Towards Digital Immersive Commensality – Insights and Strategies for Shaping Virtual Social Dining

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Preface

Food is far more than sustenance. It is a gateway to exploring other cultures, strengthening our bonds, and understanding each other on a fundamental level. During my time living abroad and sharing meals with the residents of Canterbury farms in the UK, I experienced first-hand how food bridges gaps between individuals, fostering a unique friendship and mutual understanding. These interactions were more than about eating; they were about connecting, sharing, and building relationships not only with those around us but also with the food itself.

However, the sudden onset of COVID-19 drastically altered this dynamic. Lockdowns and social restrictions left many, including myself, isolated and facing severe mental health challenges. The farms, once lively hubs of communal interaction, became quiet. This abrupt shift deepened my determination to find ways to restore the communal dining experience in a, digital setting. It became a personal mission, driven by the conviction that those who share meals share more than just food; they share life, and in doing so, can help alleviate many of the mental health issues exacerbated by isolation.

The post-COVID world has struggled to regain a sense of normality. Life has not only resumed its hectic pace but has also become more isolating, with technology often serving as a barrier rather than a bridge. Within this context, virtual communal dining emerges as a critical tool. The new digital applications have the potential not just to advance technologically but to reconnect us, recreating and enhancing the experience of eating together despite our increasing busy and disconnected lives. My thesis explores how these advancements can be harnessed to bring us back to the communal table, allowing us to share meals and moments, while blending tradition with innovation to maintain the vital essence of our communal bonds.

Finally, it's important to highlight that the COVID-19 lockdown from 2020–2021 severely disrupted the second and third years of the PhD program, significantly impacting the researcher's work, family circumstances, physical, and mental wellbeing. Restrictions on in-person field studies crucially hindered data collection for studies 2, and 3, and delayed overall research progress. Furthermore, a cyberattack in March 2022 on the School of Engineering's IT systems further postponed laboratory experiments and data analysis. Despite these setbacks, the researcher ensured the quality of the work and hopes for the thesis to meet your high standards.

Khawla Alhasan, Jan 2025

Dedication

This thesis is humbly dedicated to all students who have been made to feel they are not good enough, or that their ambitions are too big to be worth pursuing. As I move into the next stage of my life and career, I am committed to lifting up all these students who will succeed in whatever way they decide is right for them.

To Bahrain, my cherished homeland, a land of rich heritage and warm hearts, which has shaped my journey and inspired my aspirations. This thesis is dedicated with immense gratitude and pride, reflecting the values and lessons instilled in me by this wonderful nation.

Abstract

This thesis investigates the concept of Digital Immersive Commensality (DICom) as a transformative approach to enhancing shared dining experiences in virtual environments. In an era of increasing social isolation, driven by demanding lifestyles and the disruptions of the COVID-19 pandemic, the traditional practice of commensality – sharing meals with others – faces new challenges. Through the lens of Human-Food Interaction (HFI) and immersive technologies such as virtual reality (VR) and augmented reality (AR), this research explores how digital platforms can not only replicate but also enrich the sensory, social, and cultural dimensions of dining together.

Adopting a human-centred approach, this thesis explores the building blocks of meaningful DICom experiences through a series of three studies. The first study examines social engagement in remote dining through video-mediated communication enhanced by AR filters. This study identifies six design potentials that demonstrate how storytelling, sensory engagement, and breaking social norms can enhance social connections and contribute to creating more immersive digital commensality experiences. The second study shifts focus to the metaverse, employing co-design workshops to uncover what people value in their food-related experiences. This process identifies 18 foundational elements, which are refined into five design directions and illustrated through a speculative catalogue of future eating scenarios. Evaluation of the catalogue with experts and non-experts leads to the formulation of five key dimensions that define the DICom framework. The third study introduces a Wizard-of-Oz VR prototype to explore the feasibility and transformative potential of these dimensions. This study uncovers six key opportunity spaces, showcasing how DICom systems can foster social bonding, sensory reconnection, and cultural authenticity.

Through this iterative exploration, the thesis makes contributions to the field of HFI by proposing a framework for DICom, identifying design strategies, and offering actionable insights into creating meaningful digital dining systems. It provides a foundation for designing DICom experiences that not only enhance social connection and sensory engagement but also support inclusivity, well-being, and cultural exploration.

List of Acronyms

VR	Virtual Reality
AR	Augmented Reality
MR	Mixed Reality
XR	eXtended Reality
HFI	Human-Food Interaction
HCI	Human-Computer Interaction
RFID	Radio-Frequency Identification
AI	Artificial Intelligence
VE	Virtual Environment
DICom	Digital Immersive Commensality
MHFI	Multisensory Human-Food Interaction
ASMR	Autonomous Sensory Meridian Response
DICDPs	Digital Immersive Commensality Design Potentials
STD	Situated Play Design
IE	Important Element
DD	Design Direction
HMDs	Head Mounted Displays

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Chapter 1: Introduction

" The way you eat not only decides your physical health, but the very way you think, feel, and experience life." - Sadhguru

1.1 Background

Food is a source of energy and a mean of survival. And much more than that! It also plays a crucial role in shaping our social and cultural identities [335]. The practice of shared meals, traced back to food remnants found near fireplaces estimated to be around 800,000 years old, highlights a long-standing tradition in human social behaviour [381]. This emphasises the importance of shared meals in shaping our collective experiences. In fact, the evolutionary anthropology identifies food sharing as a vital part of human evolution and a shared trait with other species, emphasising collaborative cooperation [174, 175]. Furthermore, bioarchaeology views shared meals as essential in linking humans biologically and socially, underscoring the fundamental role of communal eating in our social nature [60, 180].

Commensality, or the practice of sharing a meal, strengthens our bonds with one another and with food itself. Research across disciplines—from psychology to anthropology—illustrates its significance in enhancing social communion, health, and well-being [181]. Commensality shapes various aspects of eating, influencing taste perception, portion size, food choices, and overall dietary health [35, 73, 157]. Sharing meals fosters trust and intimacy, whether among families, friends, or even strangers, and has been shown to amplify enjoyment of food through shared experiences [47, 404].

Commensality affects various aspects of eating including taste [35, 85], portion size [73, 87], food intake [157], and food choice [245], also has beneficial outcomes in terms of healthy diet and social development [99]. Sharing food with others triggers an increased sense of community and togetherness, making people more engaged with each other [313] and intimate [252]. This is particularly evident in family settings, where commensality leads to healthier relationships [29], and even among strangers, shared meals with similar food can foster closer connections and greater trust [404]. Moreover, these shared eating experiences are amplified in a communal setting - pleasant food tastes better, while unpleasant food tastes worse when eaten with someone else [47].

In contemporary society, commensality is facing significant challenges as social and demographic shifts redefine the way people interact with food and each other. One of the most striking changes is the global rise in single-person households, which has led to a growing number of individuals dining alone. From 2016 to 2030, the number of single-person households is projected to increase by approximately 120 million worldwide, making it the fastest-growing household type [137]. This trend is often referred to as the "loneliness epidemic," highlighting its broader implications for mental health and social well-being [334]. Living alone, particularly among younger individuals who relocate for education or work, has been linked to higher levels of anxiety, depression, and loneliness, further complicating the social fabric that shared meals traditionally strengthened [141, 281].

The COVID-19 pandemic exacerbated these disruptions, dramatically altering dining habits and social interactions. Lockdowns, physical distancing measures, and prolonged periods of isolation curtailed opportunities for shared meals, forcing many to eat alone more frequently than ever before. Studies from China and the UK highlighted that younger individuals and those living alone experienced heightened levels of loneliness, anxiety, and depression during the pandemic [56, 141]. Even as restrictions eased, these changes have had lasting effects on social behaviours and dining practices, with many people continuing to rely on remote or solitary modes of interaction.

This societal shift away from shared dining also intersects with the increasing integration of technology into food-related practices. While digital tools have enabled new forms of connectivity, they have also introduced complexities that sometimes undermine the essence

of commensality. For instance, screen-based distractions, from smartphones to televisions, are now common during meals, reducing meaningful engagement with food and companions alike. Research has shown that such distractions can lead to overeating, decreased mindfulness, and a weaker sense of connection to others [191, 210, 240].

Emerging technologies like augmented reality (AR) and virtual reality (VR) offer transformative potential to reimagine commensality in a digital age. These immersive tools can simulate shared environments that foster a sense of presence and connection, even when participants are physically distant. AR can overlay interactive and playful elements onto real-world dining experiences, enriching video-mediated communication setups with contextual enhancements that mimic traditional commensality [40, 41, 145]. Similarly, VR can create entirely immersive spaces where participants can share meals in imaginative or culturally significant settings, breaking the barriers of physical separation [55, 221, 332]. The promise of AR and VR goes beyond replicating the visual and auditory aspects of dining together [369]. These technologies open avenues for multisensory engagement, incorporating elements like taste, texture, and smell to create a more holistic and emotionally resonant experience. By doing so, AR and VR can address not only the physical separation of diners but also the sensory and emotional gaps that traditional digital tools leave unfulfilled [344]. Taken together, these factors illustrate the need to reimagine commensality for the modern age. As traditional practices of shared meals become less common, there is an opportunity – and a necessity – to explore new ways to foster connection, community, and well-being through innovative approaches that address both social and technological dimensions.

This chapter begins by providing the background and context for the research, presenting the evolving role of commensality in shaping social and cultural identities and the challenges posed by modern societal shifts (Section 1.1). It then introduces the problem statement, outlining the limitations of current digital commensality systems and the need for a cohesive framework to address the sensory, emotional, and social dimensions of shared dining experiences (Section 1.2). Following this, the chapter presents the aim of the research and its guiding research questions (Section 1.3), focusing on exploring user interactions, sensory engagement, and the potential of immersive technologies to enhance digital commensality. The key contributions of this work are then highlighted (Section 1.4), emphasising theoretical insights, empirical findings, and actionable design recommendations for creating meaning-

ful DICom systems. Finally, the research approach is detailed (Section 1.5), describing the iterative and interdisciplinary methodology employed to develop, refine, and evaluate the DICom framework. This chapter lays the foundation for the subsequent studies and discussions presented in the thesis.

1.2 Problem statement

Despite the transformative potential of digital technologies, current approaches to digital commensality are limited in their ability to replicate the richness of traditional shared dining experiences. Existing systems, such as video conferencing or live-streaming platforms, predominantly focus on the visual and auditory aspects of dining, often neglecting the sensory engagement, shared rituals, and emotional depth that are central to commensality [289, 344]. These limitations diminish the potential of such technologies to address critical social challenges, including the growing issues of loneliness, social isolation, and reduced opportunities for meaningful connections through shared meals.

Emerging concepts like Skeating – a form of digital commensality introduced by Spence et al. [344] where people are eating while using video conferencing tools – have demonstrated some success in bridging geographical distances, leveraging screen-based interactions to mimic face-to-face dining. However, Skeating and similar systems remain constrained by their reliance on two-dimensional formats that fail to capture even the foundational sensory and social dimensions of dining. This limited representation offers only a partial approximation of commensality, often lacking emotional depth and overlooking the complex, ritualistic nature of in-person dining. While fully replicating the richness of physical dining experiences remains out of reach, emerging technologies such as VR and AR offer the potential to reintroduce some degree of multisensory engagement. Future work should therefore move beyond imitation, striving instead to design novel, meaningful dining experiences that foster connection within immersive digital commensality contexts. Furthermore, the existing literature primarily focuses on interactions among family and friends, leaving noticeable gaps in understanding how digital commensality could facilitate connections among strangers or across diverse cultural contexts [181].

The emergence of Human-Food Interaction (HFI) as a field has brought increased attention to the intersections of technology, food practices, and social dynamics. HFI extends the principles of Human-Computer Interaction (HCI) to explore how digital tools and technologies can enhance food-related activities, including cooking, eating, and sharing meals [10]. Within this context, researchers have begun to examine how immersive technologies could reimagine traditional dining experiences by fostering multisensory engagement, shared environments, and interactive social dynamics [130, 352].

The limitations of current digital commensality systems and the evolving opportunities presented by immersive technologies highlight the urgent need for a cohesive framework to guide the design of Digital Immersive Commensality (DICom). Existing systems, such as video conferencing tools and live-streaming platforms, have made initial strides toward replicating aspects of in-person dining but fall short of capturing the sensory and social richness that defines traditional commensality [289, 344]. While concepts like Skeating [344], artificial companions [234], gamified eating experiences [23], or mukbang [70] provide a foundation for understanding digital commensality, their two-dimensional interactions fail to address deeper issues of sensory and emotional resonance. The absence of a unifying framework means that designers lack the tools to systematically explore and address the components necessary for meaningful, immersive, and inclusive shared dining experiences. This lack of direction leads to fragmented solutions that replicate only superficial aspects of commensality while neglecting its core elements: co-presence, cultural rituals, and sensory connection [2, 116, 134].

This thesis seeks to address critical gaps in the literature on digital commensality by proposing and exploring Digital Immersive Commensality (DICom) as both a conceptual and practical framework. Drawing on HFI research, which emphasises the interplay between technology, food practices, and social connection [269], DICom leverages immersive technologies and multisensory enhancements to reimagine shared dining experiences. DICom builds on initial explorations in HFI [10, 195] by integrating shared rituals, multisensory engagement, and culturally significant interactions into digital dining. This thesis situates DICom within the broader discourse on digitally mediated interaction and social connection, addressing gaps in understanding how these systems influence sensory engagement, cultural exchange, and emotional depth in diverse contexts. By investigating user behaviour, sensory engagement, and social dynamics in immersive setups, this research seeks to advance the design of DICom

systems that enhance the human experience of dining together. Ultimately, the goal is to create a future where technology enriches commensality by enabling connection across distances and contexts, aligning with broader efforts in HFI to promote meaningful and socially engaging food experiences [11].

1.3 Aim and research questions

This thesis explores the design of DICom experiences that aim to foster meaningful connections by leveraging technology to enhance the sensory and emotional dimensions of shared dining in virtual settings. In this context, "meaningful" refers to interactions that transcend functional eating, creating deeper social bonds, heightened sensory engagement, and shared emotional resonance among participants [115, 176, 395]. A central objective of this work is the development of a conceptual and practical framework for DICom. This framework synthesises empirical observations, participatory design insights, and theoretical foundations to guide the design of systems that amplify the essence of commensality in digital spaces. By investigating the social dynamics, sensory interactions, and cultural implications of immersive technologies, this research aims to identify design opportunities and challenges, ultimately inspiring innovative systems that redefine how we share meals in virtual environments. To guide this investigation, the following research questions have been formulated:

RQ1: How do social interactions unfold in digital immersive commensality settings, and what factors influence the development of meaningful connections among participants during virtual meals?

RQ2: How do users experience food choices, eating habits, and sensory and emotional engagement within digital immersive commensality settings?

RQ3: How can technology enhance the shared meal experience in digital immersive commensality, and what are the opportunities and limitations of creating meaningful social and sensory connections in virtual dining?

Given the expansive scope of this research area, fully addressing all the specific gaps identified in the literature and motivations (see Chapter 2) would require a collective effort that extends

beyond the bounds of a single PhD thesis. Nevertheless, this thesis aims to make a notable contribution to the field through a series of three interconnected studies. These studies are thoughtfully designed to investigate how users experience and perceive DICom, offering insights into their behaviours, preferences, and interactions. The findings from these studies serve as a foundation for informing the design of meaningful and user-centred DICom systems that can foster richer social, sensory, and emotional connections.

To address **RQ1** and **RQ2**, I investigate these questions across Chapters 3 and 5, delving into the dynamics of forming social bonds and sensory engagement in immersive dining experiences. Chapter 3 provides a detailed exploration of how friends and strangers interacted with one another and with their food during AR-enhanced remote dining experiences amidst the COVID-19 pandemic. This chapter examines how individuals established connections, communicated, and shared experiences despite physical separation, showing the role of immersive technology in shaping their social interactions and perceptions of food. The findings demonstrate that technology-enabled meals fostered quicker connections, encouraged performative behaviours, and inspired participants to share multisensory elements of their dining experiences — often bypassing traditional dining norms and rituals. A significant insight from this study is that participants desired more than a visual connection; they sought a shared space enriched with sensory elements, such as aromas, food textures, and other multisensory features, highlighting the potential of immersive technologies to transform remote dining into a more engaging and cohesive experience. Building on these findings and additional insights presented in Chapter 4, Chapter 5 introduces the design and evaluation of a Wizard-of-Oz immersive prototype for DICom. This prototype operationalises the principles identified in the earlier chapters, offering a practical exploration of how immersive technologies can enhance both the social and sensory dimensions of remote communal dining. By evaluating this system, the study provides actionable insights into the opportunities and challenges of designing meaningful, immersive dining experiences that foster connection and engagement across physical distances.

Building on the findings of Chapter 3, where participants expressed a desire for enriched sensory and social connections in remote dining experiences, Chapter 4 extends this exploration by addressing how advances in technology and the emergence of the metaverse could fulfil these aspirations. This chapter investigates the potential of the metaverse to redefine our

connection with food and with others through meaningful, human-centric scenarios. It specifically addresses how immersive technologies can support sustainable, healthy, and culturally rich food practices, transforming the way we connect with and through food digitally. The insights from these studies lay the groundwork for the development of the DICom framework. This conceptual and practical framework aims to guide the design of immersive systems that enhance social, sensory, and emotional connections during remote dining experiences. To address **RQ3**, in Chapter 4 specifically, co-design workshops with diverse participants identified 18 key elements of daily food interactions and distilled them into five design directions. These directions informed speculative concepts that were further refined through expert and user interviews, contributing to a comprehensive understanding of the opportunities and challenges inherent in designing meaningful metaverse-based food experiences.

Specifically, (Table 1.1) provides a detailed mapping of the chapter-level research questions in relation to the overarching research questions that guided this thesis. It demonstrates how each chapter contributed to addressing the broader research aims by engaging with different dimensions of digital immersive commensality. The inclusion of specific objectives for each question further clarifies the analytical and conceptual focus of each stage.

This structured alignment of research questions not only supports the internal coherence of the thesis but also lays the groundwork for the development of the Digital Immersive Commensality (DICom) framework. By systematically addressing and mapping these questions across multiple empirical stages, the research identifies critical user needs and design considerations. These insights are then translated into actionable design principles, which are operationalised and evaluated in Chapter 5 through a Wizard-of-Oz prototype. This prototype demonstrates how immersive technologies can be used to foster meaningful connections and enrich shared dining experiences. The iterative process of empirical investigation, co-design, and prototyping ensures that the resulting framework is robust, user-centred, and adaptable to diverse contexts. Ultimately, the DICom framework provides researchers and designers with a foundation for reimagining commensality in the digital age, bridging physical distance and enhancing social bonds through innovative technologies.

Chapter	Chapter-Level RQs	Mapped Main RQs	Objective of Chapter-Level RQs
Three	1.What kinds of behaviours do people naturally exhibit while sharing a meal remotely over video-conferencing platforms?	RQ1	To explore spontaneous social and interactive behaviours during remote dining sessions and understand foundation patterns of engagement.
	2.How can these spontaneous manifestations of engagement be harnessed as inspiration for designing DICom experiences?	RQ2	To identify socially meaningful cues and behaviours that can inform the design of more engaging and immersive digital commensality systems.
Four	1.What are the elements people find important in their day-to-day food-related experiences?	RQ3	To uncover the emotional, sensory, and cultural values people associate with eating, which can inform immersive design.
	2.How can we shape our relationship with food in the metaverse in a meaningful way?	RQ3	To explore how digital technologies can foster new food-related experiences that carry emotional and cultural meaning.
	3.What are the potentials and challenges in building a food metaverse?	RQ3	To identify the opportunities and limitations of creating immersive, communal food experiences in virtual environments.
	4.What are the fundamental building blocks for designing meaningful Digital Immersive Commensality (DICom) systems?	RQ3	To define the key design dimensions (e.g., sensory, social, narrative) that support engaging immersive dining experiences.
Five	1.To what extent can immersive technologies foster meaningful social connections and redefine eating rituals, and what are their limitations in doing so?	RQ1	To evaluate how immersive environments support or challenge the formation of authentic social connections and new eating rituals.
	2.How effectively can immersive technologies restore sensory engagement with food and influence long-term eating behaviours?	RQ2	To assess the sensory experience of immersive experiences on users' perceptions and behaviours around food.
	3.How successfully can immersive eating experiences represent cultural and culinary traditions?	RQ2	To examine whether immersive dining systems can meaningfully convey cultural identity and culinary heritage.

Table 1.1: Detailed Mapping of Chapter-Level RQs to Main RQs with Objectives.

1.4 Contribution

The central contribution of this thesis is to provide critical insights into designing and implementing DICom that not only enhances social interaction but also creates enriched, meaningful experiences tailored to users' needs. This thesis offers considerable theoretical and practical contributions to the topic. The overall key contributions from this thesis could be summarised as follows:

- **Introducing the Digital Immersive Commensality (DICom) framework:** This thesis develops and refines the concept of DICom, a novel framework that reimagines the practice of sharing meals in digitally mediated or virtual environments. DICom integrates existing theories of commensality, presence, and multisensory interaction, providing a foundation for designing systems that foster social connection, sensory engagement, and emotional resonance in digital dining contexts (Chapters 3, 4, and 5).
- **Advancing the understanding of food-related behaviours in digital settings:** Through empirical studies, this thesis extends knowledge on how individuals interact with food and others in remote and immersive dining scenarios. The findings reveal insights into social dynamics, sensory engagement, and the potential for immersive technologies to replicate or enhance traditional dining practices (Chapters 3 and 4).
- **Exploring opportunities and challenges in emerging food technologies:** The research identifies critical opportunities and challenges for integrating emerging technologies, such as VR and AR, into food-related experiences. By engaging users in co-design workshops and speculative design exercises, the thesis surfaces practical insights for creating meaningful, culturally rich, and sustainable digital dining systems (Chapters 3 and 4).
- **Providing actionable design guidelines:** This thesis offers comprehensive design guidelines for HFI practitioners, emphasising user-centred approaches to crafting immersive and socially engaging food experiences. These guidelines include:
  - Six design potentials for enhancing social interactions in digital dining (Chapter 3).

  - A collection of 18 key elements, five design directions, a catalogue of 10 speculative ideas, and recommended features for developing food-focused metaverse applications (Chapter 4).
  - Six design opportunities for leveraging multisensory and immersive technologies to foster connection and engagement in digital dining (Chapter 5).

- **Demonstrating practical implementation through prototyping:** Chapter 5 illustrates the design and evaluation of a Wizard-of-Oz multisensory VR prototype, showcasing how theoretical insights from the framework can be translated into actionable, user-tested systems. This prototype exemplifies the potential of immersive technologies to enrich digital commensality and highlights pathways for future development.

The findings from these studies were published in 2 peer-reviewed conferences and journals, to extend the existing knowledge in the research community by contributing to the overall understanding of designing DICom for more socially and emotionally engaging eating experiences. (Table 1.3) summarises the publications which have arisen directly from this thesis work.

Chapter	Conference/ Journal	Title	Status	Citation
Three	CHIPLAY 2022	The Playful Potential of Digital Commensality: Learning from Spontaneous Playful Remote Dining Practices	Published	Alhasan et al., 2022 [6]
Four	CHI 2023	No Pie in the (Digital) Sky: Co-Imagining the Food Metaverse	Published	Covaci et al., 2023 [84]

Table 1.2: Publications list arising directly from this PhD thesis.

Chapter	Workshop	Title	Status
Three	The Future of Human-Food Interaction - CHI 2021	Digital Commensality Helps Strangers Connect - a Qualitative Study	Presented

Table 1.3: Workshops list arising directly from this PhD thesis.

In addition, the following Table 1.4 presents collaborative work completed during the research period, showcasing projects where skills and methodologies developed during this PhD were applied. These works, while not directly stemming from the core studies of this thesis, highlight the broader applicability and impact of the expertise I acquired throughout the research journey.

Chapter	Conference/ Journal	Title	Status	Citation
None	i JET 2023	Roblox in Higher Education: Opportunities, Challenges, and Future Directions for Multimedia Learning	Published	Alhasan et al., 2023 [4]
None	IJGBL 2025	Optimizing Gamification Adoption in Higher Education: An In-depth Qualitative Case Study	Published	Alhasan et al., 2025 [5]

Table 1.4: List of collaborative publications showcasing works unrelated to the core topic of this PhD thesis, but demonstrating the application of skills and methodologies developed during the PhD research.

1.5 Research approach

This thesis adopts a multi-phase, empirical methodology to explore, develop, and refine the DICom framework. This approach is rooted in the iterative and interdisciplinary nature of HFI research, combining empirical insights, design exploration, theoretical grounding, and iterative refinement to ensure a robust and adaptable framework.

Empirical observations formed the foundation of the framework, drawing on data from real-world interactions. These studies investigated how users engage with current technologies in remote dining scenarios, focusing on sensory engagement, social behaviours, and emotional responses. By identifying recurring patterns and pain points, these observations provided a nuanced understanding of the opportunities and limitations of existing systems, shaping the framework's foundational principles. **Design exploration** further enriched this process through participatory design workshops and co-creative activities involving diverse user groups. These collaborative sessions generated valuable insights into desired system features, cultural considerations, and sensory preferences for immersive dining experiences. Engaging with users directly allowed for the inclusion of varied perspectives, ensuring the framework addresses both universal and context-specific needs. The thesis aligns with a "research through design" approach, which emphasises reflexive engagement with design practice as a means of generating knowledge [122, 128]. By leveraging action-reflection models [325], the research moves iteratively between theoretical exploration and practical application. This design-led process enables the generation of new ideas and design recommendations that serve as a blueprint for future technological developments, rather than solely validating existing methodologies.

The framework is also **theoretically integrated with existing literature** in HFI, sensory science, and digital commensality. This synthesis of prior findings ensured that the framework is conceptually sound and aligned with established knowledge in the field. To translate these principles into actionable systems, **prototyping and testing** play a critical role. Initial prototypes of immersive dining systems – such as those leveraging VR or AR technologies – were developed to operationalise key aspects of the framework. These prototypes were then evaluated with users to assess their effectiveness in fostering co-presence, shared rituals, and multisensory engagement, providing practical validation of the framework's components. Finally, the framework underwent **iterative refinement** based on feedback from users and experts. This iterative process ensured the framework remains flexible and responsive to diverse needs and evolving technological contexts.

This methodology is generative rather than purely validative [128], aiming to suggest new design avenues rather than asserting definitive solutions. By documenting and reflecting on lessons learned, the research contributes a novel perspective to the HFI field, offering actionable insights and inspiring user-focused solutions that promote connection, well-being, and inclusivity in remote dining experiences.

Taken as a whole, this approach aspires to shape the future development of digital commensality technologies, advancing HFI research while guiding the evolution of more mindful and socially connected food cultures in increasingly virtual contexts. This research positions DICom as a vital framework for designing systems that not only address social and sensory dimensions of dining but also foster inclusivity and cultural exchange in digital environments.

1.6 Thesis structure

The structure of this thesis is as follows: Chapter 2 presents a comprehensive review of the literature relevant to this thesis. It begins with an exploration of the significance of food in shaping human social and cultural practices. The chapter then delves into the concept of commensality, examining its traditional forms and the social, sensory, and cultural dynamics it fosters. Finally, it transitions to an analysis of digital commensality, exploring its applications and limitations in current technological contexts, and situates these within the broader

field of HFI. The chapter concludes by introducing the need for immersive systems to address the gaps in existing approaches to digital commensality, setting the stage for the framework proposed in this thesis.

Chapter 3 introduces the results of an exploratory study that examined how people used video-mediated communication, partially enhanced with AR filters, to share meals remotely. By analysing the behaviours of 36 participants dining together online, the study identified six key aspects that contribute to making remote dining more socially engaging. These findings highlight how video tools with AR enhancements can move toward the concept of immersive commensality by fostering deeper social dynamics and enjoyment during remote dining. The insights from this study provide valuable guidance for designing DICom technologies that enhance social interactions and elevate the overall dining experience.

