.
- Write subscripts upright unless there is a need to italicise them. Write abbreviated subscripts and numerals e.g. as follows: $\triangle \sigma_w$, σ_1, σ_{min}. For instance, in the summation $\sum_i^\infty x_i$ the subscript needs to be italicised because it represents a variable.
- If you wish to express change in e.g. pressure $\triangle p$, write $\triangle$ in a regular font. In some cases, $\triangle$ may also be a variable and should then be italicised. π is the ratio of a circle's circumference to its diameter. π may be the pressure ratio.
- Do not italicise mathematical operators such as sin x or lg y.
- Distinguish absolute values as follows: "variable_=_number_unit", with the exception of a percentage sign after a numeral, e.g. a = 5.2 mm, γ = 97.7%
- Use a decimal point (".") in accordance with international standards. In contrast, a decimal comma is used in theses written in Finnish. This also applies to figures and tables.

List of symbols and abbreviations

List symbols and abbreviations and their definitions that are not common knowledge separately on their own page before the table of contents. Divide them into groups: Roman symbols, Greek symbols, and finally, abbreviations. Give the page the heading Symbols if there are no abbreviations or Abbreviations if there are no symbols.

When you use a symbol or abbreviation in the text body for the first time, introduce it to the reader for example as follows: "The concept design for manufacturing and assembly (DFMA) is...". After this, you can use only the abbreviation, and the reader can verify its meaning from the abbreviation list. Do not add concepts to the list of symbols and abbreviations that you do not mention in your text body.

D APPENDIX: APPENDICES TO THE THESIS

Appendices may include e.g. interview questions, survey forms or other content relevant to the work but not necessary to include in the text body.

In your text body, refer to the appendices by adding their title in parenthesis Appendix A where relevant. Give all appendices a title based on their content and list them in the table of contents in the order in which they are referred to in the thesis.

Single-page appendices do not require page numbering. Multiple-page appendices do.

E APPENDIX: PUBLISHING THE THESIS

LUT's degree regulations state that Bachelor's and Master's theses are public documents. They are published in the LUTPub repository, and related instructions are available on the [library web site](#).

Together with the first examiner, make sure that the commissioner of your thesis is aware of the publicity requirements from the very beginning of the discussions. If it is necessary to include information in your Master's thesis that the commissioner wants to keep secret, the university may allow keeping the Master's thesis confidential for up to two years. In such cases, the commissioner needs to provide the university with a notification on the confidentiality requirements. The student is responsible for submitting the confidentiality notification to Student Services no later than in connection with the assessment application. The notification must relate the scope of the confidentiality, grounds for it and the confidentiality period in full years. The confidentiality period starts from the date the thesis is assessed. Information that needs to remain confidential for over two years must be excluded from the thesis text. The thesis will be evaluated based on the version submitted to the university.

All theses in LUTPub must fulfil accessibility requirements. Your text must be as legible as possible to readers. Remember

- to use styles to create headings,
- embed hyperlinks into your text or a description of the linked content; do not include URL addresses,
- add/check the alt text of your figures and tables describing briefly the main content in writing.

F   APPENDIX: LATEX TRICKS

During this appendix, some general commands are demonstrated.

Using *chapter*, *section*, *subsection* commands, it is possible to add new titles that will be automatically added to the table of contents.

References in the bibliography can be cited using *cite* command. For example **stratton1976needs**. *Cite* command supports also multiple sources. For example: **hirsijarvi2009tutki**; **virtanen2011esimerkl** In addition author's name can be referenced using *citeauthor* command. For example: **hirsijarvi2009tutk**

Using *gls* command, it is easy to reference abbreviations. For example when the command is used first time: Computational Fluid Dynamics (CFD), abbreviation is fully opened. When the command is used second time, only short version of the abbreviation will be used: CFD. This feature is useful, if the text is later refactored. Using *glspl* it is possible to insert plural form of the abbreviation. For example Organic Rankine Cycles (ORCs).

Titles, figures, tables and many other things can be labeled using *label* command. Later these labels can be automatically referenced using *autoref* command. For example Appendix F. Additionally link is automatically created.

Using *itemize* environment and *item* command, it is possible to define unordered lists. For example:

- Item 1
- Item 2

Using *enumerate* environment and *item* command, it is possible to define ordered lists. For example:

1. Item 1
2. Item 2

Lists can also be nested naturally. For example:

1. Item 1
   (a) Sub item 1
   (b) Sub item 2

When placing figure, LaTeX tries to find optimal placement that use space as efficiently as possible. Sometimes this doesn't end up looking great, because figures are placed too far

a way from the text. Figures can be forced to be placed before point x using *FloatBarrier* command.

It is also possible to create new commands using LaTeX using *newcommand*. See example definition and usage of the green check mark bellow:

This is a green check mark: ✓.

Using appropriate commands, it is possible to create quite advanced structures. For example when presenting survey questions following definitions could be useful:

1. How good this template was?

	1	2	3	4	5	6	
Very bad	○	○	○	○	○	○	Very good