Chapter 4 presents the findings from the second study, which explored how the metaverse could transform our relationship with food and inspire the design of immersive, human-centric eating experiences. Moving beyond the specific lens of digital commensality, the study adopted a broader perspective to understand what people value in their interactions with food, aiming to identify foundational insights that could guide the development of immersive systems in this space. Employing a co-design approach, the study involved six workshops to uncover key elements of meaningful food interactions and compiled a speculative catalogue of novel food experiences. The catalogue, designed to provoke thought and inspire innovation, was evaluated through interviews with both experts and non-experts. This iterative process refined the proposed ideas and offered a comprehensive understanding of important features and building blocks for DICom. Ultimately, this chapter offers a foundation for DICom by identifying essential elements, speculative ideas, and actionable insights to inform the design of future immersive dining systems.

Chapter 5 presents the results of the final study, which focused on implementing and testing key components of the framework established through the previous chapters. This was achieved through the design, development, and refinement of a *Wizard-of-Oz* prototype based on VR technology. Drawing on insights from Chapters 3 and 4, as well as foundational studies in the literature, this prototype operationalised the core principles of DICom to evaluate their practical application in fostering immersive, social, and communal dining experiences.

The study specifically examined how immersive technologies could enhance social dynamics, sensory engagement, and overall user experience in virtual dining contexts. Additionally, it explored user perceptions of eating in an immersive setting, providing critical insights into the opportunities and challenges of designing meaningful, human-centric systems. This chapter presents the outcomes of the prototype evaluation with 14 participants, highlighting its impact on social relationships, sensory connection, and behaviour toward food in these settings. These findings contribute to refining the DICom framework and provide actionable guidance for future developments in immersive dining technologies.

Finally, Chapter 6 synthesises the findings, implications, and limitations of the three studies conducted in this thesis, providing a comprehensive discussion that addresses the research questions and outlines the components of the DICom framework. Drawing from the results in Chapters 3, 4, and 5, this chapter identifies the key insights that inform the design of DICom systems and illustrates how these insights collectively contribute to the proposed framework.

The chapter reflects on how user perceptions of immersive dining technologies, social interactions, and sensory engagement shaped the framework's foundational principles. It briefly describes the framework's components, emphasising their relevance to fostering connection, engagement, and inclusivity in remote dining experiences. Additionally, the chapter explores the broader implications of the findings, highlighting both the opportunities and challenges in designing DICom systems that enhance the social and sensory dimensions of dining. Finally, Chapter 6 discusses the limitations of the research and identifies potential future directions, advocating for further exploration of the framework's applications and adaptability to diverse cultural and technological contexts.

Chapter 2: Literature Review

2.1 Overview

The literature review chapter focuses on a range of topics that relates to the key research components in this thesis. First, the literature that relates to the significance of food was reviewed (Section 2.2); this includes highlighting the intimate and culturally significant role food plays in human lives, emphasising its ability to foster social bonding. Then, the concept of kitchens as social spaces was investigated (Section 2.3), aiming to understand how they serve as hubs for collaboration, learning, and connection. Afterwards, in (Section 2.4) the review focuses on commensality (the act of eating together) and its importance in maintaining social ties; the chapter addresses the erosion of commensality in contemporary society and examines how technology influences dining practices. Next, the chapter introduces the emerging field of Human-Food Interaction (HFI), including innovative approaches such as remote commensality, live broadcast dining (Mukbang), and the integration of artificial companions in dining experiences. Additionally, it emphasises the playful dimensions of HFI in (Section 2.5). Finally, the literature presents the potential of immersive technologies to bridge gaps in social dining, fostering deeper connections and engagement in virtual environments in (Section 2.6).

2.2 Food and us

Eating is 'fundamental, fun, frightening and far-reaching', as stated by [314], this quote encapsulating the breadth of influence food has on us. These influences are recurrent, sometimes unpredictable and always – although often neglected – about intimacy. When we eat, the outside world is internalised and with that, comes the adage 'we eat what we are' [301] – culturally, emotionally, and environmentally. Our relationship with food is ancient and continues to form extremes from conflict and hunger to identity and satisfaction [180]. Eating is more than introducing food in our bodies. From a very young age, we learn to associate food with soothing and we understand that sharing food can be a way to show empathy for other's distress [147]. Eating serves important social functions by providing a means for identity construction, a context for social engagement, and a shared experience for strengthening social ties [335]. Eating with others in a group, is fundamental to social bonding through the collective sensory experience of how we transform ingredients into meals and how meals transform us [116].

Food holds intrinsic value across diverse cultures, influencing various behaviours. The anthropology of food considers both physical and cultural factors, with senses interacting based on memory. Socially constructed food memories evoke nostalgia and prompt future recollections. Food also acts as a social metaphor, traditionally eaten in large gatherings to foster unity. Solidarity eating, where groups hunt, gather, and eat together, shows communal strength. Practices like Himachal Pradesh's 'Bhaat,' where everyone helps prepare and share a meal [101], reinforce the idea that "the family that eats together, stays together" [292]. Similarly, other cultural traditions, including military 'regimental feasts' and ceremonies like Christmas, Thanksgiving, birthdays, and anniversaries, express unity. Fasting during religious observances like Ramadan, also demonstrates a sense of socialisation and passed down through generations [331].

These collective experiences are not just social, they are also deeply sensory. In every culture, food rituals begin before the first bite. Eating starts with the eyes and nose, in what is known as the pre-ingestion experience. Visual presentation, colour, and aroma trigger anticipation and emotional responses, shaping how we perceive flavour and satisfaction [297, 333, 347, 377]. These anticipatory cues are often shaped by cultural norms, consider the emphasis

on visual harmony in Japanese cuisine or the evocative smells of spiced dishes in Middle Eastern cooking. These anticipatory senses form a crucial part of how individuals experience and evaluate food, with studies showing that visual and olfactory cues significantly shape taste perception and appetite regulation [346]. Once the food is ingested, a key yet often underexplored component is mouthfeel the tactile sensation of food in the mouth. Mouthfeel encompasses qualities such as temperature, viscosity, crispness, and astringency, and is instrumental in defining satisfaction and hedonic response [63, 278]. Unlike taste and smell, mouthfeel provides temporal feedback as food is chewed and manipulated, forming a dynamic and evolving sensory experience. In immersive contexts for dining, acknowledging the role of pre-ingestion cues and mouthfeel is essential, as these dimensions contribute not only to sensory realism but also to emotional, cultural, and behavioural engagement with food [152, 162, 361]

2.3 Kitchens as social spaces – foundations for digital commensality

Historically, the kitchen—once viewed as merely a practical space for food preparation — has increasingly been recognized as a social and collaborative hub within the household [33]. More than just a functional area for cooking, it also serves as a multipurpose space for social interactions [188]. For instance, swapping recipes can be a powerful form of engagement [360], as can mentoring friends and family through their culinary learning processes [316]. The kitchen frequently becomes the setting for group activities such as playing games, having conversations, or watching television [33], ultimately helping to foster connections among individuals [188].

Cooking together holds a special significance in everyday life. We cook with friends, family, colleagues, and even strangers—not just to create a meal, but to strengthen social ties. This shared activity, or commensality, transforms cooking into a dynamic social event where people deepen relationships, exchange daily stories, and discover new insights about food preparation [284]. Yet modern lifestyles, which often disperse family members across different cities or countries, can disrupt these communal experiences [62].

Over time, the cooking process has evolved to improve efficiency, reduce costs, and enhance the social dimensions of food preparation [140]. Technological innovations and novel kitchen appliances have gradually replaced or upgraded traditional cooking methods. Recent HCI research, in particular, has explored new ways to support everyday cooking tasks using smart tools and appliances, such as "Augmented Reality Cookbooks" [261] or sensor-equipped frying pans [365].

Research on enhancing cooking practices within home food environments has largely centered on creating and refining "Smart Kitchens" [185, 195, 398]. At their core, these aim to automate services and improve safety, comfort, communication, and technical management in the kitchen [185]. For instance, "Cooking Navi" [146] helped users prepare multiple recipes simultaneously, catering to a wide range of skill levels, while "KogniChef" [265] guided users step by step through recipes and managed kitchen appliances to facilitate a smoother cooking experience.

Other studies have introduced innovative ways to streamline kitchen tasks. For example, "U-Kitchen" [7] leveraged RFID tags to enable seamless communication between ingredients and a kitchen server, whereas sensor-embedded systems [263] have improved task recognition and prediction. "CounterActive" [183], an interactive kitchen counter, combined projection, RFID tags, and electric field sensing to create a multimedia cooking environment. Likewise, AR solutions, such as those by Bonanni et al. [46], were shown to enhance user confidence and efficiency by overlaying interactive interfaces on surfaces and appliances. Meanwhile, "Panavi" [365] employed a sensor-embedded frying pan to guide users in achieving more advanced culinary techniques.

Despite their benefits, many such systems require user input at inconvenient times or lack adequate accuracy, potentially disrupting the cooking flow [195]. Efforts like "Shadow Cooking" and "Mini-Cook" [321, 322] strived to reduce common mistakes and simplify recipe-following, while immersive multimedia interfaces projected onto kitchen surfaces lessened distractions [222]. "Smart Kitchen" [323] further enriched the cooking experience by enabling gesture and voice control, along with AR, creating a more engaging and social atmosphere.

In designing for a broad range of users, special attention has also been given to older adults and individuals with cognitive impairments [43, 169, 280]. Ambient assisted living systems

have shown promise in boosting autonomy and daily functioning, especially for those living with dementia. Conversational agents have offered personalised recipe guidance and nutrition advice [219], though challenges persist in maintaining accurate recognition, tailoring interactions, and balancing users' needs with diverse kitchen environments.

While most smart kitchen solutions excel at delivering rich contextual information and supporting cooking tasks, they often fail to build social capital or foster remote togetherness [195]. Some systems, however, explicitly address this gap. "Cooking Together at a Distance" [62] introduced the "Performance Apron" and "Talking Bottle" to share cooking sounds and voice messages between separated family members, enhancing their sense of connection. "e-Care" [65] integrated educational cooking tasks in the kitchen to strengthen child-parent bonds. In a similar vein, the "Messaging Kettle" [21] and the "Cooking Stories" mobile app [225] enabled remote family members to engage in daily kitchen routines together, fostering emotional closeness.

Nevertheless, introducing new technology into a setting as intimate and routine-driven as the kitchen calls for careful consideration of cultural practices, established habits, and the potential inconvenience of invasive features [21, 65]. Ensuring that technologies adapt to a variety of household layouts and culinary routines remains a challenge [219]. Although these constraints highlight the complexities of implementing smart solutions, they also underscore the importance of designing for commensality. By focusing on the kitchen's intrinsic social potential, designers and researchers can create technologies that not only boost efficiency but also foster meaningful connections—bridging distances and reinforcing social bonds in both physical and digital contexts.

2.4 Commensality

In the social sciences and humanities, "commensality" is a central concept for understanding how the act of eating together can foster social bonds and cultural identity [116, 181]. Yet despite its frequent use in fields like anthropology and sociology, the term remains open to interpretation: Is it about sharing a meal, gathering around a table, or being present in the same place and time? Tracing its etymology helps clarify these nuances. "Commensalis,"

from medieval Latin, combines the prefix "com-" (shared) with either "mensa" (table) or "mensalis" (what is on the table). When derived from "mensa," commensality highlights the shared space and material object—the table—around which people come together. By contrast, deriving it from "mensalis" shifts the focus to the actual sharing of food. This subtle distinction underscores the multifaceted ways in which people interact over meals, whether through the physical act of eating, the social setting in which it occurs, or both.

2.4.1 Why is commensality important?

Eating together or being in a commensal setting is an activity that was shown to foster positive emotions, to increase everyday happiness and well-being [229, 363] and people who engage in it feel more satisfied with life (rather than when eating alone) [340]. Indeed, sharing food with others has beneficial outcomes in terms of weight and social development [99], it triggers an increased sense of community and togetherness and makes people more engaged with each other [99, 230]. Dining together can radically shift people's perspectives as it reduces their perceptions of inequality - diners tend to view those of different races, genders, and socioeconomic backgrounds as equal than they would in other social scenarios [184]. Commensality between family members leads to healthier relationships [99], while strangers who are eating together similar food feel closer and are more trusting of each other [404]. These shared eating experiences are amplified - when shared with someone else, pleasant food tastes better, while unpleasant food tastes worse [47].

Commensality fosters social bonds by turning mealtime into a communal ritual that emphasises unity and reflects social structure [116]. As people dine together, they share an experience that goes beyond food, reinforcing social ties and sometimes indicating equality or hierarchy. Sharing a meal also symbolises mutual commitment, enhancing a sense of trust, belonging and collective identity, which are key in sustaining the social fabric of communities [116, 181]. Furthermore, commensality reflects cultural values, showing how shared meals shape social structures [116, 270]. For instance, in France, food embodies the "art de vivre," reflecting meticulous attention to culinary quality and detail that extends to a broader cultural value placed on leisure, pleasure, and social connections during meals [102]. Similarly, in the Middle East, food transcends simple nourishment, symbolising deep-rooted traditions

of hospitality and generosity [336]. In Japan, the practice of sharing dishes enhances unity, emphasising food's role in fostering societal and interpersonal relationships [103]. Likewise, in India, food is intricately linked with religion and tradition, playing a pivotal role in festivals and rituals, with each region showcasing unique flavours and dishes that reflect its cultural and historical depth [326]. Commensality also embodies a significant source of cultural heritage [111]. For instance, commensality is integral to the Mediterranean Diet, which has been recognised as an Intangible Cultural Heritage by UNESCO [246]. This recognition highlights not only the health benefits of the Mediterranean Diet but also its cultural significance, where eating together strengthens social bonds and reinforces community identity [246].

Engaging in commensality can boost mental health by fostering social bonds and reducing feelings of loneliness and isolation [36]. Sharing meals creates opportunities for meaningful conversations and emotional support, which are essential for maintaining psychological well-being [36]. The act of eating together reinforces a sense of community and belonging, helping to mitigate stress, anxiety, and depression. Commensality not only supports mental health, but it also plays a critical role in improving dietary habits [36, 78]. When people eat together, they are more likely to make healthier food choices, which can lead to better overall nutrition [36, 78, 337]. This practice encourages the consumption of balanced meals rich in fruits, vegetables, and whole grains, which are essential components of a healthy diet. Moreover, the social aspect of shared meals can enhance the pleasure of eating, further reinforcing positive eating behaviours and contributing to both physical and emotional well-being [78, 337].

2.4.2 The erosion of commensality

The reign of convenience in our globally interconnected lives has shifted how we prioritise our time and effort – and with that convenience, commodification and consumption have overtaken production. Food has become abundant for the rich, lying attractively at our disposal, for us just to pick it from the shelf or to have it home delivered. We put it in our wheeled trolley or we click an online button, without having harvested or grown anything. These practices are convenient, but at the same time, they make us lose touch with food and grow distant to our food practices [98]. Detaching ourselves from our food lives brings about

a whole set of issues, at different scales. For example, it damages: (1) *the environment*, as we are less and less aware about the origin and ecological impact of the foods we consume [378]; (2) *our bodies*, as we pay less and less attention to how we nourish it [161]; (3) *our social relationships*, as we no longer have time to cherish the social dimension of dining; (4) *our culture*, as we forget about countless food-related traditions and rituals that have been key to our society for centuries [124].

Specifically, the social dining practices are constantly changing with the number of people living alone increasing over the recent decades. It is envisaged that between 2016–2030, single-person households will see faster growth than any other household type globally, with around 120 million new single person homes to be added over the period [138]. This demographic is being driven by busy lifestyles, increasing divorce rates, growing widowed and divorced elderly group, especially large in developed countries. To understand how this relates to food consumption, a survey from 2016 conducted among 2000 UK adults indicated that "15% of respondents said they had not had a meal with another family member in the last six months, 30% said they had not done so with a best friend in the last six months, and 45% had not done so with an old friend" [99]. Although exact data are scarce, anecdotal evidence shows that an increasing number of people are eating alone [204]. Thus, many of the single-person households may be missing out on the benefits of commensality and experience instead negative health consequences in terms of food consumption [357], depressed mood and loss of social connectivity, leading to a decreased feeling of well-being [76, 356].

2.4.3 The influence of technology on commensality

Furthermore, the modern emphasis on convenience and efficiency has led to new eating practices, including increased solitary dining and "mindless" consumption in front of screens [344]. Whether scrolling through social media feeds on a smartphone or watching television during meals, these distractions can dilute communal bonds and even contribute to overeating due to reduced attention to satiety cues [220, 300, 311]. Ironically, the very devices intended to connect us can fragment face-to-face connections at the dining table, steering individuals away from the shared experience that historically fostered deeper relationships and social cohesion.

Yet the impact of digital technology on mealtime is not entirely detrimental. There are cases where technology can enable new forms of commensality, especially for those separated by distance [343, 344]. Video calls and virtual dining experiences enable friends and family to share the act of dining together despite being geographically apart. They help sustain social ties and preserve a sense of togetherness, offering social connection without the co-location of a physical meal. In addition, recipe-suggestion platforms and restaurant recommendation services can help people explore diverse cuisines, broaden their culinary horizons, and discover shared interests [353, 397]. When designed thoughtfully, digital interventions can also support more sustainable food practices—through, for example, promoting waste reduction or responsible sourcing methods [108, 397].

Overall, technology's role in commensality is nuanced. While it can distance us from the visceral, communal essence of cooking and dining, it also holds promise for bridging gaps created by modern life. Striking the right balance between convenience and genuine social interaction is key to ensuring that technological innovation enriches rather than erodes the core values of dining together.

2.5 Human Food Interaction – an emerging field

Ultimately, these complexities highlight the importance of intentional and thoughtful design choices when integrating technology into our food lives. Rather than allowing digital tools to undermine commensality, designers and researchers can create solutions that foster genuine connections around eating. Such innovations are at the forefront of Human Food Interaction (HFI) research, where the focus shifts from merely automating or entertaining to actively enhancing every aspect of the food journey. As recent advancements in digital technology continue to reshape how we cultivate, cook, and consume meals, HFI provides a framework for developing interventions that improve individual well-being, social bonds, and environmental sustainability [20, 370, 391]. HFI, a specialised area within HCI, focuses on digital interactions associated with food, nutrition, and culinary experiences [20]. Furthermore, HFI examines the challenges and opportunities within this space to design technologies that can create meaningful impacts on how people interact with food. HFI has attracted significant interest within the HCI community. It was the focus of a Special Interest Group at CHI 2022 [91]

and has been the subject of multiple workshops at CHI [90, 96], CHI PLAY [69], and DIS [86, 94, 338].

Bertran et al. [10] examined the rapidly growing and diverse field of HFI through a Systematic Mapping Study. The authors identified key trends, including the emergence of three major research communities, the first is Food CHI which originated in 2017 as a SIG [168]; (Special Interest Group) which is a focused community, formed through workshops and meetings. The second community, known as Multisensory Human-Food Interaction (MHFI), has been convening workshops since 2016 (e.g. [271, 371]), and the third community appeared since 2012, computer scientists have explored AI approaches to HFI through various workshops, including Multimedia Cooking and Eating Activities (e.g [168, 202, 319]), Cooking with Computers (e.g [79, 80]), and Multimedia Assisted Dietary Management (e.g [298]). Additionally, Bertran et al. [10] review looked at 270 publications, mapping them across these domains and analysing them through lenses of focus (functionality vs. experience) and agency (technology vs. human-centred). The review highlighted that most HFI research is concentrated in technology-driven, functionality-oriented studies, with a significant emphasis on food production, eating, and tracking. However, the paper flagged gaps in exploring social bonding, experiential aspects, and the role of technology in empowering individuals in their interactions with food. To address these challenges, Bertran et al. [10] proposed a taxonomy categorising HFI research into six domains: Source (acquiring food), Store (storing and disposing of food), Produce (growing and preparing food), Track (measuring and identifying food-related practices), Eat (food consumption), and Speculate (exploring alternative food futures). The study called for more integrative approaches that balance technical efficiency with the human and social dimensions of food practices.

2.5.1 Simulated digital taste in HFI

Recent advancements in HCI have increasingly focused on the integration of taste as a sensory modality, particularly through the work of Adrian David Cheok et al. [304], who have pioneered several technologies in this domain. One of the foundational innovations is the "Digital Taste Interface" [304], which employs electrical and thermal stimulation on the tongue to evoke basic taste sensations such as sourness, saltiness, and mintiness. While this

non-chemical approach offers precise digital control and represents a notable step towards scalable gustatory interfaces, it remains limited by a restricted taste palette and variability in individual user sensitivity. This line of work was further extended through the development of the "Digital Taste Synthesizer" [302], which integrates electrical and thermal signals in a wearable tongue interface. This system demonstrated the feasibility of digitally transmitting taste sensations, thereby enabling novel possibilities for remote multisensory communication particularly in social or eating-related contexts. Such work is especially relevant in relation to Mukbang (see Section 2.5.4), where the focus on exaggerated eating behaviours can encourage overconsumption. Cheok's research offers a contrasting approach using multisensory stimulation to evoke the pleasures of eating without actual intake. In this context, where visual exposure to food alone can trigger psychological satiation, these technologies may offer a safer, more controlled way for viewers to experience indulgence without the associated health risks, offering an avenue for further exploration in the management of eating behaviours and multisensory immersion [305].

In addition, several related systems have been proposed to explore alternative means of digitally enhancing or simulating taste. "Vocktail" [275], a multisensory cocktail glass, combines colour manipulation, olfactory diffusion, and tongue stimulation to alter the perceived flavour of beverages. Although it successfully demonstrates the impact of synchronised multisensory cues on taste perception, the system is constrained by its reliance on individual calibration and complex setup requirements. The "TASTE+" [305] utensils employ low-intensity electrical stimulation to enhance the taste of food without the need for additional ingredients, with particular implications for reducing salt or sugar intake. However, limitations concerning usability, comfort, and the granularity of control remain challenges for practical deployment. The "LOLLio" system [258] a tangible, interactive lollipop provides gustatory feedback through dynamic switching between sweet and sour tastes, illustrating how taste can function as both input and output in playful interaction scenarios. Despite its innovative form, the device remains exploratory in nature and lacks broader applicability beyond entertainment contexts. Finally, "TasteScreen" [242] introduces the concept of an edible user interface by dispensing flavouring agents directly onto a display screen for users to lick. While the system underscores the imaginative potential of taste-based interaction, it raises significant concerns regarding hygiene, practicality, and user acceptability.

Collectively, these studies highlight the emerging potential of digital taste technologies to enrich immersive, affective, and interactive experiences. Nonetheless, several limitations persist across the current body of work, including constrained flavour repertoires, variability in user responses, hygienic and ergonomic issues, and challenges in achieving scalability. Further research is required to address these issues and to refine the design of gustatory interfaces for broader application within multisensory computing environments. Importantly, these advancements in digital taste simulation provide valuable inspiration and technical foundations for the development of the Digital Immersive Commensality (DICom) framework. By enabling controlled, multisensory stimulation particularly around taste, these systems open new pathways for supporting more meaningful, embodied, and socially engaging remote eating experiences.

2.5.2 Digital commensality in HFI

Within the broader domain of HFI, digital commensality has generated increasing attention as an emerging phenomenon shaped by technological advances and changing lifestyles [344]. At its core, digital commensality refers to the practice of sharing meals and dining experiences through digital technologies, whether physically co-located or entirely remote. Examples range from platforms like "VizEat" [105] and "Skeating" [340]—which facilitate virtual or semi-virtual social dining—to eating with digital agents such as robots, or even live-stream "Mukbang" broadcasts that allow viewers to watch and interact with someone else consuming food in real time.

Though these technologies offer promising new ways to connect people over a meal, they also emerge in response to social shifts that make traditional, in-person commensality increasingly difficult. Factors like globalisation, intensive work schedules, and rising numbers of individuals living alone contribute to less time for shared meals [137, 153, 177, 355, 407]. Meanwhile, the pandemic has further accelerated these trends, leading to prolonged periods of social isolation and underscoring the potential value of digitally facilitated dining experiences [150, 397]. In many cases, technologies that enable remote commensality—such as video-calling platforms or "companionship systems" connecting geographically separated diners [212]—have filled a crucial void, offering emotional support and maintaining interpersonal bonds across physical

distance.

The COVID-19 pandemic, in particular, heightened the importance of digital commensality. As countries enforced lockdowns and social distancing measures, traditional forms of communal dining became nearly impossible [60]. Many people turned to digital tools, discovering creative ways to share meals virtually and combat the loneliness that arises from eating alone [296]. These shifts also broadened the scope of HFI research, prompting scholars to delve deeper into how digital dining practices reshape our relationship with food and one another [331, 342].

Taken together, these trends emphasise the growing significance of digital commensality within HFI. On one hand, digital tools hold the potential to preserve social bonds when circumstances prevent in-person gatherings. On the other, they prompt questions about the nuances of "togetherness" and how technology might enhance—or inadvertently undermine—core aspects of commensality. In the following sections, I will explore various forms of digital commensality, such as remote commensality, live broadcasts (Mukbang), artificial companions, and playful or gamified dining experiences, alongside the challenges and limitations of designing technologies intended to cultivate meaningful connections over meals.

2.5.3 Remote commensality

Remote commensality is the practice of sharing meals virtually, using digital technologies to bridge physical distances [139, 209, 399]. Remote commensality is facilitated through video conferencing tools or through custom-designed systems. I will describe some of these studies below.

The "Food Media" [399] and "Co-Dine" [398] systems were designed to enhance remote dining experiences by integrating interactive technologies such as gesture-based interaction, ambient tablecloths, and food teleportation, with the aim of fostering emotional connections among distant family members. The study revealed that technologies like gesture controls and 3D-printed food had enhanced remote dining, creating an immersive experience that fostered emotional connectedness beyond traditional video calls. Despite its potential, the system faced challenges, including the complex integration of technologies, the need for precise

calibration and synchronisation, and the necessity of enhancing user-friendliness for diverse home environments.

Other systems focused on video recording to address teledining for users in different time zones. For instance, "Asynchronous Co-Dining" [408] was a remote co-dining experience conducted through audio recordings. Twenty-four participants ate while listening to these recordings, which enhanced their feelings of intimacy and connectedness. Workshops and analysis confirmed that asynchronous audio recordings helped overcome the barrier of different time zones, suggesting their potential to maintain family bonds across distances. One limitation of the study was its focus solely on recorded audio as a means of enhancing intimacy in remote co-dining, potentially neglecting other sensory elements that contribute to the dining experience. Similarly, a communication system called "CU-Later" [364], was proposed to help people interact across different time zones by sharing recorded meals and activities. It included a camera, microphone, synchronised video, and a motion sensor. Preliminary field tests indicated positive user experiences, suggesting potential for enhancing remote communication and understanding between individuals separated by time zones. The study also highlighted areas for improvement, such as the need for refinement in video framing to enhance user experience, potential difficulties in determining optimal display locations, and the challenge of automating recording processes to align with users' schedules. Another example is "KIZUNA" [264], a system facilitating time-shifted teledining, which allowed people in different time zones to virtually dine together by synchronising video playback with their dining progress. This system enhanced communication and the sense of presence among diners, reducing distractions and improving conversation flow. However, reliance on recorded teledining disrupted the natural flow of live conversations and reduced the spontaneity and responsiveness vital for genuine connections, potentially leading to weaker social intimacy and less engaging interactions. These examples showed that although asynchronous methods effectively resolved timing conflicts, they prevented people from being fully synchronised in real-time. Furthermore, survey results highlighted that the main reason for sharing meals is conversation [171]. This underscores the importance of developing technologies that support communication while still allowing live conversations, thereby preserving the essence of social interactions during mealtime.

Remote commensality also included systems that used projection for teledining experiences.

For instance, "Telematic Dinner Party" [29] applied computer-mediated communication to maintain connections through shared meal experiences among physically distant individuals. The authors concluded that having the table act as an imaginary friend could help individuals feel a sense of togetherness and playfulness among remote participants and could enhance social presence and engagement across distances. In a similar manner, "NetPot" [119] improved group dining for remote participants by using projected remote diner actions, chopstick tracking cameras, and Skype audio teleconferencing to simulate a communal Chinese hotpot meal. The results showed that the system enhanced the dining experience by maintaining essential aspects of communal meals. However, it was unclear whether the improvement was due to the restoration of meal factors or the novelty of the technology. Additionally, diners did not always pay significant attention to others, raising questions about the system's overall effectiveness. "RoomXT" [155] was a mixed reality communication system designed for home use that enhanced a user's physical environment for more natural and spontaneous interactions. The system employed a wall-sized projection display, head-tracking, and 3D rendering to seamlessly blend real and virtual environments, creating visual continuity. Key findings showed that these systems could combat isolation for elderly and disabled individuals. The emphasis on aesthetics and device-free interaction underscored user acceptance, suggesting new ways to foster social connection at home. However, integrating this technology into home environments proved challenging.

While other systems aimed to connect family and friends through recorded or live projection methods, Korsgaard et al. [214] investigated how mixed reality systems could enhance meal experiences for older adults at risk of malnutrition due to social isolation. Mixed Reality (MR) integrates elements of both virtual and augmented reality, creating interactive environments where physical and digital objects blend seamlessly and interact in real-time [144, 251]. It examined the impact of virtual environments and avatar-based interactions on meal enjoyment and energy intake. The findings showed that MR systems did not significantly increase energy intake but improved the dining atmosphere and the perception of food quality. They also helped reduce loneliness during meals. Based on previous studies, the subjective experiences of participants have not yet been examined, as the main focus has remained on the development of systems which are complex to apply in home environments or heavily reliant on recordings. Furthermore, the detailed mechanics and dynamics of communal dining

have not been thoroughly explored.

2.5.4 Live broadcast dining – the phenomenon of Mukbang

Live streaming is a unique form of social media that allows for the real-time recording and broadcasting of video over the internet (e.g, Tiktok, Instgram, Youtube, and Twitch) [71, 154]. This technology enables broadcasters to share a diverse range of content, including video games, product demonstrations, talent shows, personal moments, sports, and more. Viewers have the flexibility to watch these live streams from any location. In recent years, a new trend in live streaming known as "Mukbang" has become popular for sharing eating experiences. Mukbang, originated from South Korea in the early 2010s, which is an online broadcast phenomenon where hosts, known as *broadcast jockeys*, engage in eating large quantities of food while interacting live with their audience. This trend combines the Korean words for "eating" (muk-ja) and "broadcast" (bang-song), and was initially popularised through platforms like AfreecaTV [199, 243, 344]. Over time, it has evolved into a diverse and often extreme display of consumption, characterised by its interactive format and the sensory experience it provides. This phenomenon has gained international popularity and sparked discussions over its positive and negative impacts.

Viewers are interested in watching Mukbang live streams for different reasons. It provides a sense of companionship and social connection to viewers who may be eating alone [71, 200]. The interactive nature of live streams allows viewers to communicate with the host and each other, creating a virtual dining experience that can alleviate feelings of loneliness and isolation. The entertainment aspect of Mukbang is significant; viewers enjoy the theatrical performance and often exaggerated expressions of taste and pleasure by the hosts (e.g., suspense, throwing up, eating spicy food) [22]. More specifically, in Mukbang livestreams, viewers engage with the broadcast jockey by typing comments, making specific eating requests, sending virtual "star balloons" and reacting to the content [71]. These interactions allow viewers to influence the stream, fostering a participatory environment that transcends traditional viewing experiences. Through directing the broadcaster's actions and interacting with each other, viewers create a dynamic community, making them feel like active participants in the eating experience. This format blurs the line between viewer and performer,

deeply integrating viewers into the Mukbang experience. For many, Mukbang is a way to experience different cuisines and food trends vicariously. Hosts often eat a variety of foods, including local delicacies and international dishes, providing viewers with culinary exposure they might not otherwise explore [200]. Furthermore, people find the sounds of eating such as chewing and slurping—relaxing or even pleasurable. Mukbang videos that focus on these sounds can serve as a form of Autonomous Sensory Meridian Response (ASMR), helping viewers to relax or fall asleep [22, 199, 293]. Mukbang has also served as a platform for cultural exchange, as hosts introduce foods from various cultures to a global audience. This not only promotes understanding and appreciation of different culinary traditions but also enriches the global food [200].

While Mukbang offers several benefits, it also comes with notable risks and downsides, particularly related to health, psychological effects, and societal impacts. The major problem associated with Mukbang is the promotion of overeating and the consequences of consuming excessive food portions [201, 350]. This could result in obesity, heart disease, diabetes, and other metabolic disorders [189, 199]. Additionally, the overemphasis on quantity over quality in Mukbang can mislead viewers about nutritional norms and healthy dietary practices [189, 412]. Furthermore, it can disrupt and change negatively the table manners [199]. For both viewers and creators, Mukbang can impact mental health. For instance, viewers struggling with eating disorders might find Mukbang triggers addictive symptoms of watching; also, excessive viewing of these live streams can lead to anxiety and depression, as shown in [197, 198]. The significant amounts of food often featured in Mukbang videos can contribute to a culture of food waste, a critical issue in a world where food scarcity and hunger are still major problems, as outlined in [299]. Despite Mukbang offering the opportunity to the host and viewers to interact however, broadcast jockeys are often subjected to negative feedback from viewers. The interactive nature of Mukbang was shown to sometimes expose broadcasters to cyberbullying, which can have severe emotional and psychological effects [172]. Although Mukbang is designed to alleviate loneliness by creating a sense of virtual companionship, it can also lead to increased physical social isolation, as individuals may choose to interact online rather than engaging in real-life social activities [179]. Consequently, although Mukbang can offer virtual companionship and cultural exploration, it also raises questions about whether it genuinely supports digital commensality or just reinforces unhealthy eating habits

and isolation. More research is needed to understand how live streamed eating experiences like Mukbang can be designed or guided to foster positive social engagement, rather than undermine it, within the broader context of digital commensality.

2.5.5 Artificial companions

The current trends of solitary dining experiences, whether by choice or circumstance, can have a negative social and psychological implications [125], and an increased number of meals alone [66, 186, 291]. This led to engaging with digital devices like smartphones or televisions during meals which can encourage unhealthy food choices [351]. Solitary dining is not limited to the younger demographics; it also includes elderly individuals who might live alone due to various reasons such as physical limitations or separation from family, or sometimes by necessities like medical self-isolation [64, 125, 166, 211]. Furthermore, research conducted in [409] has highlighted the negative aspects of solitary dining. This study specifically linked eating alone to increased dissatisfaction, emphasising concerns about loneliness and distracted eating [112].

Although eating with family and friends is difficult to replace however, research has proposed "Artificial Companions", which referred to the use of digital or physical companion (e.g, virtual avatar, robot) in simulating the presence of a companion during meals or eating experiences, even when the person is physically eating alone [235]. These Artificial Companions can play a role in reducing the negative impacts associated with eating alone [344]. In addition, they are designed to replicate social interactions, making them a promising solution for enhancing the dining experience [270].

Artificial Companions can adopt various shapes, ranging from humanoid to abstract designs, and utilise different methods of communication, such as voice, touch, or movement [125].They are used in numerous environments and have demonstrated positive impacts on the perception of social presence [287]. However, existing work on social Artificial Companions in the eating-related settings is relatively limited [235, 270]. In this section, I will cover only the Artificial Companions used in digital commensality, which aligns with my thesis.

Artificial Companions serve various purposes, including promoting mindful eating. Research in [170] indicated that individuals tend to eat more slowly when meals are presented by

an agent, compared to when they are eating alone. Similarly, "Guardian of the Snacks" [193], a tangible multimodal system designed to promote mindful snacking for individuals dining alone, particularly relevant during the COVID-19 pandemic. It addressed the challenges of solo dining, aiming to mitigate unhealthy snacking behaviours by offering playful companionship and gentle reminders. However, users could manipulate snack intervals, portion sizes, and choices, potentially compromising the system's effectiveness. Ultimately, user self-motivation was crucial for behaviour change, as the system did not actively enforce it.

Other studies looked into enhancing food choices. Gallagher et al. [125], investigated the effects of Artificial Companion on eating behaviours during communal settings. The experiment involved a toy robot displaying non-verbal behaviours to influence participants' food choices and taste perceptions. Although initial results suggested a positive influence by the robot on participants' food choices, the findings were not statistically significant. "Drink-O-Mender" [308], a robotic system is designed to deliver personalised nutrition advice by analysing the types and quantities of drinks consumed by users. The system successfully guided users toward choosing healthier beverages. Feedback from visitors was generally favourable regarding the robot's design, although some concerns were expressed about difficulties in how its interactions was perceived. Moreover, there were challenges with user expectations regarding the robot's capabilities, such as speech recognition and facial tracking, which were not implemented. Building on similar technological interventions, another study assessed the use of an Artificial Companion named "Gabby" [127], which is a mobile technology that promoted healthier lifestyle habits, including increasing fruit intake, managing stress, practising mindfulness, and engaging in physical activity. After one month, participants who received coaching significantly reduced alcohol consumption and increased their daily fruit intake. The findings suggested that using artificial companion for health coaching can be an effective and feasible approach to encourage healthy eating and stress management, particularly among diverse urban women. Furthermore, using Artificial Companions can also lead to losing weight as presented in a system called "Lucy" [285], a digital assistant developed to support weight loss by monitoring eating behaviours and using crowd-assessed meal photos to estimate nutritional content and dietary adherence. Lucy provided personalised support, including meal logging, dietary advice, and motivational messages. Evaluations indicated strong user acceptance and effectiveness, showcasing Lucy's potential as a helpful tool for

nutritionists and patients in weight-reduction programs.

Promoting healthy eating habits through Artificial Companions extended beyond adults, as several systems also focused on encouraging children to adopt healthier diets. "Health-e-Eater" [306], a system featured a magic plate and robotic companion designed to enhance healthy eating among 2-5-year-olds in low-income families, addressing childhood obesity. This system employed sensors and interactive feedback to encourage healthy choices during meals. The study highlighted parental concerns about fostering healthy eating in children, particularly with picky eaters and the lack of interactive tools. In response, the Health-e-Eater system enhanced nutritious choices during meals. Likewise, Baroni et al [30], examined how a humanoid robot used motivational cues to encourage healthier eating among 8-9-year-old children, particularly increasing their fruit and vegetable consumption. The robot's verbal cues were more effective than its bodily cues in persuading children to set and achieve ambitious dietary goals. The results showed that these tailored motivational strategies significantly enhanced the robot's effectiveness, regardless of gender differences. This suggested that humanoid robots could play a crucial role in promoting behaviour change toward healthier eating in children. However, the study noted key limitations, such as relying on children's promises for behaviour change, which might not fully materialise into actual actions. Furthermore, children might not fully understand their commitments.

Robotic technology can also offer unique opportunities for solo-diners to feel less lonely in dining. For instance, "FoBo" [194], a robotic companion designed to enhance the solo dining experience by mimicking human behaviours and making eating alone less isolating. FoBo featured robotic arms, sound synthesis for eating noises, and an expandable belly to indicate fullness. FoBo acted playfully, even burping and reacting to overeating. The research highlighted FoBo's potential to transform dining with technology, moving beyond traditional roles to integrate fun into daily activities. However, limitations included FoBo's ongoing development, with some functionalities not yet fully implemented. The study focused more on the speculative and conceptual aspects of dining robots rather than on empirical user interaction data. Additionally, integrating FoBo into various dining settings, such as homes, restaurants, and workplaces, presented challenges due to differing user needs and interactions. McColl et al. [244] investigated the impact of a socially assistive robot called "Brian 2.1", on elderly individuals during mealtime at a long-term care facility. The robot, designed to motivate

and engage seniors through greetings, encouragement, and humour, was tested with eight participants aged 82-93. Results showed high engagement and positive attitudes towards the robot, with an 87% compliance rate. This highlights Brian 2.1's potential to improve mealtime independence and social interactions among older adults. The study's limitations involved a small sample size of eight, covering only two meals. Additionally, the robot could not respond to verbal dialogue and faced technical issues with its sensory systems.

One of the challenges of using Artificial Companions is to manage multiple conversations with more than one individual. Addressing this, research [121] has introduced a humanoid robot bartender designed to manage dynamic, multi-party social interactions. It evaluated the robot's ability to take drink orders effectively, emphasising task success and dialogue efficiency as key to user satisfaction. The system featured advanced vision, linguistic processing, reasoning, and control capabilities, allowing it to address both task-oriented and social interaction needs. The study also outlined potential enhancements, such as better input processing and integrating reinforcement learning to improve decision-making. Key findings showed that the robot successfully managed interactions with customers, prioritised tasks, and maintained social engagement in a bar environment. Most participants successfully ordered drinks and appreciated the robot's likeability and perceived intelligence. Although minor technical issues arose, they did not significantly impact functionality. However, the study noted limitations such as the fixed scenario order, which might have influenced participant responses; the use of a simplified questionnaire; and a focus on a specific task context.

Niewiadomski et al. [268] investigated the use of social robots as artificial commensal companions during mealtime to combat social isolation and improve eating behaviours. Using Kinect sensors and nonverbal communication models, the researchers developed a prototype that could interact and provide feedback on eating actions. Findings indicated that participants enjoyed meals more with the robot than alone and experienced subtle changes in their food choices and consumption. This suggests that, especially for the elderly or those living alone, could enhance well-being by simulating the benefits of communal eating.

Although there are benefits from dining with Artificial Companions, there are also challenges. Nonetheless, these robots still cannot fully capture the complex dynamics of human commensal interactions; they also cannot engage in open conversation, as their capabilities are limited

to voice recognition. Furthermore, they are difficult to adopt in high-end gastronomy such as, fine-dining establishments known for Michelin-star quality, where precision, innovation, and multisensory presentation are essential due to the high costs of implementation and maintenance [342]. Additionally, there is consumer resistance and a psychological impact of robotic food preparation on consumer perceptions of quality and naturalness, suggesting that human involvement might still be preferred for perceived quality and authenticity in gastronomic experiences [342].

Mancini et al. [234] introduced an artificial commensal companion, a virtual agent designed to interact with humans during meals to simulate the social benefits of eating together. The results showed that while participants liked the concept, they found the version repetitive and lacking natural interaction, highlighting the need for improved synchronisation and richer behaviours such as, better timing of the agent's responses to the user's eating and speaking. Despite these advancements, artificial companions whether robotic or virtual, still face challenges in replicating to some extent the richness of human commensal interactions and in being socially accepted, as many individuals continue to resist or show a preference against dining with non-human agents. While they offer promising solutions to combat social isolation and enhance mealtime experiences, their limitations in natural interaction, cost, and adoption remain barriers to widespread acceptance. Future research must focus on improving their conversational abilities, integrating more sophisticated social cues, and ensuring accessibility to create more human-like, emotionally resonant, and culturally adaptable dining companions.

2.5.6 *Playful* approaches to HFI

Most of us recall being told by our parents not to play with our food, as it is seen as wasteful and considered bad behaviour. Yet, play is a fundamental aspect of both childhood and adulthood, essential for exploring our relationships with objects, our surroundings, and expressing ourselves [135]. I propose viewing playful eating as an attitude similar to Caillois [58], treating it as a pleasurable, non-serious pursuit. Playfulness involves creativity, imagination, and enjoyment, as well as structured challenges and rules. In the context of food, it transforms the act of eating into a playful experience by blending spontaneity with discipline

[58]. Gillin [135], described play as an activity that frees players from everyday life's boundaries, where the act of playing is the goal itself. Campreguer et al. [59] defined playfulness as a playful attitude that is fun, creative, social, and engaging, even when not involved in the actual act of play. Playfulness is not an activity on its own but an attitude that can be applied to various activities, allowing it to coexist with non-playful tasks and bringing the benefits of play to situations where play is not the primary focus [59].

HFI literature has explored playful interactions with food, emphasising the experiential qualities of play in eating rather than just entertainment. For instance, Altarriba Bertran et al. [13], advocated for extending playfulness to chefs and food designers to enhance dining experiences. Chisik et al. [68], introduced "gastroludology" promoting new playful approaches to eating and drinking. Furthermore, Mueller et al. [255] suggested using interactive technology to transform eating into a playful experience, leveraging the close physical proximity of food to our bodies and merging it with technology to create unique playful eating experiences. Playful experiences involving food not only enhance mental well-being but also promote happiness and foster significant social connections during communal meals [253, 390, 392]. Previous studies have shown that playful dining experiences can be joyful and encourage participants to engage all their senses [15, 114]. Expanding on this concept, recent research has suggested that integrating digital technology with eating could introduce new ways to create playful experiences that enhance pleasure, excitement, and enjoyment [114, 400].

According to Bogost [45], in high gastronomy, playing with food occurs in the eater's mouth, utilising its sensory properties such as changing tastes, smells, textures, states, and sounds [340]. Food offers rich sensory experiences along with cultural, social, ethical, and personal dimensions, making it an interesting material for play. Both eating and playing have strong social connotations[1] [340]. The synergies between play and eating have been explored by many chefs around the world [12], as well as by food designers and researchers [400]. The social connotations around eating and play are not only present in fine dining but are also deeply integrated into people's everyday life. Countless examples of playful rituals with and around food, which can date back millennia, have become relevant parts of different cultures [379]. For example, "Kattabos" is an ancient Greek drinking game that involved trying to fling wine lees (i.e., yeast deposits at the bottom of a wine bottle) from a cup at a

[1] https://theconversation.com/gaming-fosters-social-connection-at-a-time-of-physical-distance-135809

target that was placed in the middle of the room [339]. Playful food interaction can be an essential part of a society and include rituals involving distinct steps that take into account the normative and symbolic meaning of a food item [379]. For example, the "East Frisian Tea Culture" is part of the German Unesco "Nationwide Inventory of Intangible Cultural Heritage"[2]. The tea ceremony requires putting a sugar rock (so-called Kluntje) into a cup onto which the hot tea is poured causing a characteristic cracking sound. In a second step, cream is added at the edge of the cup using a special flat spoon. The cream is supposed to slowly rise to the top forming cloud-like structures (so-called Wulkje). The tea itself is not stirred but drunk so the different layers offer a diverse drinking experience. Such kinds of playful eating rituals, which are seamlessly embedded in culture, have been explored before in HCI as sources of design inspiration for increasingly playful food technology [39].

The use of interactive technologies to enrich a playful social eating experience is not new. "You better eat to survive" [23] - a virtual reality game that uses eating as a way to facilitate social game play - is one example that aims to build trust by creating dependencies around cooperative eating activities. Similarly, "Arm-A-Dine" is an augmented eating system where players collaborate through feeding actions in a game, while wearing robotic arms [247]. Sound was linked to eating in a playful social gustosonic experience "WeScream!" [390], "Singing Carrot" [389] and "Sonic Straws" [392] where users generated musical melodies while eating or drinking. The authors found that playful social gustosonic experiences support coordinated eating and drinking actions, contribute to self-expression, increase the awareness of relatedness and enrich the overall eating and drinking experience.

Research in HFI has also explored using playful approaches through artificial companions like robots to improve the dining experience for people who eat alone. For instance, "FoBo" [194] a speculative design for a robotic dining companion that seeks to improve the solo dining experience. FoBo was designed to mimic human dining behaviours playfully (e.g. burping sounds), making eating alone more engaging and less isolating. Users in the study indicated that FoBo enhanced their solo dining by providing engagement and reducing loneliness. Likewise, "Social Dining Table" [187], a table featuring robots, called the "KonKon" interface, uses knocking sounds for communication, aiming to enhance interactions between users and robots. Experimental findings confirm that this communication method and adap-

[2] `https://www.unesco.de/en/east-frisian-tea-culture`

tation model allow users to effectively guide the robots using simple social cues. There are works in HFI that have explored the use of playful dining tables to enhance social dining experiences without disrupting traditional meal dynamics. For example, the "Future Dining Table" [282], assists in facilitating conversation among diners who are unfamiliar with each other. The system identified isolated individuals by detecting a lack of speech, reduced eye contact, and increased eating frequency, and then prompted conversation by displaying news information. Another example, "Keep-Up-With-Me" [253], is a novel interactive dining table designed to synchronise the eating pace of diners. This mechatronic table adjusts the height of each diner's dish based on their eating rate, subtly guiding them to match the pace of their companions. The authors have shown that synchronising diners' eating paces through discreet adjustments of dish heights, led to the enhancement of the social dining experience.

The integration of serious gaming in HFI not only enriches the overall eating and social experience but also encourages healthier eating habits. For example, the"We4Fi" [288] mobile app promoted healthier eating habits through a collaborative game where users posted and rated photos of their meals. By using gamification elements such as competition, leaderboards, and social interaction, the app motivated behaviour change and made the process of improving one's diet engaging and enjoyable. Similarly, the "Foodie Moodie" [107] serious mobile game was proposed to gather data from players reflecting the types of food they eat when they have a certain mood. Results from users indicated the app helped them adopt healthier eating habits in a more enjoyable manner.

Many individuals, including children, tend to eat unhealthily [42]. To encourage healthier eating habits, play was utilised in various forms, particularly through digital augmentation systems like "FoodWorks" [126]. This system motivated children to eat disliked vegetables by projecting colourful animations onto their plates, transforming the meal into a game. As children ate, they could earn virtual badges and rewards for consuming specific foods, making the experience both interactive and enjoyable. The findings suggested that this approach effectively shifted children's focus away from their food aversions, making mealtime more pleasant and promoting healthier eating habits. In a similar matter, some systems address chewing to enhance the eating experience. The "Food Practice Shooter" [217] integrated eating and chewing into a first-person shooter game. In this game, players had to consume certain foods, such as vegetables they initially disliked, to reload their weapons and defeat

monsters. The game introduced fun mechanics, like counting chews to determine the number of bullets or smiles to charge the weapon. This system successfully led 90% of participants, who initially disliked certain foods, to consume them during the game. However, this may have been driven by the game's mechanics rather than true preference change, raising doubts about the lasting impact on their eating habits. Likewise, "Feed the Food Monster" [26], a two-player AR game, was designed to promote proper chewing habits by turning the act of chewing into a playful and engaging experience. The game simulated the digestive process through an interface where players fed virtual monsters by chewing food correctly, with promising results in making mindful eating enjoyable in a social dining setting. The key finding of the study was that the game effectively improved proper chewing.

Few systems have been developed to boost motivation for exercise and physical activity. One of these is"EdiblePlus" [192], which transforms physical activity data into 3D printed chocolate treats, thus allowing the authors to explore how this playful and edible representation of exercise data can enhance self-monitoring and motivate an active lifestyle. Field tests with participants revealed that these chocolate treats were well-received, fostering positivity, reflection, and motivation towards physical activity, despite initial concerns about using chocolate in a fitness context. "TastyBeats" [255] used heart rate data from physical activity to create a personalised sports drink, which users could consume. Participants enjoyed watching the colourful drinks being mixed based on their heart rate data, which made the activity feel like a fun, rewarding event rather than just a routine task. The system was shown to increase awareness and motivation for physical activity, while encouraging playful social interactions, such as friendly competition to see who could create the most impressive drink.

Other systems used playful, interactive designs to subtly influence user behaviour and promote mindful habits through social interactions and technology-enhanced everyday objects. "SWAN" [196], an augmented spoon, integrated playful, interactive behaviour into cutlery design to promote mindful eating in the presence of screen-based distractions. This system's effectiveness stemmed from its playful responses, such as tilting, dropping food, or refusing to serve when the user was too focused on a screen. The system was evaluated through design iterations and initial user trials, where the authors observed SWAN's ability to engage users and redirect their attention from screens to their meals. A different example, "Grumpy Bin" [9], a smart food waste container was designed for student housing to encour-

age reduced food waste through playful social interactions and peer accountability. Unlike traditional approaches, it used social dynamics and humour to foster behaviour change by allowing household members to collectively judge and respond to each other's waste habits, leveraging social media for added impact. The authors found that leveraging playful social interactions and peer accountability, such as public exposure on social media, encourages more sustainable food waste behaviours in student housing.

2.6 Towards digital immersive commensality

The integration of technology into food experiences is becoming increasingly widespread, opening exciting opportunities within HFI. For example, HFI can develop systems for online meal sharing [29] or design artificial commensal companions for individuals who dine alone, which not only addresses social isolation but also highlights the possibilities for personalisation and adaptability in virtual interactions [233]. The phenomenon of Mukbang, where people watch others eat online [71], demonstrates how virtual experiences can foster a sense of togetherness while also revealing the potential to create shared emotional and cultural experiences in digital contexts, even when physically apart. Similarly, sharing meals through video-conferencing platforms can replicate the social benefits of face-to-face dining, reinforcing the idea that commensality enriches social interactions and reduces feelings of isolation [60].

Current HFI systems, such as remote dining setups, mukbang, and artificial companions, are predominantly screen-based, resulting in relatively limited possibilities for interaction. While these platforms have advanced technology-mediated commensality, their focus remains primarily on visual and auditory modalities, neglecting the rich multisensory engagement that characterises traditional communal dining. This reflects a broader trend in digital systems, where the emphasis on visual and auditory modalities often comes at the expense of more holistic, multisensory engagement. Various authors have demonstrated the benefits of integrating multisensory experiences into technology-mediated interactions.

Among them, George Ghinea's work on multimedia quality of perception has been particularly influential. Ghinea and colleagues argue that the integration of multiple sensory

channels enhances user experiences by improving immersion, satisfaction, and engagement in digital environments [82, 83, 131–133]. Their research shows that multisensory systems – those that incorporate modalities such as smell, wind, and touch – can evoke stronger emotional responses, improve memory retention, and the perception of quality [8, 232, 250, 329]. Ghinea's work emphasises the interplay between sensory input and user perception, demonstrating that even subtle multisensory cues can significantly impact how users interpret and interact with digital content. This is particularly relevant for HFI systems, where the sensory aspects of taste and smell are deeply tied to emotional and social experiences.

Complementing Ghinea's insights, Velasco et al. have extensively explored the role of multisensory design in shaping user experience, particularly in food-related contexts. Velasco and colleagues argue that sensory inputs – such as visual presentations, auditory cues, and olfactory stimuli – play a pivotal role in shaping perceptions of food and drink, as well as influencing social dynamics in dining scenarios [369–371, 373, 374]. Their work demonstrates how even minor adjustments in sensory design, such as altering the shape, colour, or texture of plates, or the background music during meals, can evoke profound changes in how users experience and emotionally connect with food. For example, the colour or sound associated with food can influence taste perception and emotional responses, such as associating higher-pitched sounds with sweetness or warmer colours with richer flavours [28, 167, 272, 386, 405]. These findings suggest that multisensory cues are not just peripheral but central to creating meaningful interactions in food-related systems, providing a nuanced understanding of how sensory inputs can shape perceptions, memories, and social dynamics during dining experiences.

Obrist et al. further extended the understanding of multisensory engagement by examining how technologies can be designed to evoke and enhance emotional experiences, particularly in digital environments. Obrist and colleagues emphasise the importance of "experience-centred design," which creates systems that align with users' sensory preferences and emotional goals [279]. Incorporating modalities such as touch, taste, and smell was proposed to lead to richer, more engaging interactions, transforming digital dining into a deeply immersive and emotionally resonant activity [273, 274, 276, 277]. Additionally, Obrist et al. [279] identified ten grand challenges in HFI, categorising them into technology, user, design, and ethics domains. Among these challenges are developing systems that can sense and synthesise food,

embedding interactivity into dining, and designing for the complexity of taste. A central focus of their work is enhancing interactivity to foster remote commensality, connecting diners across locations to enrich social and sensory eating experiences. This approach aims to address loneliness and create new opportunities for shared dining in digital contexts.

These findings underscore the limitations of current mediated commensality systems, such as Mukbang and video conferencing platforms, which primarily rely on passive, screen-based interactions [29, 60]. While these systems have successfully mediated remote dining to some extent, their focus on visual and auditory modalities neglects the immersive, multisensory richness that defines traditional communal dining. The social and sensory dimensions of dining – deeply rooted in shared rituals, emotional bonding, and a sense of co-presence – are often diluted in these existing systems.

Traditional concepts of commensality emphasise physical co-presence, where the act of eating together is not merely functional but a shared social and cultural ritual. While mediated commensality, such as dining via video calls, has attempted to replicate these dynamics, the integration of immersive technologies remains largely underexplored. Building on the principles of multisensory engagement, immersive technologies like VR and AR have the potential to go beyond replication, reimagining the social, cultural, and sensory dynamics of dining in virtual spaces. These technologies can deepen engagement by recreating shared environments, fostering emotional connections, and enabling sensory stimulation that mirrors or even enhances in-person dining experiences.

This thesis aims to address these gaps by investigating how immersive dining systems can be designed to create engaging, socially enriching experiences. The focus is on understanding how users behave within these setups, how they interact with immersive elements, and how these systems can foster meaningful connections. By examining natural user behaviours and preferences, this research identifies key opportunities and challenges in designing systems that are not only functional but also emotionally resonant and culturally adaptable. This approach allows for a deeper understanding of how immersive technologies can simulate key aspects of multisensory and social engagement found in in-person dining, while also creating novel experiences and scenarios that go beyond physical settings, offering new ways to explore food, strengthen emotional connections, and reimagine what shared meals can mean in virtual

environments.

This research takes an exploratory approach to uncover the principles and elements that define effective immersive dining systems. Through user-centred methodologies and inductive analysis, it seeks to identify recurring patterns of behaviour, sensory engagement, and social interaction in immersive dining contexts. The findings from this process culminate in the development of a conceptual framework for Digital Immersive Commensality. This framework emerges as a result of the research, encapsulating the design principles needed to create remote dining experiences that are multisensory, interactive, and socially meaningful. By grounding the framework in empirical insights, this thesis ensures that it is not only theoretically robust but also practically applicable for designers and researchers in HFI and immersive technology.

The overarching goal of this work is to inspire a new generation of remote dining systems that move beyond passive, screen-based interactions. These systems aim to replicate and enhance the shared rituals, emotional connections, and sensory richness of in-person meals, creating transformative experiences that bridge physical distances. By investigating the potential of immersive technologies to redefine remote commensality, this thesis contributes to the growing field of HFI and provides actionable insights for developing technologies that enrich our social and sensory connections with food and with each other. Ultimately, this research lays the foundation for a future where digital dining systems not only address the challenges of social isolation but also open up new possibilities for connection, creativity, and cultural exchange.

To support this vision, the transition from tele-dining to immersive dining is examined in more depth in Chapter 5 (Section 5.3.1). Although Chapter 2 offered a comprehensive review of literature on commensality and immersive technologies, that specific discussion was positioned later in the thesis to better contextualise the methodological rationale and the development of the immersive prototype evaluated in Study 3.

2.7 Summary

This literature review has explored the intricate connections between food, culture, technology, and human interaction, providing a foundation for the research presented in this

thesis. It began by examining the cultural and social significance of food, highlighting its role as a medium for identity construction, community bonding, and emotional wellbeing. The evolving role of kitchens as social spaces and their transformation through technological interventions underscored the potential of these environments to foster both tradition and innovation.

The chapter also analysed commensality, elucidating its importance in social cohesion and identity while acknowledging its erosion in contemporary lifestyles. Technological influences on commensality were critically reviewed, balancing the detrimental impacts of convenience-driven solitary dining with the opportunities offered by digital tools to reconnect people through shared meal experiences.

The emerging field of HFI was positioned as a vital area of research, exploring the integration of technology across food practices. Concepts such as remote commensality, Mukbang, and artificial companions illustrated diverse ways technology mediates dining experiences, while playful approaches demonstrated how interaction design can enhance engagement and social connection. Finally, the chapter introduced the potential of immersive technologies to transform digital commensality, emphasising the importance of multisensory and emotionally resonant designs. These insights set the stage for developing a framework for Digital Immersive Commensality, aimed at addressing the limitations of current systems and fostering meaningful connections in virtual dining contexts. Through this exploration, the chapter underscores the need for a balanced approach that integrates cultural, social, and sensory dimensions in designing future HFI systems.

Chapter 3: Towards Digital Immersive Commensality – Learning from Spontaneous Remote Dining Practices



Figure 3.1: How can we recreate meaningful shared dining experiences via video-mediated communication?

3.1 Overview

This chapter explores the concept of Digital Immersive Commensality (DICom) through analysing spontaneous remote dining practices. The chapter begins by highlighting the evolving nature of social dining, illustrating how commensality fosters emotional connection, well-being, and community. However, as modern lifestyles and technological shifts lead to social isolation, this chapter investigates how digital tools, particularly video-mediated communication enhanced with Augmented Reality (AR), support shared remote dining experiences. The study draws on data from remote dining sessions involving strangers and friends, capturing natural interactions and spontaneous behaviours. Through qualitative analysis, the chapter identifies six Digital Immersive Commensality Design Potentials (DICDPs), such as

narrative sharing, shared activities, multisensory engagement, and performative eating, that contribute to enhancing remote social dining. These findings inform the development of immersive dining systems that bridge physical distance.

3.2 Introduction

Commensality refers to the social interactions associated to the act of eating together [181]. Sharing a meal with someone was shown to foster positive emotions, to increase everyday happiness, well-being [229, 363], to strengthen the sense of community and togetherness, making people more engaged with each other [99, 230]. However, despite these beneficial outcomes of commensality, social dining practices are constantly changing because of busy lifestyles, more people living alone, increasing divorce rates and disruptive events such as being required to socially distance due to Covid-19 [109, 138, 156, 177, 407]. Thus, many of the single-person households may be missing out on the benefits of commensality and experience instead negative health consequences in terms of food consumption [357], depressed mood and loss of social connectivity, this leading to a decreased feeling of well-being [76, 356]. One possible solution to this challenge could be to enable remote commensality by making use of digital technologies that bridge social distance [249].

Previous research in HFI has explored ways to leverage technology to make eating-related activities more social and enjoyable [113, 254], as I discussed at length in Chapter 2. For instance, studies have proposed systems that create opportunities for shared dining experiences in remote settings considering different time zones [264, 364, 398, 399] or adopting a playful approach [208, 247, 389, 390, 393]. However, many of these systems focus on technical implementations rather than user-centred design, often neglecting the organic ways people interact and adapt to remote dining platforms. Significant gaps remain in understanding how individuals naturally and spontaneously engage during remote dining experiences, and how these behaviours can inspire the design of technologies that are not only functional but also meaningful and socially enriching.

To start understanding what is important to include in an immersive system, I took a step into that direction and looked at AR filters as a way of combining digital objects with the

real world. AR filters were shown to have benefits such as, a transformative role in enhancing interpersonal communication by fostering immersive and interactive experiences within users' physical environments [77]. For instance, AR messaging influences user behaviour and perception, revealing its potential to create expressive and engaging communication forms [223]. The integration of AR filters, in particular, has been found to impact user experiences through increasing originality, aesthetic appeal, and interactivity, thereby boosting overall enjoyment and engagement [118]. Furthermore, research indicates that AR filters not only enhance entertainment and self-expression but also contribute to easing social interactions, particularly for individuals experiencing social anxiety [411]. Javornik et al. [178], investigated the motivations behind AR face filter usage on social media and uncovered the broader implications for user well-being, self-perception, and social dynamics. Their research demonstrated AR's capacity to shape digital communication in increasingly personalised and immersive ways.

This chapter marks the initial exploration of Digital Immersive Commensality (DICom), a framework that reimagines mediated dining by focusing on immersion, interaction, and sensory richness. Building on the concept of enabling meaningful social connections through technology, this study takes a step toward immersive commensality by analysing AR-enhanced video conferencing tools and their impact on remote dining experiences. While traditional video-mediated tools provide basic visual and auditory connections, the addition of AR filters creates opportunities for a more interactive and engaging dining experience, moving closer to the immersive environments envisioned within the DICom framework.

The study aimed to inspire the design of remote dining experiences by documenting and analysing the spontaneous behaviours that emerge during such interactions. By focusing on natural and unprompted actions, it sought to uncover insights into how people engage, adapt, and connect in remote dining contexts. Specifically, it asked:

1. What kinds of behaviours do people naturally exhibit while sharing a meal remotely over video-conferencing platforms?

2. How can these spontaneous manifestations of engagement be harnessed as inspiration for designing DICom experiences?

These research questions seek to understand the experiential dynamics and sensory richness that enable meaningful and immersive remote dining experiences. To answer these questions, I began this study by documenting and analysing the spontaneous behaviours of strangers sharing meals online via video-conferencing tools. To enrich the scope of the research, I then collaborated with Eleonora Ceccaldi (a researcher from CasaPaganini - InfoMus, University of Genoa), who conducted a parallel study focusing on the behaviours of friends in similar remote dining contexts. This collaboration allowed us to combine our efforts and explore two complementary datasets: one capturing the dynamics of strangers and the other illustrating interactions among friends. By examining both datasets side by side, I was able to identify commonalities and recurring patterns in how people engage during remote dining experiences, regardless of their relationship with other participants. These insights revealed overlapping behaviours and engagement strategies, highlighting six design potentials for creating DICom experiences. These potentials demonstrate how immersive elements, such as AR filters, begin to bridge physical distances by fostering shared experiences and deeper connections. My list of Digital Immersive Commensality Design Potentials (DICDPs) has *generative* rather than *validative* value [128]. That is, they are not meant to offer a solid, comprehensive understanding of all the possible desirable forms of engagement within remote dining scenarios, or their potential impact on people's experience of digital immersive commensality; rather, they provide contextual, design-oriented inspiration for designers interested in developing technologies and experiences that enable meaningful ways of remote dining. As design-oriented intermediate-level knowledge [**lowgren2013annotated**], the DICDPs are transitional and incomplete, and their value lies in their contextual richness and their possibility to inspire HFI designers and help them understand real people's practices and desires. My work thus aligns with a longstanding tradition of design inspired approaches to HCI [122, 128]. This approach has been successfully used in other areas of HCI, in and beyond the scope of food practices, e.g., in the exploration of the playful potential of food culture and traditions [39], in playful drones research [294], in accessible technology design [100], or in urban technology innovation [18].

This research and its associated publications were led and coordinated by myself, involving two complementary research teams working on distinct datasets. Apart from my supervisors, all collaborators in this study were external researchers. The first team focused on

the strangers dataset and included myself, my supervisors, Dr. Alexandra Covaci and Dr. Jim Ang, as well as Dr. Ferran Altarriba Bertran, with whom I collaborated as an external expert in play design. My supervisors were actively involved in conducting interviews alongside me, and supported the study through continuous guidance and collaborative engagement in the coding and analysis phases. Dr. Altarriba Bertran contributed to the methodological framing by introducing and contextualising the Situated Play Design (SPD) approach, which shaped our interpretation of emergent playfulness and improvised behaviour during remote dining encounters. The second team, which focused on the friends dataset, involved Dr. Eleonora Ceccaldi and Dr. Maurizio Mancini, with whom I closely collaborated. Dr. Ceccaldi conducted a parallel investigation into similar remote dining contexts, while Dr. Mancini contributed to both data collection and analysis. Additional contributions to the analysis of the friends dataset were made by Prof. Gijs Huisman and Dr. Mailin Lemke. Each team independently conducted the initial rounds of coding and analysis on their respective datasets. As the lead researcher, I coordinated the analytical process and facilitated collaboration between both teams. Following multiple iterative cycles within each team, I led the integration of the two datasets for cross-comparison. This collaborative synthesis, guided by my direction, enabled the refinement of final codes and the co-development of higher-level themes that reflected shared patterns and insights across both studies.

3.3 Methodology

In this study, I present an exploration of DICDPs, with the aim of inspiring future design work in the space of digital immersive commensality. While the concept of Situated Play Design [14] originally focuses on identifying playful behaviours that emerge naturally in specific scenarios, I extend this approach to uncover other forms of meaningful engagement during digital immersive commensality experiences. These design potentials represent contextual behaviours and practices that emerge organically in remote dining settings, offering inspiration for designing technologies that are socio-emotionally productive and contextually meaningful.

Situated Play Design provides a valuable framework for identifying "play potentials" [14], defined as existing manifestations of playful engagement that emerge in day-to-day scenarios. This study builds on the core principles of this approach – grounding design in observed

behaviours and situational contexts – but expands its scope to include other types of experiential potentials that go beyond play. Specifically, DICDPs capture a broader range of user behaviours and interactions during digital commensality, including acts of cultural expression, ritual, and social bonding that contribute to meaningful dining experiences. By doing so, this study acknowledges that while playfulness is an important aspect of engagement, it is not the only dimension that can inspire impactful and contextually resonant designs.

This approach extends existing play theory constructs, such as "modes of play"[92], by demonstrating how similar principles of observation and contextual grounding can uncover non-playful but equally significant forms of engagement. Previous works in HCI have successfully adapted Situated Play Design to highlight potentials in areas such as HFI [14, 16, 67], drones [294], and accessible technology [100]. Inspired by this flexibility, the study positions DICDPs as a new conceptual contribution that broadens the applicability of the Situated Play Design framework to include diverse types of potentials beyond play.

By identifying and analysing these potentials, the study highlights specific opportunities for enriching the experiential and social texture of remote dining. These design potentials provide actionable insights for creating systems that foster meaningful, culturally resonant, and socially connected dining experiences in digital spaces.

3.3.1 Methodological rationale

The methodological foundation of this study is based on a qualitative, exploratory approach. This choice was driven by the research aim; to uncover how individuals experience and co-create social and sensory engagement during digitally mediated meals. Qualitative methods are especially well-suited for studying new or underexplored phenomena, as they allow researchers to observe and interpret behaviours in context, rather than reduce them to numerical representations. This was critical for capturing the subtle, embodied, and often unpredictable dynamics of digital immersive commensality. While standardised quantitative instruments such as Positive and Negative Affect Schedule (PANAS) [362] or the Inclusion of Other in the Self (IOS) scale [24] were considered, they were ultimately determined to be limiting for this study's goals. These tools limit responses to predefined constructs and lack the capacity to capture spontaneous, performative, and multisensory interactions. Additionally,

due to constraints in time and resources, a quantitative approach, requiring larger sample sizes, statistical power, and technical infrastructure was not feasible. In contrast, qualitative inquiry provided both the practical and conceptual means to generate rich, nuanced insights aligned with the study's exploratory aims and research questions.

Situated Play Design (SPD) [14] was applied as the guiding methodological framework for its unique capacity to reveal improvisational, playful, and situated behaviours within designed interactions. SPD was particularly well-suited to explore how participants engaged with each other and the dining setup in a co-constructed, socially meaningful manner. It is inherently design-oriented, focusing on observing and capturing spontaneous behaviours that can inspire future design interventions, making it especially relevant for uncovering Digital Immersive Commensality Design Potentials (DICDPs). Alternative frameworks such as Ethnography [148] and Research through Design (RtD) [122, 128] were considered but not selected. Ethnography, while valuable for exploring cultural practices, requires long-term immersion in natural settings, an approach incompatible with the structured remote dining sessions in this study. RtD, though widely used in Human-Computer Interaction (HCI), focuses on iterative prototyping and artefact development. However, during the COVID-19 lockdown period in which this study was conducted, I had no access to laboratory facilities or the resources required to develop a custom remote dining platform. As a result, I relied on readily available communication tools to conduct the sessions. Given this context, RtD was not a practical or methodological fit. SPD, influenced by the work of Dr. Ferran Altarriba Bertran [11, 14], whose studies share relevant thematic concerns, particularly around situated play and social interaction, offered a more suitable framework for analysing socially and sensorially rich spontaneous behaviours and for informing the development of the DICom design framework.

For analysis, inductive thematic analysis [50] was selected over other qualitative methods such as reflexive thematic analysis [48, 51] and ethnography. This decision was grounded in the collaborative nature of the research. Inductive thematic analysis enabled multiple researchers to engage in an iterative coding process, deriving themes directly from the data without imposing pre-existing theoretical frameworks. Reflexive thematic analysis, in contrast, places greater emphasis on the individual researcher's subjectivity and interpretive authority, which was less compatible with the team-based approach used here. Additionally, inductive analysis

allowed for separate coding across two distinct datasets (friends and strangers), followed by cross-comparison and integration into shared thematic categories. Ethnographic analysis was also considered but ultimately set aside due to its focus on long-term cultural immersion, which did not align with the structured and temporally bounded nature of the sessions. The use of inductive thematic analysis supported the emergence of the DICDPs, ensuring that the findings were grounded in participants' actual experiences and remained relevant to the research aims.

Overall, each methodological choice in this study was carefully made to best address the central research questions. The qualitative approach provided the necessary interpretive depth; SPD offered a contextually grounded framework for exploring playful and social engagement; and inductive thematic analysis facilitated a rigorous yet flexible analytical process. These decisions together ensured that the study's findings were both empirically grounded and theoretically meaningful, contributing directly to the formulation of the DICom framework and advancing knowledge in the area of digital immersive commensality.

3.3.2 Ethics

Strangers dataset: Participants were fully informed about the objective of the study and signed the written informed consent. The study protocol was approved by the Faculty of Sciences Research Ethics Advisory Group at the University of Kent (ref: 0891920).

Friends dataset: This study was conducted in accordance with the ethical standards applicable in Italy, where formal ethics approval is not mandatory for this type of research. Prior to participation, all participants were thoroughly informed about the purpose of the study and the details of the recording protocol. Participants were also explicitly made aware of their right to withdraw from the study at any time without any consequences. Informed consent was obtained from all participants through the completion of a consent form, ensuring that their participation was entirely voluntary and based on a clear understanding of the study's procedures and objectives.

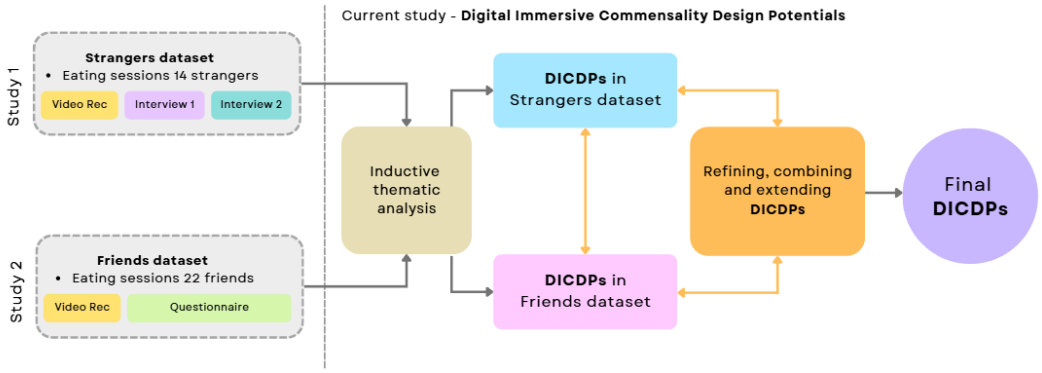


Figure 3.2: For this study, I used datasets from studies focused on friends and strangers eating remotely - (*strangers dataset* and *friends dataset*). The *strangers dataset* consisted of: 1) analyses of the 28 video recordings of the sessions; 2) one post-eating sessions interview looking into how the act of digital immersive commensality was perceived; 3) one post-video analysis interview focused on the DICDPs observed during digital mealtimes. The *friends dataset* consisted of: 1) analyses of video recorded interactions; 2) responses to the digital commensality questionnaire [60]. I used inductive thematic analysis [50] to find DICDPs from both datasets and then I performed two rounds of refining our themes. Once I settled on a final set of codes, we analysed all the data accordingly.

3.3.3 Data sources

I looked at datasets from two digital commensality studies conducted during the Covid-19 lockdown by the research team, which I present below and illustrate in Figure 3.2.

3.3.3.1 Strangers dataset

The first study looked at remote dinning for people in single households with the aim of developing an in-depth understanding of the social dynamics in these digital setups. For this study, I involved 14 solo living participants (10 females and 4 males, aged 18-32 years old, three Europeans, and 11 Middle Eastern), who did not know each other prior to the study.

Participants were randomly assigned to two one-to-one remote eating sessions on Facebook Messenger Rooms - a video chat platform with AR abilities, 360-degree backgrounds and no time limit on calls. I instructed them to eat during the sessions; no other instructions were given related to how they should interact. Remote dinners were recorded, and at the end of both sessions me and another researcher carried out two semi-structured interviews - one interview investigated how digital commensality was perceived by participants, and the other looked into the design potentials we observed during the meals. Some examples of questions

ID	Nationality	Age range	Gender
S1	Syria	18-24	F
S2	Bahrain	18-24	F
S3	Bahrain	25-34	F
S4	Cyprus	18-24	F
S5	Bahrain	25-34	F
S6	Austria	18-24	F
S7	Bahrain	25-34	F
S8	Bahrain	18-24	M
S9	Bahrain	25-34	F
S10	Bahrain	25-34	F
S11	UK	25-34	F
S12	Bahrain	25-34	M
S13	Bahrain	25-34	M
S14	Saudi Arabia	25-34	M

Table 3.1: The participants from the strangers dataset.

asked during the first semi-structured interviews are: 1) Please tell us your general impression of your remote eating experience. How have you felt during the session? Was there something that stood out?; 2) How are you usually having lunch or dinner? Alone/with someone else? With/without technology? 3) How is today's experience different from your usual meals? How is today's experience different from the times you share meals with others in the same space? 4) How would you compare the benefits of eating remotely with the benefits as eating with someone in person?; 5) How did the digital technology influence the social aspects of dinning?

The second semi-structured interview centred around the design potentials consisted of questions such as: 1) We observed you engaged in X type of behaviour (here we described briefly the behaviour the person was involved in). Did this type of play have any impact on your gastronomic experience?; 2) Could you think of other types of play you might find appealing in the context of these remote dinners? 3) Do you remember any past dining experience where you had fun? Why did you enjoy it? Do you think some of these elements can be brought in a remote dining experience to make it more enjoyable?, etc. All interviews in

the *(strangers dataset)* were transcribed verbatim by me and another researcher and then corrected by hand against the original recordings. The video recordings of the remote eating sessions were analysed for verbal and non-verbal behaviours and transcribed. Together with a team of two researchers, I coded and classified the information into themes to answer the research questions. We occasionally use quotes from the transcribed interviews and images from the videos when needed to provide context and illustration of the findings.

3.3.3.2 Friends dataset

The second study aimed at investigating participants' behaviour and opinions on remote commensality through video chat. For this, we asked 22 volunteers (11 pairs of friends) to join a Zoom call and to eat pasta in one remote eating session while they were being recorded. 12 were females and 10 males. Out of 22 participants, 16 were between 18 and 24 years old, 3 between 25 and 29 and 3 were over 55, all European. Upon deciding to take part in the study, participants signed a consent form, agreeing to their video recordings being used for research purposed and to their anonymised or aggregated data being shared. Participants were instructed to talk and act freely without moving the camera. After the eating session, we asked them to fill in the digital commensality questionnaire [60] and to answer a set of open questions related to their experience. The video recordings of the remote eating sessions were analysed for verbal and non-verbal behaviours and transcribed. Initial codes were assigned based on our guiding research questions regarding 'remote commensality', 'technology', and 'connectedness'.

ID	Nationality	Age range	Gender
F1	Italy	18-24	F
F2	Italy	18-24	F
F3	Italy	25-34	F
F4	Italy	18-24	F
F5	Italy	18-24	M
F6	Italy	18-24	M
F7	Italy	18-24	M
F8	Italy	18-24	F
F9	Italy	18-24	M
F10	Italy	18-24	M
F11	Italy	25-34	F
F12	Italy	54-74	F
F13	Italy	18-24	M
F14	Italy	18-24	F
F15	Italy	18-24	F
F16	Italy	18-24	F
F17	Italy	25-34	M
F18	Italy	18-24	M
F19	Italy	54-74	M
F20	Italy	54-74	F
F21	Italy	18-24	M
F22	Italy	18-24	F

Table 3.2: The participants from the friends dataset.

3.3.4 Apparatus and setup

Facebook Messenger Rooms is a video conferencing feature introduced by Facebook to meet the surge in demand for virtual communication tools during the COVID-19 pandemic. Unlike many competing platforms, Messenger Rooms allows users to create virtual meeting spaces for video calls without time limits, and participants do not need a Facebook account to join, making it more accessible to a broader audience. This platform was used for the strangers dataset.

One of its distinguishing features is the integration of AR effects, which overlay digital visuals, such as filters or animations, onto participants' faces or environments in real-time. These playful and creative enhancements go beyond basic functionality, adding a layer of personalisation and interactivity. Messenger Rooms reflects a broader trend in digital communication: the integration of immersive and interactive technologies to simulate aspects of physical presence and sociability.

Zoom is a cloud-based video conferencing platform that enables real-time audio and video communication across geographically dispersed users. Commonly used for virtual meetings, webinars, and remote collaboration, Zoom supports synchronous interaction through features such as screen sharing, chat, breakout rooms, and virtual backgrounds. Currently, the platform does not natively offer AR features, it can support AR filters through third-party plugins and integrations (e.g., Snap Camera), allowing users to overlay playful or expressive visual effects during live sessions. This extensibility makes Zoom a flexible tool not only for professional communication but also for creative and social engagements.

It is important to acknowledge that video conferencing platforms such as Zoom and Facebook Messenger Room were not originally intended to support dining experiences. Their primary function is in professional or educational contexts, such as virtual meetings, webinars, and online collaboration. However, this study set out to explore how these platforms could be adapted to support shared eating experiences. The goal was to examine how users navigate, interpret, perceive, and perform the act of dining together within such digital environments, and how this mode of interaction may shape their engagement with both the food and the other person involved. By reimagining conventional communication tools for social and sen-

sory experiences, the study aimed to explore how the act of eating together could evolve within the constraints and creative possibilities of existing technologies in the future.

3.3.5 Data analysis procedure

To ensure consistency and rigour across the two datasets analysed in (friends and strangers), deliberate measures were taken to establish inter-researcher reliability. Although the datasets were originally collected and analysed by two separate research teams, we conducted multiple iterative rounds of collaborative discussion to review preliminary codes, reconcile divergent interpretations, and agree on a shared analytical framework. A common codebook was co-developed and refined to ensure thematic consistency and methodological alignment across both datasets. All researchers applied the same inductive thematic analysis procedure, which was documented and revisited at key milestones. This collaborative process was essential not only for analytical consistency but also for maintaining methodological coherence in the development of the DICom design potentials.

As the lead researcher, I was particularly aware of the risk of researcher bias, especially given the deep personal and academic investment in the topic. To reduce the influence of personal bias and enhance analytical objectivity, I worked closely with multiple collaborators throughout the analysis process (see Section 3.2). Their independent perspectives provided critical checks and balances that helped surface insights I might have otherwise overlooked or unintentionally framed. While it is challenging to eliminate bias entirely, this team-based approach allowed for more balanced interpretations and increased the trustworthiness of the findings. Furthermore, we acknowledged the limitations related to participant self-reporting, especially during post-session interviews where participants may have felt inclined to offer responses they believed would satisfy the researchers. To mitigate this, questions were phrased neutrally, and participants were reassured that honest, critical feedback was valued. Nevertheless, we remain mindful that the social nature of the sessions and the novelty of the topic may have influenced participants' responses. These limitations were considered during interpretation and integrated into our inductive approach to analysis.

Phase ID	Activity	Duratic	N(r)
1	Collect raw data (annotated video recordings, transcribed interviews, questionnaires) from both datasets with potential to reveal design potentials based on what participants naturally engaged in during their remote dinners.	2 days	2 r for each dataset
2	Analyse raw data from each of the two datasets by employing an interaction analysis approach [182] to identify spontaneous activities that were perceived as promising. Based on this, I identified initial recurring codes in each dataset.	10 days	2 r for each dataset
3	Identify common themes with design potential in the two datasets. For this, I analysed the codes identified for each dataset on a Miro[1] board. Using the Miro board, we conducted remote analysis over Zoom to find recurrent forms of behaviour – i.e., DICDPs that could inspire the design of more immersive dining experiences. I began by exposing myself to the data, i.e., I looked at the data on the Miro board to familiarise myself with the kinds of remote eating activity it contained. Then, in groups of two-to-three researchers distributed in different Zoom breakout rooms, we used an inductive thematic analysis approach [50] to explore in-depth a sample of the data and begin to identify recurrent forms of emergent behaviour. We divided the data among all groups so that all datasets were represented in the analysis; groups used the Miro board to document their findings. Then, groups reconvened in the main Zoom room to share their observations of playful activity. In that discussion, we began to identify common themes that could be used as early, tentative DICDPs.	2 hours	7 r

[1]For the unfamiliar reader, Miro is an online tool for collaborative visual mapping of concepts and ideas. It allows remote collaborative work on multimedia elements such as text, graphics, photos, or videos.

4	Revise initial themes based on the clustering of commonalities between data from both datasets through the lens of early findings.	7 days	2 r for each dataset
5	Identify final themes. We began by allowing the larger research team to share their revised lists of themes. We visualised the themes on the Miro board and allowed all participants to become familiar with them. Following, we worked on combining and extending them into a unified, comprehensive list of DICDPs. For this, according to our data sets, we clustered them into six higher-level categories of digital immersive commensality experiences people seemed to enjoy while sharing a meal remotely. Each of those DICDPs was concretised by a number of different ways in which it manifested in our data, i.e., specific things people did in order to live those higher-level experiences.	2 hours	7 r
6	Analyse interaction. We performed a thorough analysis of both datasets to identify inspirational examples of people's activity that served as best illustrations of the DICDPs in our list. We divided the **six potentials** into two pairs of researchers (three categories each), and when a first round was completed, we exchanged them. Based on this, we collected a set of examples for each theme from both datasets.	15 days	4 r
7	Finalise analysis. An additional pair of researchers who contributed to the first phases of the analysis consolidated the findings in a third-wave analysis round.	5 days	2 r

Table 3.3: Data analysis procedure. Here I describe in detail the stages of our analysis and their outcomes, their duration and the number of researchers N(r) that were involved in each phase.

Using the two datasets as a point of departure, we set out to explore the types of practices both friends and strangers engaged in when eating remotely. Our analysis was divided in

activities described in Table 3.3.

In the next section, I present the outcomes of our analysis: six types of experiences participants seem to enjoy while sharing a meal remotely, a set of concrete interactions they can do to access those experiences (i.e., DICDPs), and a collection of instances of real activity from our data sets that exemplify those potentials. I note here that thematic analysis used to analyse the datasets does not involve quantifying codes and themes as it is commonly done in qualitative analysis approaches such as content analysis. I report on codes and themes that I observed across the two data sets.

3.4 Results

Observing the participants' spontaneous activity while sharing meals online revealed compelling ways people engaged with the affordances of remote dining, especially in the strangers dataset through AR-enhanced Facebook Messenger Rooms. To inspire designers and illustrate how these affordances can serve as design material, I ground the six identified design potentials (see Table 3.4) in concrete examples of participants' interactions with and around food. Each subsection below details how these potentials manifested within the dataset.

Among the emergent behaviours observed in this study, **performativity** played a central role. Participants frequently engaged in playful, imaginative actions, such as impersonating characters, mimicking accents, exaggerating gestures, or using props and digital filters, to animate their interactions. These behaviours, often accompanied by vocal expressions like "yummy" or "mmm," went beyond entertainment, functioning as powerful expressions of individuality, fostering emotional connection, and shaping social dynamics within the constraints of digital environments. This performative dimension was not isolated but appeared consistently across the data and shaped several of the six Digital Immersive Commensality Design Potentials (DICDPs) identified through a careful analysis of participants' behaviours and interactions. These DICDPs capture recurring patterns that illustrate how people creatively engaged with one another and their food across digital platforms. Performativity, in particular, emerged as a unifying thread manifesting through norm-breaking behaviours (Section 3.4.4), creative customisations (Section 3.4.5), and exaggerated enactments of play-

fulness (Section 3.4.6). While discussed in more detail later, it is introduced here to signal its relevance in addressing Chapter-specific RQ1 (the spontaneous nature of remote commensal behaviours) and RQ2 (how such behaviours can inspire DICom design). As such, performativity provides a key interpretive lens through which this study understands social bonding and sensory engagement in digital immersive dining.

3.4.1 DICDP1 "The stories we tell" – Narratives as catalysts for connection

My study revealed five ways in which storytelling might enrich a digital commensality experience: (1) describing one's food and food preparation; (2) discussing personal non-food preferences; (3) gossiping; (4) using digital affordances to trigger or enhance storytelling; and (5) using non-digital means (e.g., gestures) to achieve a performative story augmentation.

The first type of interactions I observed revolved around participants using the meal as an opportunity to share stories. The digital environment in which the meals took place operated as a bridge, connecting co-diners and stimulating moments of social dialogue. I observed different ways in which participants engaged in storytelling, which I think have inherent design potential. First, all participants (both friends and strangers dyads - for the remaining of the study I will use ***S*** *to refer to participants in the strangers dataset and* ***F*** *for participants in the friends dataset*) talked about the food they had prepared and presented as an ice-breaker activity, commenting on the appearance of their food to make it look visually appealing for the other person, as well as commenting on its taste and anticipating the enjoyment of eating it. See one of these interactions in Figure 3.3. I note here that this type of remark was always followed by laughter, which signals participants manifesting a sense of playful intimacy.

Describing their respective meals and their preparation led to various playful situations (e.g., diners enjoyed laughing at each other's unsuccessful food preparation attempts). This is exemplified by a conversation between F17 and F18 where participants start laughing when F17 comments about their food "*[it's] good, I am eating like... glue!*". Other topics brought up around the (virtual) table were non food-related: participants discussed events, culture, suggested touristic places in their countries, and opened up about their struggles. Gossip was



Figure 3.3: Participants S1 and S2 showing and talking about their food as an 'ice-breaker' activity. This prompts discussions about their hobbies (i.e., watching animes).

also part of these conversations with co-diners sharing stories about friends, colleagues, teachers or politics. Figure 3.4 illustrates an episode where F1 reveals details about an upcoming date to F2; the atmosphere is relaxed and participants seem to be enjoying themselves.

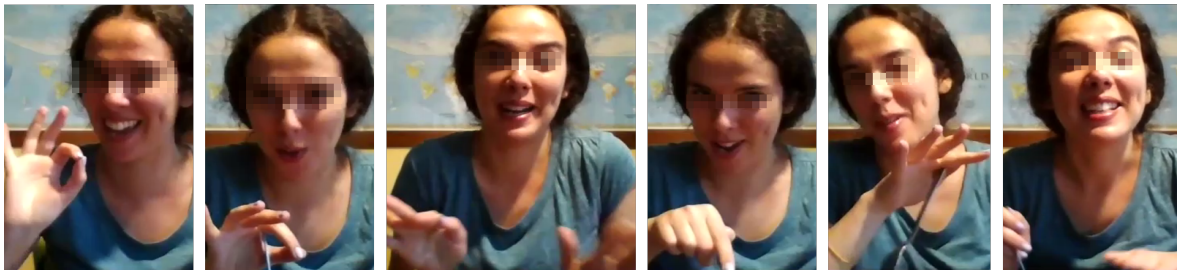


Figure 3.4: F2 telling F1 about her upcoming date using gestures to augment certain parts of her story.

In some instances, technology acted as a trigger for story-sharing. Participants leveraged the affordances of the digital interface to choose conversation subjects or augment their stories. For instance, while eating together S7 and S10 used different AR filters as a starting point for stories that became the social glue for their interaction – an AR filter with daisies reminded S10 about her favourite movie – *You've got mail* and this prompted a heated discussion with S7, who also liked the movie. The discussion continued with participants experimenting with other AR filters and sharing stories triggered by them (see Figure 3.5). When the available technology did not allow for certain desired effects, participants used gestures or objects in their proximity to support their discussion. Overall, participants found benefits resulting from their communication around the virtual table – "*well, this type of communication, after all... is agreeable, it seems that we are like eating in the same place*" (F21); "*Instead of facing the TV (while eating), I face a person.*" (F14).



Figure 3.5: Different AR filters prompted S7 and S10 to exchange various stories about their hobbies, holidays, favourite movies.

When asked about their opinion regarding the potential of digital technology to support remote dining experiences, many participants emphasised the importance of conversations and sharing stories: "*It would be nice to have something that organises our discussion and makes it more relevant to the food itself and common interests*" (S1); "*I think that a cool idea would be [..] having some AI that could suggest a topic based on our interests and the topics that we've talked about.*" (S12).

3.4.2 DICDP2 "Doing things together" – shared action as a platform for remote food-centric interaction

In my study, I observed that participants engaged in different activities that functioned not only as accessories to their meals, but also as an enhancer of their social connection with their co-dinner. Accordingly, they: (1) played games centred around their meal; (2) simulated physical touch and interaction; and (3) took selfies as reminders of the experience.

These digital commensality experiences were by no means all talk and no action. I observed that participants often engaged in different types of activities parallel to the eating act. Those were particularly playful when co-performed by both participants in a session. Some of these activities included participants engaging in guessing games (e.g., "guess my age"), singing Karaoke or playing with digital food *planning* activities - for example, F1 and F2 used their shared meal time to choose a mutual friend's birthday gift. Interestingly, I also observed both friends and strangers who took part in my study engaging in *physical* activities, where they tried to simulate an embodied experience by virtual interaction with their co-diner. For instance, when S3 offered S6 an anniversary digital cake, S6 blew the virtual candles on top

of it (see Figure 3.9c). Similarly, S1 used an AR filter that enabled her to simulate she is grilling burgers; she then pretended to taste them and to offer them to S2. When inquired about this behaviour in the interview, S1 mentioned "*Feeding someone else (virtually) creates this feeling that you are really with that person.*" Straightening this idea, F21 and F22 noted "*it is a pity that we do not have wine, otherwise we could make a toast!*"

Technology played once again an important part in the remote dinners, supporting different aspects of activities participants engaged in. Among the *digital* activities I observed in my study, the most popular ones include taking selfies together (i.e., to keep as memory of the eating sessions) or playing AR games. Three pairs of strangers spent 5-10 minutes experimenting with AR games. This enabled them to experience feelings of fun: "*this is funny, I look stupid *laughs**" (S5); "*Let's play the tennis game again, it's fun!*" (S14) – see Figure 3.6, where we illustrate some of these digital moments. These activities appeared to facilitate group creativity and collaboration, enhancing participants' abilities to socialise: "*Having this meal while communicating with people, made me feel some enjoyment because of the interaction tools. They helped us a lot to build [...] very good communication, it was funny and I had a good moment at that time*" (S14).



Figure 3.6: Participants in strangers dataset enjoyed being engaged in various AR games (i.e., playing tennis, singing to a virtual cat).

During the post-dinner interviews, participants in my study were enthused about the opportunities brought by digital commensality. They mentioned an interest in taking part in challenges and competitions centred around food (e.g., eating spicy/sour food, speaking while stuffing their mouth with food, eating faster or having a timer for describing their dish). Several participants specified they would like to have tools that allowed food rating: "*I work as a food blogger so I would like tools to rate the food by adding emojis, leave our reviews about*

restaurants." (S5), while others saw potential in co-creating something with their co-diner by engaging in drawing-based activities: "*We can do an activity together - like painting together the same drawing*" (S11); "*I would draw a word or something on his plate*" (S7).

3.4.3 DICDP3 "Eating and the senses": appropriating the digital medium multisensorially

Friends and strangers in my study created a shared sensory atmosphere enveloping the digital space, dominated predominantly by (1) customised combinations of visual, olfactory, gustatory, auditory, and touch cues. For example, participants (2) showed their meals to each other; (3) discussed ingredients of their meals; (4) indicated the texture of the food by touching and squashing it; (5) shared music; and (6) used interjections to describe the taste.

Throughout my study I observed that participants attempted to overcome the limitation of not being co-located by crafting their own multisensory experiences, where they could share visual, audio, verbal, olfactory and gustatory cues. Smell and taste were partially conveyed through visual cues as eating sessions usually started with co-diners pointing their cameras towards the food (see Figure 3.7 for illustration), with *both strangers and friends* displaying beautiful dishes, created with attention to plating. As well as verbal cues, expressions like "yummy," "so good," satisfied sounds such as "mmm," and playful whistling were commonly used to show delight, signalling that the food was delicious and hard to resist. These behaviours were observed across both the friends and strangers datasets, showing the shared desire to use verbal cues to compensate for the distance and to express the sensory enjoyment of the food.

Unsurprisingly, *smell, taste, and texture* turned out to be important components in the interactions initiated by participants who often detailed the ingredients of their meals: "*I made an Austrian meal. [...] It is with potatoes, mushrooms, and cheese.*" (S5); "*My dessert is with honey and cheese. It's delicious!*" (S6); "*I am eating gingerbread biscuits*" (S10); S7 showed her food (i.e., rice and fish) and exclaimed "*My room smells like fish!*". Directly or indirectly, *touch* was also involved in augmenting the digital eating experience, as participants used cutlery, ate with their hands, made funny gestures, played with food or tried to pass digital food to their co-diners. This did not only seem to influence the enjoyment of the



Figure 3.7: Participants attempt to create a shared multisensory space. They try to convey information about the food texture by squashing it in front of the camera, inform about the smell of their space by showing a fragrance candle or show their food to the camera.

food, but also enhanced the interaction between participants. Co-diners in my study used sounds from their interaction with food (e.g., crunching, smacking, exclaiming "yummy!") and music to influence their commensality experience. By employing different combinations of senses, participants maintained a multisensory social connection despite physical distance. Interestingly, all participants were unanimous in their desire to merge their digital multisensory spaces, imagining various scenarios that could enable this. Sharing the same food – by cooking the same recipes, or benefiting from *sensory kits* (i.e., boxes with food, candles, table accessories that can be delivered to co-diners), which can be thematic or mysterious, thus inviting participants to be playful during the discovery act – was a popular idea throughout the study. Other scenarios involved more sophisticated uses of technologies for augmenting the eating experience – for example sharing digitally the taste and smell of the meal (F5, F15, F16), sharing a playlist that can prompt people eating together to guess a song or to perform Karaoke, sharing and interacting in a virtual environment, using robotic arms and sensors/actuators to turn remote eating into a more tactile experience (F15) or using a 3D food scanner. Designing visually appealing interactions around commensality was highlighted in post-eating sessions by both strangers – who expressed interests in using AR filters for enhancing the appearance of food – and friends "*To ensure a greater illusion of being together, it might be interesting to have the opportunity to visualise (for example from above) what my friend is eating*" (F18).

3.4.4 DICDP4 Disrupting (old) social norms

Conventional norms around mealtime were challenged during the remote eating sessions, with participants: (1) making loud gustatory sounds; (2) eating in an exaggerated manner; (3) crafting unconventional eating spaces; (4) wearing informal clothes (e.g., pyjamas).

Unlike shared meals with a more rigid structure (e.g., banquets, dinner parties), my study provided the context of a fluid social form that was maintained, shifted or changed by participants through their interactions and appearance. My observations indicate that digital commensality provided participants with an opportunity to challenge the cultural norms around eating and to engage in a ludic – rather than etiquette – embodiment of table manners. Participants used a variety of "norm-breaking" strategies to "break the ice", make their co-diners laugh, and re-start the conversation after moments of silence (e.g., slurping noodles, eating the sauce that remains on the plate after finishing the meal). This happened *in both data sets*, independent of the level of familiarity between the participants and shows that the digital space contributes to a shift in social norms. These disruptions often carried a performative quality, slurping loudly, eating with hands, or gesturing playfully toward the camera were not only breaches of dining etiquette but also intentional acts that invited engagement and humour. Participants used these moments to exaggerate behaviour and elicit reactions, showing an awareness of being "watched" and of performing for a remote co-eater.



Figure 3.8: Participants disrupting commensal social norms by slurping, playing, eating with their hands, sharing their workspace.

I remarked that participants in both stranger and friend dyads took a playful and casual approach for their self representation that does not necessarily fit with norms around traditional commensality: "*I feel more relaxed if I am virtually meeting with someone because if you are going to go out with someone, it is all the hassle that you have to dress up something nice, you have to look nice because you will not be alone with this guy. So this starts to build up*

and you will start to feel stressed and not feeling relaxed." (S12) This state of comfort became the staging for greater intimacy among co-diners. This intimacy was further supported by the fact that during the sessions participants selected non-normative locations to have their dinner (e.g, bedroom, home office, the interior of a car), into public commensal settings, thus enabling a greater degree of flexibility about the formal norms of hospitality. Co-diners became guests and hosts at the same time, and the requirements about bodily control, manners and regulated appetites faded. For example, the dinner between S7 and S8 (illustrated in Figure 3.8) depicts a scenario where the two participants choose an informal setting, did not pay particular attention to the table arrangement, slurped their noodles loudly, ate with their hands and used funny AR filters.

3.4.5 DICDP5 Customise everything – Customising the digital medium and the self for an enhanced eating experience

Throughout the study, participants engaged or expressed an interest in experimenting with the customisation of various aspects of their eating experience such as their environments, appearance or celebrations. My study shows the importance of an "artful" uniqueness embedded in social interactions around food, where participants applied and envisaged various customisation strategies in various celebratory scenarios, such as customising (1) their self-representation; (2) the physical settings where commensality happens and the framing of the shots; (3) the digital medium for celebratory events that create moments of uniqueness and connectedness.

Many of these customisations were performative in nature for example, wearing digital accessories, changing backgrounds, or using filters to impersonate celebrities or animals. These expressive choices allowed participants to creatively shape how they appeared and were perceived by others. This performativity blurred the line between digital play and dining, enhancing emotional presence and encouraging mutual engagement. To set the scene for the digital dinners, participants were observed *customising their physical locations and the framing of the shots.* By moving the camera to reveal different elements of their households (e.g., shelves, posters, pets) and by bringing objects into view of the camera (e.g., candle, chopsticks, vaccination certificates, etc.) to support their interaction, strangers and friends were

"inviting" their co-diner to their physical space, using technology to bridge their respective eating environments. I observed that when commensality happened in a personal space, it led to a form of *implicit* self-disclosure, where our participants revealed aspects of their lifestyle and personality, visually, through the streaming of their personal living space to their eating partner. Such self-disclosure, albeit not explicitly expressed, helped provide conversation intimacy and engaged participants in playful behaviour. When participants chose to reveal different elements from their households, their co-diners reacted with enthusiasm and in some cases, enacted interactions with these extended commensality spaces. One scenario to illustrate this is presented in Figure 3.9a, where S2 introduces her parrot to their co-diner, who starts talking to the bird as if they were in the same space.



(a) Customised physical locations – S7 waving to a parrot located in S2's environment



(b) Customised self-representations produced enjoyment and improved positive affect for S3 and S10



(c) Customised rituals

Figure 3.9: Co-creating a joyful eating experience through customisation

The use of AR made it easy for participants in the strangers dyads to *customise their appearance*. Participants showed varied preferences for the real-time camera filters, which allowed them to visually "reinvent" themselves through virtual dress-up. Overall, the creative effects enabled by AR technology were perceived as beneficial for overcoming social awkwardness and enhancing the overall experience "*They add a lot, they cover the face and enhance the appearance.*" (S2 and S9); "*They helped me feel more relaxed and less serious. It just felt they broke the ice more.*" (S1); "*They enable me to be anyone I want.*" (S7). An example scenario presented in Figure 3.9b illustrates S3 and S10 using AR filters that matched their outfits. In the post-session interview, S3 mentioned this interaction had a positive effect on her experience, serving as an important social function "[*My co-diner] commented on how the filter matched my clothes and it was nice.*"

Finally, I observed how effortlessly six of our participants used AR as a celebratory technology

and staged impromptu graduation celebrations, birthday parties with virtual cakes, happy birthday songs, and "blowing out" digital candles – see Figure 3.9c. This led to an increase of conversation intimacy and to a fast connection between the participants, mediated by the relaxed and informal atmosphere.

Participants showed interest in playing a more active and creative role in choosing how to present themselves to others. Some mentioned they would like to customise different aspects of existing AR filters by designing aesthetics that speak to them and reflect their culture. Interestingly, two strangers were also open to allow others to alter their appearance as exemplified by a quote of S12: "*you can give control to the other participants to apply filters to you. And you will be surprised with what they choose for you. Right? So it's good to start interesting, humorous kind of conversations*". Participants' comments highlight that digital immersive commensality afforded through AR filters is likely to have a high hedonic connotation, commanding a playful, enjoyable experience. All strangers and most friends expressed an interest in further enhancing the sense of co-presence and co-awareness during remote commensality by using technology to simulate co-location: "*Maybe we can choose to be in the same place, sharing. Maybe being in a boat, maybe sitting in a place and viewing a nice scenery, maybe at the beach, maybe inside the car.*" (S11). Other suggested to tie such environments to the food being eaten: "*I would like having different digital rooms [...] divided by the type of dish or the cuisine we are going to eat*" (S2); "*For example, I have decided to eat Italian food. So I will choose someone for example, from Italy to eat with, at the same time, I would like to have background of Venice, and wearing Italian hats and maybe even having Italian music in the background.*" (S1). To meaningfully join and celebrate a variety of events, the richness of customisation options was a popular request: "*In the future we will celebrate virtually especially when we can't get everyone in the birthday. It would be very nice to use customised filters for all kind of parties, like baby showers or weddings.*"(S5); "*If you have a birthday, you can have a special dinner with the person and with some of the pictures, memories, maybe some videos, because it's much easier to dine virtually*" (S13). Moreover, participants showed interests in attending other types of celebratory events (e.g., releasing a movie, watching live sport events) in the remote digital setup and spoke with enthusiasm about the possibility of recreating movie sets and choose how their food should be visualised by their co-diner: "*even the food could be inspired from the movie - get me food that looks*

like the butterbeer from Harry Potter".



(a) S1, S2, S13, S14 perform with AR food (b) S2, S9 and S4 stepping into various characters

Figure 3.10: Performative interactions during digital commensality

3.4.6 DICDP6 Performative eating – How commensality is shaped through enactment

In my study, digital commensality supported uni- and bidirectional on-camera performances in various ways: (1) impersonating characters; (2) interacting with digital props; (3) imagining events; and (4) engaging in creative activities.

The practice of eating together while apart inspired *both strangers and friends* to co-construct involvement through performing. In our datasets, this performance happened mostly bidirectionally – often participants leveraged the digital space to perform for each other and used technology to step into various characters or to illustrate situations while eating. For example, S9 and S2 played the roles of an Italian chef, a cat and Elvis Presley as illustrated in Figure 3.10b. Although the platform used by friends in our study did not have AR features, performing was present as one of the commensal activities. For instance when F9 and F10 started playing an imaginary game where they pretended to be in the fanciest restaurant in the world where they meet their favourite chef. They jokingly argued on which area of the world has the best food and therefore, where the best restaurant would be. These playful performances were further supported by a range of expressive behaviours, such as gesturing toward the camera, changing voice tones (e.g., mimicking the deep voice of Elvis Presley), and using exaggerated facial expressions to create shared moments of humour and emotional connection. Vocal cues like adopting an Italian or Memphis accent, combing the AR hair like Elvis Presley, or laughing loudly were common and often intentionally amplified. Far from being incidental, these behaviours functioned as mechanisms of co-presence and bonding, helping participants co-construct a socially rich eating experience.

Participants further engaged in performances, using digital content as physical props. In the context of the eating sessions, co-diners interacted with digital models of food (e.g., grilling and eating digital burgers - see Figure 3.10a left), performing for digital pets resting on their heads, eating and throwing digital food from one to another - Figure 3.10a right. Changing the background during the conversation, helped one of the participants convey more vividly information about her future plans - when S7 asked S10 about her post-pandemic plans, she chose a beach background and started pretending she was enjoying the sun. Interestingly, digital immersive commensality created a space where co-diners can perform, where food becomes secondary, serving more as a prop, together with the digital content provided by AR.

The option of being able to engage in improvised performance while eating was often mentioned as a plus by strangers in our study. Participants repeatedly expressed interest in having the possibility to alter their voice to impersonate a character (e.g., the Queen of the United Kingdom) or to have access to a variety of digital props and backgrounds.

3.5 Discussion

3.5.1 A situated design approach to digital immersive commensality

Existing research in food-technology design suggests that, in ordinary life practices (such as eating together with others), technology should build on existing experiences that are contextually grounded, rather than introduce new, superfluous experiences [253]. Existing works in HFI have begun to investigate those kinds of contextual, bottom-up forms of experiences, for example, Altarriba Bertran et al.'s extraction of play potentials from food culture and traditions [39]. Here I contribute to this growing body of works with an exploration targeting the specific scenario of remote eating, with the aim of opening up exciting opportunities for designing meaningful interventions in this space.

The spontaneous practices I observed in my study (summarised in Table 3.4) illustrate ways in which people are able to find joy in remote eating. Consequently, I argue that my list of DICDPs can inspire the design of digital immersive commensality services and experiences

Table 3.4: Summary of the DICDPs observed during my study of people's digital immersive commensality practices, including: the list of six potentials (left); a short description of their main qualities (centre); and a set of ways in which each of the DICDPs manifested in our datasets (right).

DICDPs	Description	Manifestations
The stories we tell	Narrative interactions in digital commensality dinnertime conversations	(1) describing one's food preparation; (2) discussing non-food personal preferences; (3) gossiping; (4) using digital affordances to enhance storytelling; (5) using non-digital means (e.g., gestures) to achieve a performative story augmentation
Doing things together	Activities performed collectively, parallel to the eating act	(1) playing games prompted or not by technology; (2) simulating physical touch; (3) taking selfies as a reminder of the experience
Eating and the senses	Digital commensality - taste, smell and touch added	(1) customised combinations of visual, olfactory, gustatory, auditory, and touch cues; (2) showing meals; (3) describing ingredients; (4) indicating the texture of the food with non-digital means; (5) sharing music; (6) using verbal interjections to describe taste
Disrupting (old) social norms	Digital commensality as unconventional social form	(1) making loud gustatory sounds; (2) devouring in an exaggerated manner; (3) employing unconventional eating spaces; (4) displaying informal clothes (e.g., pyjamas); (5) playing while eating
Customise everything	Customisation of the digital persona and eating setting to enhance the festive dimension of a meal	(1) customising self-representation; (2) customising physical locations and framing of the shots; (3) customising celebratory meals and rituals
Performative eating	Where commensality meets enactment	(1) impersonating characters; (2) interacting with digital props; (3) imagining events; (4) engaging in creative activities

that cater to people's need for social interaction and enjoyment. Importantly, the six design potentials we are featuring here are contextually sensitive and inherently bottom-up – rather than being motivated by theory, they emerged from the unconstrained actions of a diverse pool of research participants. I see that as an important and necessary move in HFI, a move that will better reflect the messy, contextual nature of food practices [95]. Next, I address my research questions by reflecting on these findings.

Despite the generative, bottom-up, and contextual nature of my work, I have observed certain connections between our design potentials and phenomena that have previously been studied from a more validating angle [60]. For example, although physically impossible due to the digital technology mediation, participants still enacted food sharing practices (e.g.,

by "virtually" feeding each other). Such practices are indeed found to be a hallmark of commensality starting from a young age [147], and the sharing of food is associated with positive mood and well-being [229, 363]. Research also shows that eating together can make people more engaged with each other [99, 230], for example, by talking about the food that is being consumed or by reminiscing. These behaviours were readily apparent in our datasets and design potentials in this space revolved around, for example, joking about failed cooking attempts, or playful banter between friends.

Including such elements in digital commensality setups could benefit eating scenarios where people can be inclined to leave a good impression, for example, when eating with strangers [158, 318, 368]. My DICDPs highlight that in this process, even eating remotely helps to establish a common ground with strangers. Taken more broadly, commensality is typically described as a multi-dimensional concept that consists of interactional, symbolic, normative, and material dimensions [134, 181]. These dimensions were also observed in our datasets – for example, in using the remote commensality setting to break the norms around food or sharing food as well as non-food related stories. In addition to this, I observed elements that usually characterise the experience of Mukbang, such as showing the food, highlighting the multisensory food experience, disrupting the food-related norms, and inserting elements of storytelling [164]. Research on this form of quasi-commensal experience has demonstrated how this kind of interaction, although unidirectional, is capable of creating a sense of belonging. Eating in a performative way, as mukbangers do, creates the illusion of commensality, especially for people who live alone and long for a feeling of togetherness [22, 164].

3.5.2 How might our DICDPs inspire increasingly meaningful and enjoyable digital immersive commensality designs?

I suggest that the design potentials I observed in the context of digital commensality can be used as seeds to ideate technologies for remote eating (I provide a set of inspirational examples for this in Figure 3.11). With this, I point designers towards types of interactions that are likely to enable diners to find meaning and joy in the act of sharing a meal online.

According to my observations, a digital immersive commensality experience can leverage technology for storytelling and communication – for instance recommending topics for con-

versations based on what people tell each other, or on their facial expressions. Storytelling with the actual food could tie in to participants' desire for cultural sharing as well as their propensity for play. In these scenarios recognition of actual food or what is said during conversations does not need to be accurate since misinterpretations by the system could enhance playfulness (e.g., a system mis-recognising someone's simple food for a fancy dinner). Alternatively, simple story prompts such as those found in "conversation cards" could also help here. Playful elements (e.g., card games like *Dixit* or *Cards Against Humanity*) could help further enliven the food related storytelling.

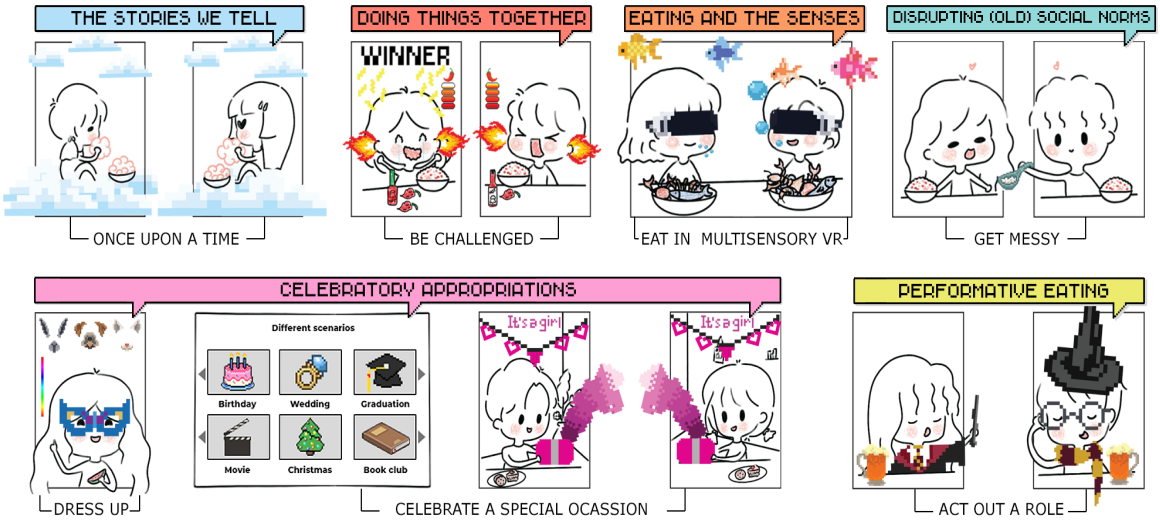


Figure 3.11: Visual summary of the six design potentials for digital immersive commensality I identified in my study. For each DCDP, I provide an inspirational example of how it may give rise to interesting, novel forms of digital immersive commensality experiences.

Remote commensality technology design could also take into account how doing things together enhances the eating experience by creating a sense of belonging and togetherness. Sharing activities might enable diners to perceive the physical distance reduced. This could be as simple as providing activities to be performed during the interaction or as complicated as allowing diners to prepare the food together through 3D printed ingredients. The "goal" of playing a game, for example, could already help people break the stigma of eating alone or give them a context and motivation to eat together with a stranger online. Research shows that people typically want to make a good impression when eating with strangers [158], but my observations show that playful behaviours still emerge and being playful can be a way to break the ice.

In addition to this, in our datasets, participants often pointed at the impossibility to share

touch and smell as the major downsides of their experiences *"I really wished it were possible to share the smell and taste of the food, to share our senses and feel as if we were in the same place. But that still feels impossible. Maybe, though, we could share a kit with the same aromas and ingredients"* (S10). Future designs may need to take these shortcomings into consideration, to provide novel multisensory digital commensality experiences which can be more immersive, for example by allowing co-diners to share smell or taste. HCI research projects have started to explore how to design for smell and taste by creating devices that can evoke specific sensory experiences [345] and allow one to share a flavour experience digitally [303]. Moreover, given that the sense of touch functions as a communication channel in the context of remote commensality, digital tactile devices - such as ultrasound haptic displays [330] or pneumo-actuated displays [414] - could further enable co-diners to express their emotions and, as a result, create a physical link and a sense of togetherness [209].

Interestingly, in my study, I observed how commensality can foster forms of interaction that do not seem to follow the same culture-specific etiquette of physical commensality. I believe that future technologies might tap into this to create cross-cultural interactive experiences, leveraging the possibility of technology to bring people from all over the world together. Another key aspect that, in my understanding, can enable rich commensal experiences is customisation. People, in my study, seemed to value creating their own commensal experience and to appreciate the customisation possibilities afforded by the technology. The participants often reported how simply creating the illusion of being in the same room, for instance through AR, might help them feel as actually together and, hence, improve their commensal experience. Lastly, the interactions hereby described point towards a link between commensality and the possibility to perform, to the point of food being a mere prop in the performance. A technology that affords engaging in a fun performance is, I believe, a technology that fully exploits the potential of a digital commensal experience.

In a world where solo dining is increasingly common, future technologies could not only provide digital immersive commensality experiences that ease the feeling of loneliness, but could also pave the way towards new forms of engaging, fun and playful interactions around the (virtual) dining table. However, foreseeing the future of the technology-commensality relationship is far from easy. First and foremost, should remote eating technologies be designed *adhoc*, with the aim of supporting commensality, or should they be an improvement

of technologies that already exist, to become more "commensality-friendly"? Video-chat applications, such as Skype, Zoom or Meet, (i.e., the ones we exploited in our study) were not designed to be used specifically for remote dining and will probably still be used for their main purpose of making video-calls. Moreover, with future technologies designers will have to face the challenge of understanding whether digital immersive commensality should point towards replicating offline commensality, for example, providing multisensory experiences, creating the illusion of co-presence, or whether they should have different goals and be aimed at providing totally new experiences and new ways of (virtually) being together. Can technology design ultimately provide artificial commensal companions? Can it create new food experiences that do not yet exist? Only time will tell what future remote eating technologies will look like. Nonetheless, I hope the inherent design potentials for digital immersive commensality I observed in our datasets and illustrated in this study can inspire designers to start exploring them.

3.6 Summary

In this study, I presented a design-oriented exploration of the potential for Digital Immersive Commensality (DICom), a concept that remains largely underexplored in current technological systems. While traditional digital dining platforms primarily facilitate remote connections, they often lack the immersive and expressive elements that could make these experiences more engaging and socially meaningful. Recognising this gap, I investigated how incorporating immersive features might enrich these systems by offering new opportunities for social interaction and emotional engagement around food.

By analysing the behaviours of 36 participants who shared dining in remote, screen-based scenarios some enhanced with AR filters, I identified key design potentials that can inform the development of future DICom systems. Notably, the theme of performativity emerged as a central theme in understanding how participants co-constructed their remote dining experiences. It illuminated how spontaneous and creative behaviours, such as storytelling, impersonations, exaggerated gestures, and vocal expressions like "mmm". "yummy" or playful whistling, were used to compensate for the lack of physical co-presence. These performative acts helped participants enhance their emotional connection with others and their sensory

engagement with the food.

This theme directly addresses the thesis (RQ1) by illustrating how social interactions unfolded in DICom settings, particularly through playful and expressive behaviours that fostered meaningful interpersonal connections. It also informs the thesis (RQ2) by showing how these expressions influenced participants' sensory and emotional experiences of food, thus enhancing the overall quality of the remote dining interaction. Furthermore, performativity provides clear answers to the chapter-specific 1 and 2 questions by revealing the kinds of behaviours participants naturally exhibited while sharing meals remotely and by highlighting how such spontaneous manifestations of engagement can inspire the design of more interactive, playful, and emotionally resonant DICom experiences.

Ultimately, this work lays a foundation for reimagining commensality in immersive contexts. By incorporating social, performative, and multisensory dimensions into remote dining experiences, future DICom systems can go beyond conventional remote eating platforms and enable more engaging, dynamic, and socially meaningful digital commensality.

Chapter 4: No Pie in the (Digital) Sky: Co-Imagining the Food Metaverse



Figure 4.1: How can we shape our relationship with food in the metaverse in a meaningful way?

4.1 Overview

Building on the exploration of design potentials for Digital Immersive Commensality (DICom) in Chapter 3, this chapter shifts focus to a broader investigation of how immersive technologies might transform our relationship with food. While the previous chapter concentrated on understanding the natural interactions of users in digital commensality scenarios, here, the aim is to expand the scope and explore the foundational elements that underpin meaningful food interactions in immersive contexts.

Through a co-design approach, this study engaged participants in six workshops designed to uncover what people value most in their food-related experiences. The outcomes were synthesised into a speculative catalogue of novel food interactions, combining imaginative and practical ideas to inspire innovation in the design of immersive dining systems. These

ideas were further refined through feedback from experts and non-experts, offering critical insights into the features and building blocks essential for designing future DICom systems.

4.2 Introduction

The term metaverse was initially introduced by science fiction writer Neal Stephenson in his 1992 novel Snow Crash [413], where it described an immersive, computer-generated virtual world. Although the concept has since evolved, no universally accepted academic definition currently exists. In the context of this thesis, the metaverse is understood as a constellation of digitally mediated spaces that incorporate immersive technologies such as virtual, augmented, and extended reality (VR, AR, XR) to facilitate shared experiences that blur the boundaries between physical and virtual realms. These experiences are not exclusively avatar-based; rather, presence and connection may emerge through multisensory interactions, shared rituals, and embodied co-participation within dynamic digital environments.

Within the scope of this research, I frame the food metaverse as a human-centred, speculative space designed to support meaningful, joyful, and culturally rich food-related practices. Rather than focusing on gamified or overly commercial applications, this vision emphasises connection, co-presence, and sensorial engagement. It advocates for rethinking digital dining as an opportunity to foster community, food literacy, and sensory reconnection.

Recently, interest in the idea of metaverse has leapt. However, the metaverse is not totally a new concept. Following the previous three major technological innovation waves (i.e., the introduction of personal computers, internet and mobile devices), the metaverse bridges the connectivity of social media with the unique affordances of existent spatial immersive technologies [260] such as Virtual, Augmented and eXtended Reality (VR/AR/XR) and promises to develop as an *interconnected, shared and limitless persistent world* where our physical and digital lives converge. Although still fuzzy, this perspective seems to fit our continuously evolving habits, which outgrow the bounds of the internet as it was first created. People are now used to customising avatars or virtual homes, to foster virtual relationships, to meet friends in virtual spaces or to collaborate in holographic work meetings. The increasing appeal of replicating physical daily habits into the virtual realm is supported by data reported

by the Wunderman Thomson agency [406], which indicates that 74% of people consider that metaverse is the future and 1 in 2 respondents see it as a part of their daily life. While the virtualisation of certain daily activities (e.g., employment and work, entertainment, retail) is easier to foresee, more *sensory* and *intimate* habits – such as eating – appear at first glance to have little in common with the digital realms.

However, this apparently unlikely pairing seems to go together like chocolate and chilli for food-brands and restaurants, who are all making moves within the metaverse, establishing a presence on platforms such as Roblox, Fortnite or Horizon Worlds [57, 120, 165, 312], ready to capitalise on the idea that eating is more than gustatory delight – it is, at heart, a social activity. Their approach is to build virtual versions of their physical restaurants, where users represented by avatars play, and earn benefits, unlock premium access or consumer loyalty in physical locations. In imagining and experimenting with food in the metaverse, I observe that most existent solutions are carving out space to recreate virtual eateries as gathering places for avatars, replicating what is already existent in social media. **The first steps into the food metaverse neglect the complex social and cultural systems in which food is embedded – they are fast and careless, just like *fast food*.** The risks associated with these approaches and with the massive adoption of these technologies cannot be underestimated – they could exacerbate existing issues in our relationship with our bodies and with the food. This could have an impact on further detaching us from our food lives, in a context where the acceleration in our lifestyles and in globalisation (in both geographical and digital sense) is already alienating us from food and damaging our relationship with our food practices – bodily, socially, culturally, and environmentally [124, 161, 378]. The metaverse could add to these problems by increasing the disconnect from the real world, impacting body dysmorphia or exacerbating eating disorders, to name just a few. **Now**, that the metaverse is at a nascent stage, **an opportunity emerges to understand and rethink how technologies could intervene in our food lives, and to get people together to reflect on and imagine if and how our experiences with food can be meaningfully translated or enhanced in the metaverse**.

Here, I focus on the potential positive aspects of the metaverse and I start a process (that should remain ongoing), where I do not design for communities, but **I co-produce with them my future digitised experiences with food**. I claim that by following principles

of collaboration, shared ownership, and an iterative process of action and reflection, we, designers can build a humane and human-centric (food) metaverse that can lead to a (more) positive food future where we can go beyond consumption, by learning to value food and by engaging with it in more mindful, joyful, exploratory and sustainable ways. In this study, I start mapping this type of metaverse by capturing the different important aspects of the relationship between people and food – the inherent things they value and that bring joy in their day-to-day food lives. I then take participants in a speculative co-design exploration of the potential of the metaverse to elevate, enrich and help us reclaim and reconnect with our food practices.

The research questions this study is investigating are:

1. What are the elements people find important in their day-to-day food related experiences?
2. How can we shape our relationship with food in the metaverse in a meaningful way?
3. What are the potentials and challenges in building a food metaverse?
4. What are the fundamental building blocks for designing meaningful Digital Immersive Commensality (DICom) systems, and how can these dimensions guide the development of immersive food experiences?

My contribution is three-fold: First, I provide a list of ***elements*** **people value in their day-to-day food related experience** (Section 4.5.1). My second contribution is an annotated portfolio (Section 4.5.2) in the form of a catalogue of speculative design concepts, covering food-related experiences in the metaverse. **The concepts featured in the catalogue build on, embody, and instantiate the aforementioned *elements* and have as starting point ideas imagined by users as meaningful and desirable technological interventions in their food lives**. Finally, my third contribution is the insights gained from **evaluating my catalogue of speculative ideas** through 11 interviews and 157 sticky notes on Miro[1] from non-experts, as well as eight interviews with experts, including food anthropologists, food designers, and immersive technology specialists. These evaluations

[1]For the unfamiliar reader, Miro is an online tool for collaborative visual mapping of concepts and ideas. It allows remote collaborative work on multimedia elements such as text, graphics, photos, or videos.

were instrumental in shaping five key dimensions of the DICom framework (Section 4.5.3). In addition, the learnings from those conversations allow us to indicate potential directions for developing **a food metaverse, which is sensitive to people's nutritional, social, emotional, and cultural needs**. Overall, I believe my work provides both inspiration and guidance to designers to explore new food metaverse ideas, taking inspiration from the interaction between people, food and environment.

This research and its associated outputs were led and coordinated by myself, with my active involvement across all stages of the study. I was responsible for initiating, designing, and implementing the research, as well as overseeing data collection, analysis, and the development of the final outputs, including direct involvement in writing the results and discussion sections. Throughout the study, I was supported by my supervisor, Dr. Alexandra Covaci, who provided ongoing guidance and contributed directly to data collection through conducting evaluation interviews, demonstrating workshops, assisting in the coding and analysis of the data, and supporting the development of the discussion and results sections. My second supervisor, Dr. Jim Ang, also offered valuable guidance throughout the process. Additional key collaborators included Dr. Mayank Loonker, who helped conduct several interviews, facilitated workshops, contributed to data analysis, and supported the development of the catalogue concepts; and Dr. Luma Tabbaa, who also participated in workshop facilitation, analysis, and the co-creation of catalogue ideas. Dr. Bernardine Farrell provided helpful input during the analysis and discussion stages. Her expertise in anthropology offered valuable interpretive insights that deepened the understanding of the data. The research also involved artist Ahmed Albastaki, who led a design team including Rashid Buflasa, Wadeea Sallmat, and Nehal Isa. Together, they collaborated closely with our research group to illustrate and visually develop the catalogue based on our findings. Together, this multidisciplinary team contributed to shaping the study through shared reflections, iterative design discussions, and collaborative sense-making of the collected data.

4.3 Literature Review

This chapter builds directly on the theoretical foundations established in the Literature Review (Chapter 2). As discussed in (Sections 2.4.2, 2.5.2, and 2.6) the erosion of traditional

commensality and the limitations of current digital commensality systems highlight the need to reimagine how eating experiences can be meaningfully shared in virtual contexts. These gaps inform the rationale for adopting immersive and speculative design approaches in this study. Through co-design workshops, this chapter explores the values, practices, and aspirations that people associate with future food experiences in the metaverse, contributing to the broader discourse in HFI and advancing the conceptualisation of digital immersive commensality. To frame this exploration, the next section examines how eating is currently envisioned within the metaverse landscape.

4.3.1 Eating in Metaverse

Some of the open challenges and opportunities of HFI (as outlined, in Section 2.5), can be justified by the fact that existent HFI solutions work in isolation, usually involving only one platform, which could limit user's agency, the focus of the experience, and the domain of intervention (i.e., the food practice addressed). The metaverse can change this by enabling the creation of an interconnected and limitless world where our digital and physical lives fully converge. A platform agnostic spatial web based on the blockchain technology, the metaverse promises to bake the virtual into the fabric of reality and create a social place where users represented by avatars can meet new people, strengthen existing relationships, and build new communities. Among its key features I note here that the metaverse is *interoperable* (not tied to a specific platform), *reactive* (people will be able to engage and interact in real time in virtual worlds), *persistent* (a place that continues to exist whether people are online or offline), *user-defined* (owned and shaped by people), utilise (ownership is distributed), and *everyday* (seamlessly woven into daily activities) [406]. Ready to capitalise on its potential, companies are already starting to dip their toes in the metaverse, by developing applications which cover many of the day-to-day aspects of life, such as real estates, work, entertainment, gaming, shopping, travel, health or marketing [27, 61, 173, 366]. However, no daily activity has a greater impact on us and our society than our interactions with food: how we grow, gather, prepare, consume and share food. Although people are not able to eat or drink digitally, restaurant and food brands have started to experiment with the idea of experiencing food in virtual worlds. The first steps in this space are made (ironically, but also not surprisingly) by fast-food restaurants such as McDonalds, Wendy's or Chippotle and

are focused on encouraging consumption and marketing, not on (re)connecting us with and through food. The metaverse will transform things further, as it will go one step above our real and our social media lives, extending them into the virtual realm and augmenting our abilities. This poses the risk of transforming us in tourists of our own reality. I thus see **a need to rethink how technology impacts our food lives** and intervene from day one in **designing a metaverse that should not push us further away, but help us reshape our relationship with food**. Given the importance of food in our lives, I argue that there is a need for a different type of intervention – where we enable people to act as *food citizens*, to reclaim the importance of food in their lives beyond pure survival, to be more mindful and more invested in all their food practices, and to find joy in leading food lives that are sustainable, healthy, and socio-culturally rich.

As a concept the metaverse has existed since the early 1990s, however it has gained traction in recent years, further accelerated by the rapid technological advancements resulting from the COVID-19 pandemic. This was made possible due to the fast development and exponential popularity of cutting-edge technologies, namely Artificial Intelligence, Blockchain, Augmented and Virtual Reality, digital twins and the Internet of things. Nowadays, the Metaverse is slowly also becoming a part of consumers' daily habits, with many companies (big or small) starting to exploit its potential by developing applications covering many aspects of life, such as real estate, work, entertainment, gaming, shopping, travel, health or marketing [27, 61, 173, 366].

Since interest in the Metaverse is leaving no industry untouched, food companies are also starting to get involved. At the moment, metaverse food-related initiatives are dominated by restaurants and fast food chains tapping into play-to-earn, an emerging engagement model in this space. For example, Wendy's built a virtual location (Wendyverse) in Facebook's Horizon Worlds where people can eat virtual food and play minigames with a real world tie-in too - food offers, and Coca-Cola sponsored the first Indian wedding to take place in the metaverse where guests left with Coca-Cola discounts and gift cards to use in the physical world. Other ventures include Chipotle's Roblox virtual burritos, the first NFT restaurant called Flyfish and Miller Lite's metaverse bar. Nevertheless, the main driver for current food brands dipping their toes into the virtual realm is marketing; metaverse provides a way of earning in-universe rewards, and further interweaving those rewards with existing loyalty

programs for physical products or services.

Existing ventures are mainly business-centred and commercial in nature, hence they do not always connect users with food practices that are important to their lives. Even in OneRare [2], which is considered the first food metaverse (foodverse), most of the activity and interactions are virtual or marketing-oriented, therefore there is a lack of meaningful connections established with and through food for the users themselves. Since the development of the metaverse is still in its early stages, there is a need to suitably design the human side of it before the technology rapidly develops and further promotes consumerism. Food experiences (because of their characteristics) are a very good point to start with.

4.4 Method

4.4.1 The aim

With this study, is exploring what and how different activities in our food lives can be designed and reshaped using metaverse technologies and how this might transform the relationship between humans and food. For this, I take inspiration from other work proposing bottom-up speculative inquiries, which involve people in the design process (e.g., playful urban technology [19], playful HFI [11], or privacy futures [403], etc). In this project, I followed a co-design research approach [256], where I included – as creative partners in our design process – participants representing diverse demographics. Designing for food related experiences in the metaverse is a multidimensional and complex problem consisting of technological, social, psychological, behavioural, cultural and economic aspects. Thus, the purpose of the co-design engagement was **to: (1) tap into the individual knowledge**, to discover their unique perspectives; (2) **facilitate the emergence of a collective, multidimensional perspective** through collaboration between possible users in framing problems and exploring solutions and, (3) **arrive at design ideas or solutions, which when implemented, may be accepted more readily by the end users** as they were based on collective needs and desires.

[2]OneRare is a food-themed metaverse where users collect, cook, and trade dish NFTs using blockchain technology. `https://onerare-next.vercel.app/`

4.4.2 Methodological rationale

Chapter 4 adopts a Research through Design (RtD) approach [128] supported by inductive reflexive thematic analysis [48, 51], reflecting the speculative and exploratory goals of the study. This chapter investigates how food-related experiences can be reimagined in the context of the metaverse, with a focus on uncovering the values, expectations, and aspirations that participants associate with future virtual food practices. RtD was selected as the primary methodological stance because it enables the generation of knowledge through design-led inquiry, particularly in underdefined or emerging domains. Rather than validating an existing hypothesis, this chapter aimed to provoke thought and generate new design possibilities through co-design workshops, speculative idea mapping, and iterative reflection. These methods are well aligned with the principles of RtD, as they emphasise creativity, collaboration, and knowledge generation through making. By engaging participants in speculative and participatory activities, the study encouraged them to imagine alternative food futures beyond the limitations of their current habits, technologies, or everyday routines.

Co-design workshops were specifically chosen because the research questions are centred on users' experiences, values, and expectations in immersive dining contexts. Since the goal of the study was not only to investigate but also to actively shape future food-related interactions in the metaverse, it was essential that the design ideas be co-developed with users themselves. This participatory approach ensured that the findings were not only grounded in real-world needs and perspectives but also aligned with the human-centred aims of the broader thesis. It allowed participants to act as co-creators rather than passive informants, enriching the design process with their imagination, lived experiences, and cultural insights. Additionally, the artefact-based outputs from these workshops such as sketches, storyboards, and conceptual mock-ups served as critical material reference points that informed and inspired the development of the speculative catalogue of ideas presented later in the chapter. These artefacts helped translate abstract values into tangible design directions, making them an integral part of the RtD process.

Other methods were considered but ultimately determined to be less suitable for the aims of this chapter. For instance, a Technology Acceptance Model (TAM) [238] survey could have measured participants' perceived usefulness and ease of use of immersive food-related

technologies. Similarly, Multisensory Amplification Scale (MSAS) [384] could have assessed how strongly participants value sensory inputs like taste, smell, or texture. However, both approaches rely on predefined constructs and are better suited to evaluating existing technologies or behaviours. They lack the flexibility to support the open-ended, imaginative exploration required for this study. As this chapter aimed to provoke speculative thinking and co-create future food experiences, such structured instruments were too limiting. Instead, a Research through Design approach grounded in co-design workshops was adopted to generate rich, user-driven insights aligned with the research questions, which focus on designing meaningful, multisensory, and socially engaging digital systems. Additionally, Design ethnography [317] was not considered for this study, as its strength lies in observing and analysing existing real-world practices over extended periods. Given that Chapter 4 focused on speculative futures rather than documenting current behaviours, this method was incompatible with the study's goal of co-creating novel design directions for food interactions in the metaverse.

For analysis, Chapter 4 employed an inductive reflexive thematic analysis approach [48, 51], as it was best suited to the speculative and imaginative nature of the study. Unlike standard inductive thematic analysis, the reflexive approach acknowledges the researcher's active role in interpreting and shaping themes. This was especially important given that participants were co-creating future food scenarios, often using abstract, value-oriented, and culturally nuanced expressions. As the researcher, it was important for me to critically reflect on how my own positionality, disciplinary background, and design sensibilities influenced the analytical process. Reflexive thematic analysis embraces this subjectivity as a strength, allowing for richer, more meaningful interpretations, especially when working with speculative content that cannot be reduced to surface-level codes. In contrast, standard inductive thematic analysis seeks to minimise the researcher's influence, which would have limited the interpretive depth necessary for this kind of future-facing, value-driven inquiry. Ethnography, while well-suited to understanding lived experiences and cultural contexts, was not appropriate here, as this chapter did not aim to document current practices but to explore and construct possible futures. Therefore, reflexive thematic analysis provided both the analytical sensitivity and methodological flexibility required to generate insights that could meaningfully inform the design of speculative digital food experiences.

4.4.3 Methodology in a nutshell

The approach consisted of several phases (illustrated in Figure 4.2). I began with the aim of identifying the things people value in their daily interactions with food. For that, **in Phase 1, I conducted six co-design workshops** (two online and four face-to-face), where I **explored what people find desirable or undesirable in their daily eating experiences**, to identify a set of recurrent elements with inspirational value for designing metaverse food experiences. **In Phase 2, these activities surfaced a list 18 *elements* (clustered in four wider areas) of people's food lives** (Section 4.5.1) – i.e., *we call these elements important as they refer to the things people identified as valuable in their everyday food interactions, and I consider that in today's 'always on' society, these interactions could be mediated in a way or another by technology.* **These elements were clustered in four wider areas and used together with a set of 85 half-baked ideas imagined by participants** for **identifying five desirable design directions for metaverse food interventions**, **in Phase 3**. **Each design direction was then illustrated through two design ideas in our catalogue** based on observations of the enactments and the ideas proposed by participants themselves (Section 4.5.2) meant to inspire the embedding of metaverse technologies into our daily food practices. **In Phase 4, I used the catalogue of ideas to prompt discussion** and asked participants to evaluate them. For this, I engaged with regular users and ran online interviews with 11 of them, while 20 other participants provided written feedback on my catalogue via Miro. Additionally, I conducted eight online interviews with experts, including food designers, food culture researchers, food business owners, and individuals involved in metaverse development. This data aimed to identify the critical lenses and perspectives we might be missing, as well as the various views on the potentials and dangers posed by the metaverse to our food lives. I incorporate the main insights from these conversations in (Section 4.5.3). Furthermore, this feedback helped me identify the essential features to include into a digital immersive commensality prototype I will present in the next Chapter.

4.4.4 Methodology in detail

The approach consisted of several phases (illustrated in Figure 4.2). The study protocol was approved by the Faculty of Sciences Research Ethics Advisory Group of the University

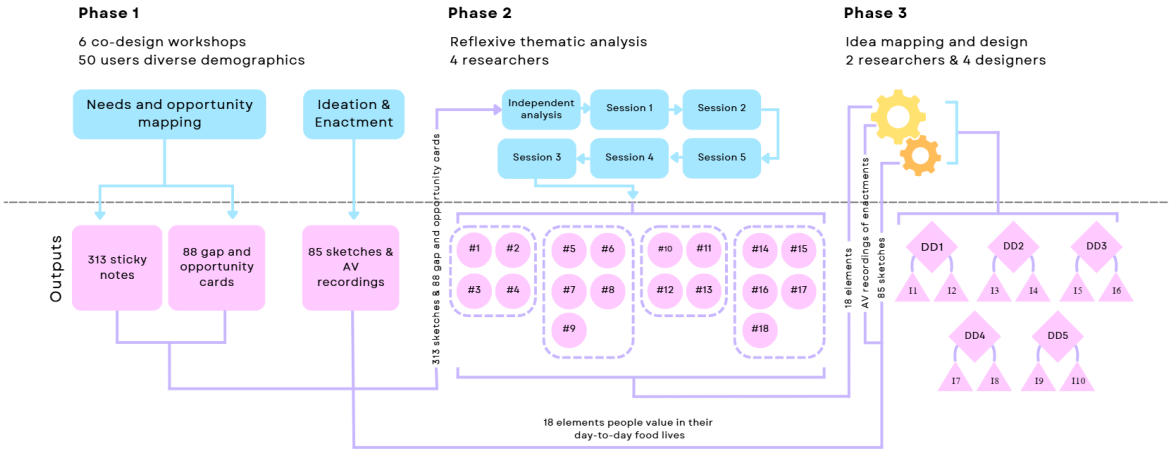


Figure 4.2: To generate the catalogue of ideas for eating in the metaverse we went through three phases: in Phase 1 I gathered data through co-design workshops; in Phase 2 I analysed the data and identified 18 elements people value in their daily food lives; in Phase 3 I used these elements and the ideas produced by participants to propose five design directions for this space and I illustrated each direction through two ideas.

running the study (ref: CREAG051-03-22).

4.4.4.1 Phase 1 - Co-design workshops

Through this initial phase, I aimed to: (*A1*) gain an explicit, trustworthy understanding about people's current experiences with food; (*A2*) identify gaps and opportunities that might emerge when introducing metaverse technologies to food practices; (*A3*) get people to imagine desirable interventions of the metaverse in their daily food lives.

Participants. I recruited participants for the co-design workshops via Instagram and Facebook social media platforms and university mailing lists, with announcements inviting to co-create "exciting, meaningful, fun, mouthwatering eating experiences for the metaverse". A total of **50 participants** of diverse demographics, backgrounds and household configurations attended the workshops. These were 33 female and 17 male, aged 18-24 (32%); 25-34 (52%); 35-44 (6%); 45-54 (2%); 54-74 (8%). They represented six countries from Europe (42% –with 28% from the UK; 4% from France and Spain and 2% from Italy, Cyprus and Portugal); four countries from the Middle East (38% – with 26% from Bahrain; 6% from Jordan, 4% from Iran and 2% from Algeria); five countries from Asia (12% – with 4% from Hong Kong; and 2% from Russia, South Korea, Taiwan and Bangladesh); one country from Africa (6% from Zimbabwe) and one country from North America (2% from Canada). 46% of

the participants were living with their family, 26% with housemates, 12% with a partner and 16% were living alone. All participants had previous experience with metaverse technologies such as blockchain, artificial intelligence, AR and VR, robotics and sensors, with 24% using VR more than once a week. This prior experience was a requirement to ensure participants could meaningfully engage in the speculative co-design activities. All participants signed informed consent forms before taking part in the workshops.

It is important to note here that despite the diverse demographics I tried to engage with, the participants were adults embedded in western contexts with reasonable access to, and familiarity with, digital technologies, part of so-called affluent societies, that are not determined by deprivation, but where abundance motivates individuals to explore. Therefore, the ideas and concerns that have emerged from the workshops are a reflection of their socio-economic privileges. At the same time, I acknowledge that these are the people more likely to have access to and be willing to explore the (food) metaverse first.

Sessions and data collected. I carried out **six co-design workshops** (two online and four face-to-face) consisting of **four activities** focused on the aims, as described in Table 4.1. All activities were followed by reflective discussion which was audiovideo recorded[3].

4.4.4.2 Phase 2 - Thematic analysis

Data collected during co-design workshops (see Table 4.1) was transcribed and gathered on Miro and analysed through an inductive reflexive thematic analysis process [48, 51]. Me and other three researchers started by reading and re-reading the entire dataset to become intimately familiar with the data and identify relevant information for the research questions. Next, each researcher undertook an independent coding process, working systematically through the entire dataset and identifying preliminary codes. The resulting codes (which were both semantic and latent) were further refined and redefined in later iterations of coding, during two sessions of two hours, where all the four researchers were present, discussing and reflecting on their codes. After all the relevant data was coded, we shifted towards the interpretation of the aggregated meaning of the dataset. This happened over three two hour sessions, where the four researchers involved in the reflexive thematic analysis process,

[3]The ideation cards used in the co-design sessions were designed based on cards from `https://sadiemaystudio.com//`

Activities	**Icebreaker** participants got familiar with each other and got into the mindframe of thinking about food and eating through playful activities.	**Need and opportunity mapping** participants wrote down the desirable and undesirable elements of their food experiences in various setups – at home, at work, in a restaurant – and identified opportunities for technological intervention	**Ideation** and sketching participants generated and sketched ideas exploring the use of metaverse technologies for food related activities and experiences.	**Enactments** participants used props and performances to elicit more details around their ideas and the interactions which could occur.
Data collected	–	**313 sticky notes** participants used to describe their likes, dislikes and wishes of their daily eating experiences and **88 gap and opportunity cards** where they identified desirable uses of technology in a food context. Used in **Phase 2**.	**85 sketches** illustrating participants' ideal eating experiences in the metaverse. Used in **Phase 3**.	**Audiovisual recordings of the enactments**. Used in **Phase 3**.
Aims addressed	–	*(A1)* and *(A2)*	*(A3)*	*(A3)*

Table 4.1: Co-design workshops: activities, data collected, aims addressed

produced: **a list of 18 food-related elements clustered in four areas, based on similar underlying features**, which reflect the salient features emerging when thinking about food, as indicated by participants in the co-design workshops, but also the perspective shift brought by technology. These range from participants' desire to build a culinary collectivity beyond commensality to an interest in getting engaged in playful activities or enhancing their food literacy. I present all these themes and sub-themes in detail in Subsection 4.5.1.

To maintain consistency and analytical rigour across both phases of thematic analysis in this study, the initial coding of co-design workshop data (Section 4.4.4.2) and the evaluation of the speculative catalogue (Section 4.4.4.4), a shared interpretive framework and collaborative coding practices were employed. Several measures were implemented to align collaborators with the same methodological stance. All four researchers involved in coding independently familiarised themselves with the dataset and generated initial codes across the full data. These were then discussed, refined, and compared through collaborative analysis sessions. A shared Miro board was used to facilitate visual mapping of codes and themes, helping maintain coherence and transparency throughout the process.

The collaborative team was cohered through an early, mutual commitment to the principles of inductive reflexive thematic analysis and a shared understanding of the study's interpretive and exploratory aims. Prior to analysis, we discussed the importance of centring participants' perspectives, staying open to emergent insights, and embracing researcher balanced subjectivity as an asset rather than a flaw. These shared values were reinforced through team reflections and debrief meetings, where we iteratively reviewed our evolving interpretations and thematic directions. The use of guiding documents outlining analytic principles, coding protocols, and sample coded transcripts also helped standardise our approach while allowing room for interpretive flexibility. Rigour was also maintained in the management of co-design workshops. All sessions followed a consistent structure using ideation prompts and clearly defined goals. Sessions were audio-visually recorded, and post-session reflections were collected and included in the analysis to capture both verbal and performative contributions, thus ensuring analytical depth and comparability across contexts.

While inductive reflexive thematic analysis acknowledges the active, interpretive role of the researcher, potential biases though challenging to eliminate entirely were mitigated through collaboration with a diverse interdisciplinary team. This diversity helped counterbalance individual perspectives and offered richer thematic insights. At the same time, a degree of researcher subjectivity was not only expected but valuable in this context. Given the speculative and imaginative nature of the data, the researcher's reflexive engagement added interpretive depth and contextual sensitivity, enhancing the overall understanding of participants' visions and experiences. Finally, the study recognised the potential influence of participant self-reporting, particularly during the evaluation phase. Some responses may have been shaped by a desire to please the researcher or to idealise future scenarios. To address this, participant feedback was triangulated across interview transcripts, written reflections, and expert commentary. Participants were also reminded that critical feedback was welcomed. This multi-source approach aimed to reduce the potential for overly favourable responses and supported a more balanced interpretation of the data.

4.4.4.3 Phase 3 - Idea mapping and design

Next, I **examined with other two researchers the collection of 85 half-baked ideas produced by the participants** as part of workshop activities (see Table 4.1) and **the audiovisual recordings of the enactments**, to identify the types of interaction participants envisage around the dinner table and their behaviour in imagining that context. We then **mapped these ideas and notes about participants' interaction to the 18 elements discovered in Phase 2** to validate that **the list is exhaustive**. Then, together with four designers, **they examined the collection of early ideas produced by participants to identify recurrent themes and settled on five design directions** that (1) they found interesting and (2) represented all the participants' ideas. Next, **to explore the inspirational value of our approach**, four designers produced **two ideas illustrating each design direction** in four two hour-long sessions. **I made sure that the final collection represented the breadth of my research and all participants' ideas** by keeping track of how each concept evolved in relation to the *elements* we uncovered in the study and the related literature. The 10 resulting speculative food metaverse concepts were finally mocked up into a *catalogue of speculative food-centred ideas for the metaverse*. These were presented in the form of an annotated portfolio [226], highlighting desirable technology-mediated food experiences for the metaverse. The speculative approach does not mean that our ideas are far-fetched, rather, using a similar approach to [19, 207, 227], I used speculation to bring some light on the features of the metaverse, which is still a fuzzy concept, not yet a commonplace part in people's imaginary. The original catalogue can be found here[4]. I detail the design directions and the corresponding ideas in Subsection 4.5.2. The original workshop sketches by the participants, which inspired the design team, are included in Appendix I (Figure 1).

4.4.4.4 Phase 4 - Evaluation of the catalogue

For Phase 4, the objective was to further evaluate the catalogue, explore perceptions of various eating applications, and gather in-depth feedback to inform the design of my system prototype. To achieve this, I invited eight experts in food design, anthropology, metaverse,

[4] `https://bit.ly/metafoodcatalog`

and multisensory technology, as presented in Table 4.3. Additionally, I recruited non-expert participants through Instagram advertisements, inviting individuals interested in eating experiences to take part in the study's interviews. I involved 11 participants (7 females and 4 males), aged as follows: 18-24 (18.2%), 25-34 (54.4%), 35-44 (18.2%), and 55-64 (9.1%). They represented nine countries: three from the Middle East (1 from Bahrain, 1 from Egypt, and 1 from Lebanon), three from Europe (2 from the United Kingdom, and 1 from Switzerland), two from Asia (1 from India and 1 from Pakistan), and one from North America (1 from the United States). The participants' professions included seven chefs, two technology and digital artists, and two creative writers.

The majority of participants had prior experience with metaverse technologies such as blockchain, artificial intelligence, augmented reality, virtual reality, robotics, and sensors. Specifically, 63.6% had used VR only once or twice before, while 36.4% had never used VR. In addition, 20 participants provided 157 feedback via Miro on the ideas I added there, further enriching our understanding and evaluation of the catalogue.

ID	Profession	Nationality	Age range	Gender
E1	PhD fellow in sensory and consumer science	Nicaraguan	25-34	M
E2	Architect and PhD candidate in multiscalar food systems	Peru	25-34	F
E3	Digital product designer for the Metaverse / Entrepreneur	American	25-34	M
E4	Chef / Restaurant owner / Metaverse technology entrepreneur	Emirati/British	45-54	M
E5	Expert in thinking for innovation and service design	British	35-44	M
E6	Professor in multisensory experience design	Colombian	35-44	M
E7	Food and eating designer	Dutch	35-44	F
E8	Public food anthropologist, consultant and writer	French	55-64	F

Table 4.2: Experts interviewed to reflect on the catalogue of ideas. None of these experts were part of previous phases.

Procedure. All participants signed informed consent forms before taking part in the semi-structured interviews or providing feedback on Miro. The catalogue and the list of questions were sent to the interviewees one week prior. Some examples of questions asked during the semi-structured interviews are: 1) Which ideas did you find exciting and what aspects were appealing? Why?; 2) What concerns did you have about these ideas?; 3) What do you think

ID	Profession	Nationality	Age range	Gender
NE1	Restaurant owner and marketing	Bahraini	25-34	M
NE2	Restaurant owner and graphic designer	Bahraini	35-44	M
NE3	Technology and digital arts	Bahraini	45-54	M
NE4	Teacher in digital arts	Pakistani	25-34	F
NE5	Private chef specialised in Japanese cuisine	American	45-54	M
NE6	Creative writer	Dutch	18-24	F
NE7	Creative writer	Indian	18-24	F
NE8	Chef	Egypt	35-44	F
NE9	Chef	Lebanese	25-34	F
NE1(	Chef and owner of institute of culinary arts	Bahraini/Switzerland	25-34	F
NE11	Chef	British	25-34	F

Table 4.3: Non-experts interviewed to reflect on the catalogue of ideas. None of these non-experts were part of previous phases.

is missing in these ideas?; 4) What would you add or remove or change to enhance these ideas?; 5) What are your general thoughts on eating in the metaverse?. The interviews lasted between 20-30 minutes.

To engage more participants, I decided to create a Miro board where I showcased the ideas in the catalogue and I provided an area for feedback. I shared this board with 20 participants and asked them to provide their feedback by leaving comments below each idea, to rate the idea they liked most, and the idea they liked least. In total, the participants contributed 157 comments and reactions.

The interviews were audio recorded and transcribed, with the resulting transcripts analysed by me and other two researchers. The data collected from interviews and the curated Miro board were organised on Miro and subjected to an inductive reflexive thematic analysis [49, 51]. To ensure comprehensive familiarity with the data and to identify information relevant to my research questions, I engaged in an intensive two-week process of reading and re-reading the entire dataset. Following this, two other researchers conducted an independent coding procedure, reflexively analysing the dataset to generate initial codes. These codes, encompassing both semantic and latent dimensions, were refined and redefined in subsequent

iterations. This refinement process involved two one-hour collaborative sessions where the researchers discussed and reflected on their coding decisions. After coding all relevant data, we proceeded to the analysis phase, focusing on deriving the synthesised meaning from the dataset. This analytical process was carried out during two additional one-hour sessions, during which the researchers identified seven overarching themes. These themes were then synthesised and expanded into a unified and comprehensive list of dimensions that participants found most engaging about eating experiences in the metaverse. According to the data sets, we identified 18 elements clustered into four areas of interest in the space of food and technology. Detailed presentations of these themes and sub-themes are provided in (Section 4.5.3).

4.5 Results and Discussion

4.5.1 Result Phase 2: A list of food-related elements for designing the food metaverse

With the analysis, I aimed to answer (RQ1) and (RQ2) by: (1) synthesising the findings into a list of elements – which emerged as salient for participants – that is manageable and actionable and can be used as starting point for ideation; (2) focusing on the findings that were more inspirational to orient designers towards those forms of digitally enhanced eating. With this in mind, I generated 18 *important elements* and clustered them by affinity in the themes described below.

Previous work proposes taxonomies of food practices, eating experiences or food consumption behaviour[75, 130, 348] based on contextual inquiries or on previous related work. However, the factors of these taxonomies are often too broad to be directly actionable by designers interested in building food-related experiences, or too focused on specific food practices (e.g., eating, shopping), thus not offering a complete picture of different opportunities for intervention. The identified 18 *elements* are supported by the generic determinants of the taxonomy of food consumption behaviour proposed in [348]. Moreover, they enrich the previous work through their practical value – they offer insightful and actionable information about users that could be easily considered by food-related experience designers. Additionally, my list

of elements could be used to explore the integration and interactions of determinants from several different categories.

Table 4.4: *Important* elements emerged from Phase 2, clustered under the *Connecting with others over food*, *Connecting with the self*, *Getting our food system right*, and *Comfort and indulgence*.

Important element	**Example quotes from participants**	**Designers could think about how to use metaverse technologies to...**
Connecting with others over food		
#1 Culinary collectivity beyond commensality People seek to share with others, food-centred moments beyond eating.	*"It can be very enjoyable to share food with my family"*; *"I like cooking or grilling with my special friends".*	afford distanced social experiences that cover our different interactions with food - from farming to gathering, cooking and eating.
#2 Searching 'my' food community Being part of collectives or food communities gives us a sense of identity and belonging.	*"(I like) Meeting foodies, getting together to make, eat, and rate food"*; *"(I wish) I could reflect my enthusiasm of food to more people".*	create gathering spaces that incorporate both physical and virtual elements and that connect the virtual and the (local) real world food communities.
#3 Stimulating mealtime conversations Conversations around the dinner table are highly valued by people, who see technological advancements as a potential for enhancement.	*"Having a wonderful conversation during a lovely meal"*; *"I would be interested in a topic generator over my meals".*	enhance mealtime conversations by engaging with many of the modalities people utilise such as speaking, physical interactions, emotion, speed of chewing.
#4 Seeking surprise encounters over supper Mealtimes are good contexts for gaining insights into the life ways and worldviews of others.	*"I like being around random people"*; *"Sharing eating experiences with strangers should be normalised".*	facilitate social bonding with strangers through social eating.
Connecting with the self		
#5 Celebrating being alone Solitude around meals appeared to be sometimes preferred, not enforced to our participants	"*I don't like to invite people. I love having my own space*"; *"Having a vanishing button - make everyone disappear"*	enhance the user experience of solo diners during the food preparation and consumption processes.

#6 Engaging in mindful eating habits Eating and cooking are seen as a mindfulness exercises people want to practice.	*"Eating is my getaway trip"*; *"I spend more time cooking healthier"*	afford a mindful experience by creating worlds where people can exercise their minds and senses.
#7 Making and breaking habits Technology is an enabler for improving eating habits and reinforcing new eating patterns.	*"Eating healthier food by manipulating the visuals"*; *"Change the taste through the colour or sound"*	provide support for people who have a conflicted relationship with food through the stimulation of other senses.
#8 Food memories represent a sense Food is a trigger for re-living memories through all our senses.	*"Recording all the good memories and tastes in a particular meal and be able to re-live it."*; *"Documenting food moments"*	afford new forms of food-centred narratives for preserving, remembering and recreating our food lives.
#9 Pay attention to your senses Sensorial attunement around the dinner table is important.	*"I would like to control the music and lighting"*; *"I would like a smell or flavour changer"*	make people excited and attuned with their food and eating environment by stimulating all senses.
Getting our food system right		
#10 From farm to fork: getting involved in the food system There is something exciting about learning the stories behind our meals.	*"Journey to see how the vegetables were planted and cooked"*; *"Quest for food: interactive recipes. Can be fun, mysterious, gamified."*	transform contemporary human-soil affections by telling stories that encourage love for soil and for the people who produce our food.
#11 Food choices with an eye on sustainability People look for products that can help them live a more sustainable, socially responsible life.	*"(I would like) to use more veggie than meat"*; *"I don't like wasting food"*	help people assess the environmental sustainability of the foods they buy.
#12 Searching for food literacy People want proficiency in food related skills and knowledge.	*"Teach you about food in a fun way (reward system)"*; *"Learning about how certain foods affect my body"*	empower people with knowledge, attitudes and skills about food.
#13 The cultural significance around food The heritage and rituals that surround food should be kept alive	*"Keep the heritage alive: how people used to eat, what, how, where?"*; *"loss of culture and rituals that surround food"*	allow people to create repositories for preserving food heritage, but also tools to build new food culture.
Comfort and indulgence		

#14 The comfort of home People want occasionally to avoid the hustle and relax in their familiar surroundings	*"The comfort of my own home"*; *"The feeling of comfort and the options I have at home to prepare my own food"*	transform people's kitchens - allow people to connect with others from the comfort of their home.
#15 Variety is the spice of life People enjoy change and variety around their meals.	*"We literally just eat to live. We need experiences, entertainment.."*; *"I don't like the routine of eating experiences..even the restaurants are the same."*	provide variation (in both food and environment) around our daily interactions with food, in all contexts.
#16 Embracing constructive distractions Being detached while eating is not necessarily a bad thing	*"I enjoy watching films while eating"*; *"Immersive ASMR where we can interact with the food"*	allow people to relax, while still paying attention to both hunger and eating.
#17 Please, *do* play with your food People enjoy engaging in playful activities while eating	*"Create a food character to go on an adventure.."*; *"introduce taste to gaming to enhance the connection between players."*	allow people to become more than passive observers – for instance they can have exploratory roles or interact with food as a diegetic component.
#18 The magic of cooking Learning, experimentation and performing while cooking is fun.	*"Smart annotations for cooking"*; "Cooking with celebrities (i.e., virtual Jamie Oliver)"	enable the practice of cooking skills, experimenting with ingredients, co-creating recipes or perform from their kitchens.

4.5.1.1 Connecting with others over food

Part of the data collected from participants in my study points to the individuals' fundamental need to belong [32]. When writing about their wants and needs around mealtimes, they often mentioned seeking love and community through food, this being reflective of a sense of social connectedness [388] around the dinner table. Under this theme, I identified four *important elements*, which we present in (Table 4.4). These can inspire features of metaverse-based applications aimed at single-person households, families living apart, migrants which seek to connect with their new country, or people looking for a partner.

4.5.1.2 Connecting with the self

Our relationship with food is increasingly unbalanced. With one in two Europeans obese[5] and millions suffering from anorexia and bulimia, participants in my study sought to improve the quality of their (food) lives and talked about technology that could enable them to engage entirely, and involve all their senses in choosing, preparing and enjoying their food. Under this theme, I identified elements #5 - #9 (see Table 4.4), which are focused on the desire for an inner experience of food. These present an inspirational value for experiences which can foster the improvement of our relationship with food by bringing change from the inside [396].

4.5.1.3 Getting our food systems right

The global food situation is facing unprecedented challenges tied to fragile food systems that degrade the environment and undermine public health [378]. Meeting the problem posed by our food future through production alone is not enough, as other alternatives that focus on reducing demand for food by changing our diets, reducing food waste and loss should be explored. However, this is difficult to achieve, as people are growing increasingly distant to their food practices [98]. Elements #10 - #13 (Table 4.4) point to participants' desire for experiences centred around different aspects of food literacy. By considering them, designers can enable us to re-gain our connection with the environment and our bodies, to cherish the social dimension of eating and to engage in the countless food-related traditions and rituals [359, 378].

4.5.1.4 Comfort and indulgence.

Although research suggests play can be an influential factor in the eating experience, playing or other activities that distract us from the act of eating are considered a taboo [387]. Participants in my study mentioned that they often perceive day-to-day food-related experiences as monotonous and boring, expressing an intense desire for change and variety. Engaging in cooking, playful activities or other distractions may prove to be therapeutic. The meditative qualities of a trance-like state can nurture peaceful detachedness that enables calmness

[5] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Overweight_and_obesity_-_BMI_statistics

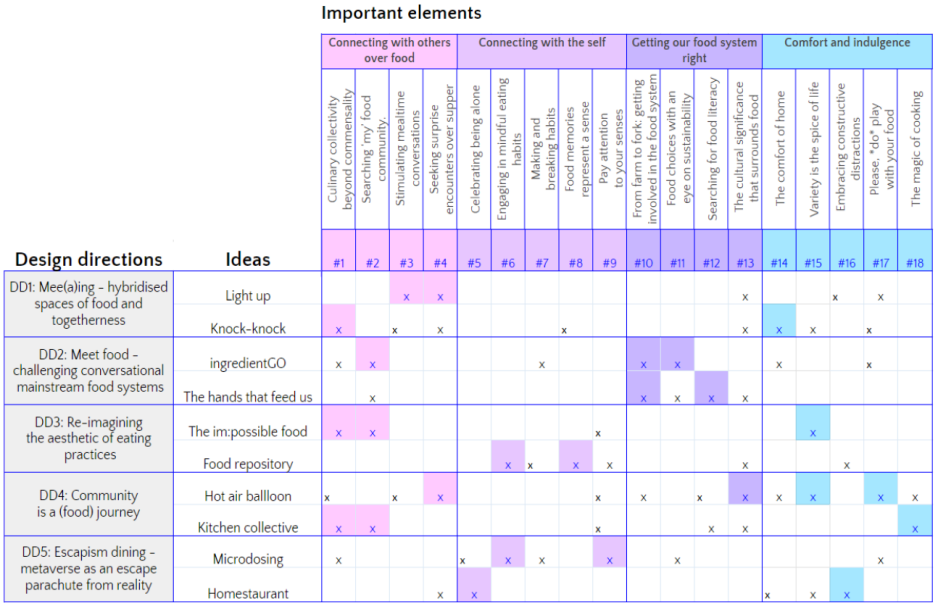


Figure 4.3: Summary of ideas (and underlying design directions) included in my catalogue, linked to the *important* elements they respond to. In highlighted cells, I show the primary predominant important elements under each idea. Cells with x which are not highlighted indicate that those elements are also considered but they are secondary.

around food. Elements #14-#18 (Table 4.4) aim to provide inspiration to designers about how to embed comfort into everyday food activities.

4.5.2 Result Phase 3: Five design directions and a catalogue of metaverse food-centred ideas to illustrate them

Following the methodology described in Subsection 4.4.4.3, I identified five design directions. Below I show how these design directions were supported by participants' sketches and how the two ideas we designed to exemplify them: (1) are rooted into participants' half-baked ideas; (2) incorporate at least one of the 18 elements identified in Phase 2. I summarise this information in Figure 4.3.

4.5.2.1 DD1: Mee(a)ting - hybridised spaces of food and togetherness

The first design direction focuses on the social and communicative significance of activities around food and it is **motivated by the social dimension displayed by the majority of our participants' ideas**. As illustrated by our participants' ideas, food was often seen as a social act that can strengthen ties, a universal language that connects us beyond borders and

cultures, fostering positive emotions. Through their half-baked design ideas, participants imagined the metaverse could **connect them with their loved ones who are not in the same space** by: (1) supporting conversations while eating in a possible (i.e., on the beach) or impossible (i.e., under the water, on the moon) immersive space ; (2) enabling them to attend remotely family events or celebrations; (3) engaging them in playful activities around their meals (i.e., compete by controlling the speed of virtual race horses with the speed of chewing); **facilitate breaking bread with strangers** by creating the context where: (1) food is the starting point of the conversation; (2) conversations are supported and enhanced by the system; (3) knowledge is exchanged; (4) they can open up while remaining anonymous; (5) they can co-create eating experiences matching their interests; (6) they can interact with different generations. **DD1** proposes to leverage the community connecting abilities of the metaverse for the next generation digital commensality [344] and collectivity platform, fostering more authentic and immersive social experiences around food.



(a) With *Knock-knock* users create virtual kitchens as public-private spaces for connection.

(b) *Light up* - An XR social application that scans food in a dark room, triggering conversations and connections through immersive interactions.

Figure 4.4: Mockups of "DD1. Mee(a)ting - hybridised spaces of food and togetherness"

To illustrate this design direction, I propose two ideas which **combine and refine a set of ideas produced by the participants**. *Knock-knock* (see Figure 4.4a) is a XR application where users can create new digital spatialities and socialities around the idea of homes as public-private spaces. Homes are not seen here as fixed territorial places, but as "transitory, multisited and open ended" [163]. In *Knock-knock*, users can create virtual homes or transform their physical homes and re-scale them seamlessly from private sites into public arenas, where strangers and friends are invited. These spaces can be built around the guests who partake in the food related experiences, so that they enable performative acts, active participation and forge relationships. *Light up* (Figure 4.4b is a social Augmented

Virtuality eating experience allowing users to join a dark virtual space where everything they see are the meals of all the people present in the same virtual space (this would be possible through a system like [262]). Thus, the food becomes the starting point of a conversation and a possible connection that is further supported by an intelligent system, which reacts and brings the environment to life based on the interaction, interests, physiological signals or discussion between the users.



(a) With *ingredientGO* urban communities co-design, co-produce, and connect in liminal spaces facilitated by the metaverse



(b) *The hands that feed us* - an immersive application that allows consumers to connect and collaborate with food producers

Figure 4.5: Mockups of "DD2. Meet food - challenging conventional mainstream food systems".

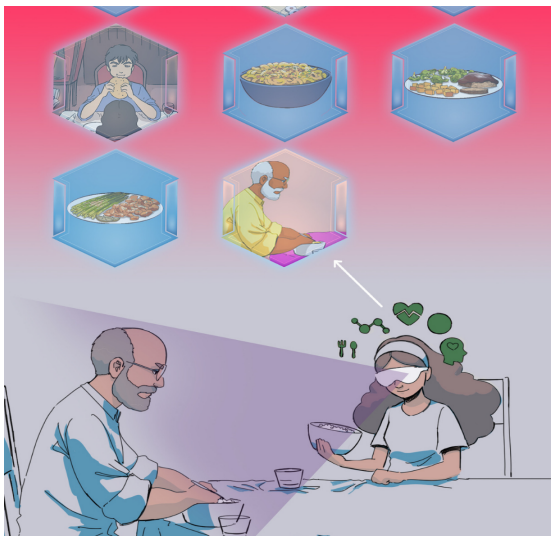
4.5.2.2 DD2: Meet food - challenging conventional mainstream food systems

Several ideas proposed by participants in my study reflected a desire **to challenge the alienating consumer-producer relationship and to experience food beyond consumption**. People imagined scenarios where they **connect, cooperate and engage in an adventurous co-production alongside those working in the agri-food sector**. They were ready to (1) go on a quest for the ingredients of their meals, (2) help the hunter, farmer and chef to gather ingredients and cook a meal in a virtual reality setup, (3) find out about the origin and the producers of what they eat, (4) become a virtual chef helper in the kitchen of different restaurants across the globe, (5) select digital ingredients from digital twin markets and experience their adventure from farm to fork. Two participants saw value in **exploring the issues of the agri-food sector** responsible for their meal (i.e., child

labour, gender inequality, exploited migrants, poverty). These serve as inspiration for **DD2**, which points to the **necessity of using metaverse technologies for establishing new forms of agency within the food chain**, which could be rooted in collaboration and foster solidarity. The blockchain, digital twining solutions and immersive technologies could be used to enhance food traceability, provide consumers with a story of the adventures their meal had along the way or allow them to connect and co-produce with producers by configuring from home the mode of production, the size, flavor, and temperament of vegetables that will be delivered to them.



(a) *The im:possible food* - a VR application that allows anyone to create and co-create new types of food and eating experiences.



(b) With *Food Repository*, users relive food memories through recorded data, emotions, and virtual reconstructions of memorable meals.

Figure 4.6: Mockups of "Re-imagining the aesthetic of eating practices"

To exemplify how designers could build on this design direction, I propose two ideas with slightly different flavours. ***ingredientGO*** (Figure 4.5a) imagines a community-driven solution for food sovereignty, where consumers and producers are co-designing and co-participating in spaces around urban agriculture. With gamification at its core, *ingredientGO* empowers the entire community to take charge of the food dimensions of their cities. Making use of liminal spaces - which employ XR technology to transform physical spaces for blended activities, built equally around digital and physical elements - people are able to co-configure their cities according to their food needs, culture and resources. This will cover several aspects such as production (e.g., vertical farms, aquaponic systems, vertical mushroom production, urban gardens, damp cellars), collection (e.g., farmers' market, pick up points, exchange stations, drone delivery), but also education (e.g., farming, sustainability

practices, nutrition), social life and leisure (e.g., community kitchens and gardens), which are important for connection. These spaces can gradually expand and adapt over time based on the community's evolving needs and activities. The second idea, ***The hands that feed us*** (Figure 4.5b) is a multisensory XR application, where consumers can visualise, experience and interact with the journey and the stories related to their meal. People can see, hear, smell the atmosphere of the production facilities, meet and connect with the producers, talk to them and get insights into their work through tours, demonstrations, sessions of digital farming or participation in the preparation and cooking process. These interactions can also enable consumers to become co-producers by influencing the mode of production and creating greater value for other consumers.

4.5.2.3 DD3: Re-imagining the aesthetic of eating practices

Many of the half-baked ideas produced by participants in my study revolved around leveraging digitalisation for transforming our aesthetic experiences around food. Through these ideas, participants seemed to perceive food replete with symbolic content, similar to fine art [3] - for example they imagined ingredients assembled in unexpected shapes and constructions; they correlated food with emotions or with expressions of care such as "soothing" and "comforting"; they talked about sensory remembrance, catching and keeping the intensity of past experiences as triggered through their taste sensation. More specifically, their ideas involved **changing the food's appearance**: (1) via voice or emotion control; (2) create imaginary characters from food as company during meals; (3) manipulate food's colour or shape; (4) synchronise the look of the food with the environment; **involving all the senses**: (1) transform any food in a *comforting food from home* through magical spices or smells; (2) share a multisensory (temperature, smell, sound, touch) eating experience with someone who is not in the same space; (3) boost the taste of food and the eating experience to suit and support their mental and emotional; **supporting creative practices**: (1) experiment with digital simulation of taste – users can develop, send, exchange, and download different flavours; (2) attend immersive autonomous sensory meridian response (ASMR) Mukbang and cooking shows; (3) imagine new types of food - for instance edible clothes; **saving, reliving, extracting data and emotions from food moments**: (1) store and reproduce favourite tastes; (2) store food related memories and emotions associ-

ated with them; (3) recreate and relieve the bodily experience of food memories; (4) leaving a legacy of food memories; (5) preserve the past through food communion; (6) understand how food eaten over a longer period impacts the body. **DD3** refers **to building features for a user-defined metaverse, which is owned and shaped by its users**. Users should be empowered with tools to actively create and engage with content, rather than passively consuming it. This should cover the sensory, emotional, performative, communicative, and temporal aspects of eating experiences.



(a) *Hot air balloon* takes users on virtual culinary adventures, detecting food and suggesting global destinations to explore recipes, rituals, and traditions through interactive experiences.

(b) *Kitchen collective* is an AR app that connects you with the local community.

Figure 4.7: Mockups of "DD4. Community is a (food) journey"

I exemplify this design direction through two ideas. ***The im:possible food*** is a multisensory XR design tool that involves the eating human in the process of creating and bringing to life aesthetic food experiences which have at the core the sensorial system. With *the im:possible food*, users are given the power to (co)-create the food experiences of the future and to take interactivity to a greater inner level of sensorimotor immersion (see Figure 4.6a). Users have limitless options - they can manipulate shapes, colours, environments or can unlock new dimensions that go beyond physical limitation (e.g., no gravity, smoke, light, etc.). This will allow people to become more than passive consumers, but creative agents who can (digitally) craft aesthetic food centred experiences that at the same time can bring alternatives, enhance our connection with and appreciation of food and enable radical thought in a world where food is dominated by economy. The second idea, ***Food repository*** (Figure 4.6b) branches from the concept of *food selfies* – a dominant form of representation of food in social and digital visual media, perceived by users as an engaging experience, which helps them sustain their interests and keeps a record of what they eat [72]. I link *Food repository* with the fact the metaverse could store large amounts of data about everything. I combine this

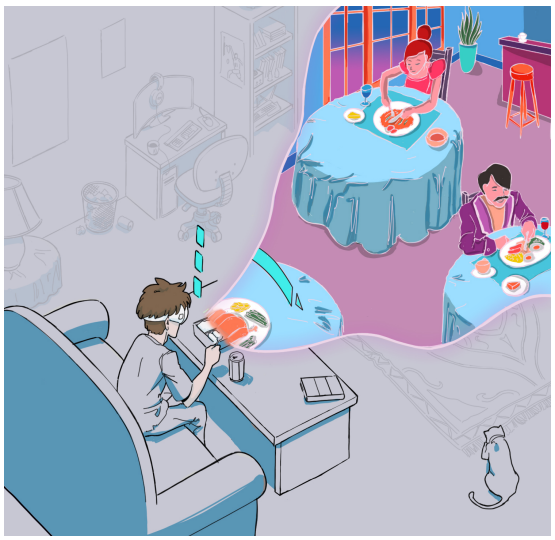
with reflexes we all have already acquired in the digital age, to build up a bank of everything we have ever eaten. Users can choose what aspects (i.e., the metadata) of their meal to save in their metaverse food space (e.g., is it a recipe, the food, its taste, the surrounding elements, who they are eating with, how they were feeling, the nutritional information, their body's physiological response to the food, etc.). Then, whenever they do not know what to cook, want to understand how the food eaten over a period of time impacted their health or performance, or want to relive in an immersive setup certain food-related memories, they can travel through their food repository. This solution could be used to tackle health problems, strengthen cultural identities, experience joy and a feeling of belonging [257].

4.5.2.4 DD4: Community is a (food) journey

Interest in discovering new cultures, people, and places was often embedded in the ideas produced by participants in the workshops. They imagined metaverse applications that would enable them to be co-located with people from different cultures in matching virtual environments, where they can **connect with, share and learn from, the global community**: (1) go on a journey to find out how raw ingredients (e.g., fish) are cooked in other cultures; (2) learn from other cultures how to prepare different dishes (e.g., sushi); (3) share their local dishes and recipes with someone abroad; (4) practice tea rituals; (5) being introduced to uncommon dishes from all over the world; **connect with, learn from and support, local communities**: (1) invite immigrants to talk and exchange recipes; (2) eat with residents in local care homes; (3) co-cooking with locals and participating in immersive cooking shows. This shows **participants perceived metaverse technologies around food as enablers of rich cultural experiences, which connect across cultures and generations. DD4** proposes to leverage immersive technologies to take people on journeys of discovery which empower them to learn from others and better understand the world. By integrating food within the metaverse, we can ease the understanding of different societal groups in their historic cultural context, and develop our social empathy [327] abilities, which is essential for our individual and collective well-being [99].

To demonstrate how this design direction could be implemented, I present two ideas. ***Hot air balloon*** (Figure 4.7a) is a social VR application that enables users to

connect with the global community in an act of discovery of the world through their food. With this application, remote people will be able to connect over meals and embark together on a culinary journey. During this adventure, they can get involved in different traditions, play, learn about tools, recipes or legends by interacting with the environment and with the others. The journey can be based on participants' meals (i.e., as illustrated in Figure 4.7a) that can be prepared by them or delivered by cloud kitchen services across the globe. The second idea, ***Kitchen collective***, looks into connecting local communities, by creating a space of care through collective cookery (Figure 4.7b). Via AR technology, users can connect while cooking from their own kitchens and become part of *culinary* support system. This can lead to strengthening community bonds through recipe exchange or co-creation, storytelling, performance, by challenging each other or swapping ingredients via drones. Boundaries of public and private become thus blurred and merge into new hybrid typologies. Sharing a (digital) space where food is involved might encourage people to retake an 'earthly rhythm' of food consumption, while amplifying a sense of empathy.



(a) *Homestaurant* brings the buzz of any virtual or physical restaurant in users' home.



(b) *Microdosing* is a multisensory VR app to disconnect from others and connect with food.

Figure 4.8: Mockups of "DD5. Escapism dining – the metaverse as an escape parachute from reality"

4.5.2.5 DD5: Escapism dining – the metaverse as an escape parachute from reality

Escaping the immediate reality – both spatially and temporally – **was one of the possibilities that animated the participants when imagining ideas for the food metaverse**. They manifested interest in becoming part of larger things and **accessing inaccessible places** like: (1) famous venues (e.g., the Colosseum); (2) expensive restaurants (e.g., the French Laundry); (3) the space or underwater; **time travelling**: (1) eat with people who have died; (2) attend amazing royal banquets (e.g., organised by Henry VIII); **becoming part of something iconic**: (1) a painting; (2) a movie (e.g., Charlie and The Chocolate Factory, Alice in Wonderland). However, participants were also focused on their inner selves and perceived the metaverse as an opportunity to **isolate themselves from the stress of the everyday life** and: (1) enter an isolation bubble; (2) relax in multisensory environments; (3) become more mindful about food; (4) avoid situations that can cause social anxiety by customising the elements they allow in they meals. These inform **DD5**, through which **I propose designers to create micro-doses of escapism from the dullness and the stress of our daily lives that allow individuals to recharge**. These bite-sized solutions for people to exercise their minds could be experienced during a launch break or instead of watching a show in the evening and should allow users be in the centre of attention or just disappear and be incognito.

To exemplify this design direction, I propose two ideas and we illustrate them in Figure 4.8. ***Homestaurant*** is a XR application, which enables users to access – from the comfort of their own homes – the buzz of any restaurant (Figure 4.8a). Via digital twins technology, these virtual dinners are combined with physical spaces (i.e., real life restaurant venues), offering both virtual and physical diners a personalised social, immersive and interactive experience. Everyone can choose their appearance and the degree of interaction with the others - they can observe, engage in conversation or become part of an artwork. ***Microdosing*** (Figure 4.8b) is a multisensory VR application which allows people to isolate and relax during their lunch break. The system detects what the user is eating and displays visual, audio and smell information that are harmonised with the taste (following crossmodal correspondences principles [206, 354]). This experience invites the user to reset and savour

the food and the moment.

4.5.3 Result Phase 4: DICom Framework dimensions

Through the analysis of the interviews, I identified five key dimensions that underpin meaningful Digital Immersive Commensality (DICom) experiences. These dimensions represent foundational building blocks that can guide the design and development of immersive food interaction systems.

4.5.3.1 Framework Dimension: Multisensory Immersion

Summary: This dimension leverages technology to create rich sensory experiences that integrate taste, smell, sound, and touch, fostering deeper connections with food and others. This aligns also with DICDP3: Eating and the senses (see Table 3.4), which demonstrated how participants crafted shared sensory atmospheres through gestures, visual cues, and multisensory storytelling. These insights reinforce the importance of sensory integration in creating immersive and meaningful dining experiences.

Food is pleasure, visually yes, but also multisensorially and so, it is soothing and heals because our bodies and minds can feel nurtured. So how can we translate this into a metaverse where we are not able to eat or drink digitally? Participants frequently mentioned the senses when discussing ideas such as *Hot Air Balloon, Im:Possible food, Kitchen Collective, Homesturant, and Microdosing* showing varying perspectives on the necessity of stimulating them during a digital eating experience. Some individuals actively sought sensory stimulation, while others were more sceptical about its necessity or effectiveness in a digital context. For example (E6)[6] mentioned: *"I think that the key challenge that many people are trying to address is how do we integrate those other senses that are difficult to integrate? Because to be honest, I personally don't buy digital taste or smell, you know, just controlling the sense of taste or smell with something that is based on current. I think it's going to be quite challenging unless you go to human brain interfaces, I guess (E6)."*

Historically and culturally there are some interesting differences in sensory approaches – for

[6]Data source: E = Expert, NE = Non-Expert, MF = Miro Feedback.

Aristotle, touch was the primary sense and taste was perceived as a form of touch, whereas Plato ignored the sense of taste and only considered temperature. Farrell [110] looked into the *virtual lifeworld* of Instagram food imagery and proposes that sound and vision have a major role in the co-construction of the sensorial methods of our 'eating bodies': *"it's weird how sometimes we associate food with sound (E4)". "You think that you do not have your senses in the metaverse, but you are the one experiencing the metaverse. And you do have your senses. So I think when you aim for really convincing storytelling, and when you really, help people to activate their imagination, when you are seeing a good movie, and in the cinema, you do cry when something happens, right? I mean, I cry all the time. And so we are capable of experiencing things only when they are meaningful. And so* ***we can experience flavour without actually eating when we see something so convincing that it actually brings us this feeling*** *(E7)." Seeing* is more than looking, as we only truly see when our socially constructed eating sensory memory and cultured taste buds are at work [110]. Our memory and the multimodal work of the senses can give "understanding, appreciation and emotional pleasure to the visual representations of food" that is not dependent on taste stimulation [110, 324, 402].

Meanwhile, other participants viewed sensory stimulation as important, describing it as a tangible element that connects the real and virtual worlds together. For example *"food is a very tangible object, it's a very tangible thing, you have to touch a have to smell it, you have to feel it, you have to taste the textures of it [...] That's so important how does it like touch on inside your mouth? How does it feel? How do you feel after a meal? All those things are very hard to put into virtual world [...] The real food could link the real world with this fantasy virtual restaurants have created. If the food is digital, then there is no connection with reality (NE8)".* This sensory stimulation should be designed to create lasting memories. As one participant explained, *"we're always left with memories that we look back on, does not matter how your experience was in the actual moment. It's what is left with you on a later stage, whether it is smells, sounds, tastes, all of these senses combined together, create this concept called memories (NE10)".* The use of senses is also considered important for mindful eating, which can help alleviate stress *"I believe that engaging my senses such as taste, can help me connect with my food and environment allowing me to relax especially after a long and distracting day at work (NE4)".* Seeing and eating the food is not enough; as (NE9)

elaborated, technology should enhance the experience by altering the taste: *"technology of giving me a food experience rather than just seeing the food and putting it in my mouth. And chefs nowadays they use a lot of things even with smell to alter the taste of food".*

4.5.3.2 Framework Dimension: Cultural and Contextual Richness

Summary: This dimension embeds diverse cultural narratives and traditions into digital dining, ensuring authenticity and emotional resonance. It also aligns with DICDP5: Customise everything and DICDP4: Disrupting social norms (see Table 3.4), as participants highlighted the value of personalising their dining environments and embracing unconventional approaches to cultural expression. These findings support the inclusion of both symbolic and objective authenticity in creating inclusive and culturally resonant experiences.

People were particularly drawn to ideas that explored food beyond its physical consumption, such as *Homesturant, Knock Knock, Light up, Hot Air Balloon, The hands that feed us, and Kitchen Collective.* As E7 put it: *"Food itself, the eating experience is physical. But on the other hand, food is also not physical. Because if you would look at the political part of food, for example, like who owns what and who has sovereignty, like maybe an algorithm can also be the owner of food instead of human beings. And I think if you see food as more than only the eating experience, then I think you can really create very interesting things with the metaverse that you wouldn't be able to create in real life. It is good to kind of make this distinction – is it really about the eating experience? I think the metaverse could be much more interesting when it comes to looking at more* ***political, cultural, social aspects of eating instead of the physical experience*** *(E7)".* Food rich in cultural connections and identities.

Participants frequently linked food to cultural elements, *"I would like something to explain where this vegetable came and from which farmer in Japan? and what it means to their history and heritage? it makes it very personal [...] you would have a strong connection with your plate (NE8)".* Mostly, participants associated food with cultural elements, frequently citing Italian and Japanese cuisines as examples they were most eager to explore. They expressed strong interest in the catalogue's concept of a **revealing mechanism**, originally intended to uncover stories when users consume food. However, participants saw an opportunity to use the mechanism to reveal the cultures represented by the foods when it's consumed. For

instance, *"I love this concept of revealing. I believe it will make me pay more attention to my food and stay in tune with the other person. I will also feel more curious to explore their food and learn from it culturally, like what it means to them and where it came from (MF)"*. When it came to discussing restaurant environments, participants noted that Japanese restaurants often fail to fully capture the cultural essence, with certain key elements missing. However, they also acknowledged that the metaverse could help bridge this gap. As one participant explained: *"I really want to go to Japan. When I go to restaurants here, they can't capture all the unique elements. They can't make cherry blossom leaves fall in front of you, and you can't experience the night lights of Tokyo. These are things you find on the streets that can't be replicated. So there will always be missing elements (MF)".*

4.5.3.3 Framework Dimension: Dynamic Social Interactions

Summary: This dimension captures the social dynamics of shared dining, from storytelling to communal rituals, whether with strangers or loved ones. It aligns with DICDP1: The stories we tell and DICDP2: Doing things together (see Table 3.4), which emphasised the significance of storytelling and collaborative activities in fostering social bonds. These interactions highlight how immersive technology can support both spontaneous and designed rituals that enhance social connections.

The participants also recognised the opportunity to use the metaverse as a solution for busy lifestyles and long distances, which often lead people to eat alone. As a result, they expressed interest in dining with strangers for various reasons. Participants noted that eating in the metaverse has the potential to reduce the loneliness; *"You can never eat alone again. You can never eat at home again (NE2)"*, and *"I live alone and there is no one to eat with and I don't mind to eat with someone I don't know. At I least I can get the chance to chat with someone while eating (MF)"*. In addition, they showed interest in expanding their social circle beyond their friends and family; *"That's good because I don't always find my family and friends to eat with. I think this is a good alternative to get to know new people in my life (MF)".*

"You can also make a shift in power, you can be involved in a way so that financially you become a part owner of a local farm and also feel more involved with that and then de-centralise power perhaps (E7)." According to [3], by considering the otherwise overlooked intrinsic

value of local food, we can enable people to become more socially and environmentally responsible. In doing so, the metaverse could play a role in reimagining aspects of food systems, such as fostering community engagement around local and sustainable food practices, shared ownership, and deeper consumer awareness.

4.5.3.4 Framework Dimension: Imaginative Exploration and Creativity

Summary: This dimension explores fantastical and surreal dining scenarios that transcend real-world limitations, fostering curiosity and creative engagement. It aligns with DICDP6: Performative eating and DICDP5: Customise everything (see Table 3.4), which revealed participants' enthusiasm for imaginative environments and performative interactions. These findings support the potential for immersive dining to inspire creativity and memorable experiences through fantastical narratives and customisation.

While discussing the ideas like *Light Up*, *Homestaurant*, and *Knock Knock*, participants frequently addressed the potential gimmicky nature of virtual meals. One participant noted, *"A big thing with the metaverse I find, is that things come across as a gimmick. So how do you add real substance to this? What you want to make sure is that there's a real compelling hook to whatever you're building (E3)?"* Another participant questioned, *"Eating in virtual worlds should it be like a gimmick? Or should it be like realistic? I think it's all about the concept itself. But when it comes for food, I don't think I want to eat or to feel I'm eating some sort of animated burger (NE3)."* Another echoed this sentiment, stating, *"food all digital will make it lose its magic (NE11)"*. Gimmicks are a specifically capitalist aesthetic phenomenon, eliciting both charm and suspicion [266]. To avoid them, experts talked extensively about expanding the utilitarian value of the food experiences we are considering. *"I mean, again, things that either have a real journey or a spectacle, that's, you know, gives you a different perspective on things. Or also, if it's actually practical. You know, that recipe creator finder .. you can actually create a recipe and then save it or send it to yourself (E3)."* Value could be added by **giving the users the agency to re-calibrate forgotten or lost knowledge, to reinvigorate the ways in which food soothes and heals, to discover, preserve and create new cultures.**

However, this does not mean *magic* becomes less important: *"But if you offer them something*

unique, something that you wouldn't otherwise be able to try.. that's going to be the catch, you know, so I would say this is where the possibility of creating experiences that go beyond our physical worlds are beyond our imagination (E6)." Participants expressed excitement about the idea of *Im:possible Food*, like trying imaginative dishes that don't exist in real life, such as *"I want to eat something not from this world .. like from Mars."* They believed that adding novel elements could boost creativity and enrich the eating experience: *"Food could become a canvas of art and imagination, offering rare opportunities to create truly new dishes (MF)."* When it comes to eating environments, the metaverse was perceived as offering a unique solution for those unable to travel. Participants talked extensively about enhanced real-world settings and magical environments, highlighting the potential for personalised, interactive, and culturally rich dining that transcends physical limitations. Many expressed enthusiasm for exploring new virtual locations, as one remarked, *"I have to go somewhere literally by myself by driving car would be a very difficult task for me. But in metaverse, I can experience and travel to any place I can experience something I have never tried before (NE4)"* The metaverse allows chefs and restaurant owners to design spaces without physical limitations, as another participant noted, *"In reality, restaurants are limited by cost and space, but in the digital world, you can go wild with design (MF)."* During the interviews, participants' voiced their own ideas building on the catalogue, where they imagined magical eating experiences, such as: *"floating on a dragon, grilling food with its flames (MF),"* *"stepping into a manga movie or something with creatures (NE8)"*, *"eating beside an active volcano (MF),"* or even *"dining inside the human body (MF)."* These scenarios illustrate a notable interest in unique and surreal dining experiences, despite underlying concerns regarding their potential to be perceived as gimmicky.

4.5.3.5 Framework Dimension: Food Literacy and Engagement

Summary: This dimension focuses on enhancing understanding of food through nutritional education, sustainable practices, and interactive exploration. It aligns with DICDP1: The story we tell, DICDP2: Doing things together and DICDP3: Eating and the senses (see Table 3.4), as participants showed interest in interactive learning about food origins and collaborative cooking. These insights underscore the value of integrating storytelling and participatory design to promote mindful and sustainable eating.

The act of exploration, of discovery of knowledge, culture or of others is made possible via immersive technologies. An exploration of food past, present and future can widen food vocabulary, taste perception and stimulate a realisation that context matters. Concepts like *Hot air balloon*, *Kitchen collective* and *Meet food* (to some extent) appeared to animate the people I interviewed, who engaged with the idea of becoming part of hyperlinked journeys, and learning in the process: *"I want to go deep into the ingredients, [..] getting to know them, and then having the opportunity or kind of more guidance on how to use them (E1)."* ; *"Can this journey (i.e., Hot air balloon) take us somewhere deeper? Can I keep going down a wiki rabbit hole: what is the origin of this recipe, what are the related things (E3)."* Similarly, participants showed interest in not only the knowledge gained but also in being part of the cooking process itself. This desire to immerse themselves extended beyond learning about ingredients; participants believed that immersive cooking environments could enrich the cooking experience. Chefs, in particular, expressed a desire to go beyond traditional techniques by accessing emotional insights from their peers during meal preparation, understanding the inspirations behind their dishes. One chef NE3 explained, *"I want to learn the mentality of a successful chef; recipes and tutorials aren't always enough. I need to tap into their emotional and intellectual processes."* The importance of storytelling was also emphasised, with participants proposing mechanisms to reveal the cultural narratives behind dishes, deepening their appreciation of food: *"Imagine telling a fascinating story about a dish's origins, then revealing it. The story would make me more intrigued and appreciative (MF)."*

4.5.3.6 The downside of the metaverse

There's also a downside to the metaverse and we need to consider numerous challenges as we move into a more immersive world, as they threaten privacy, security, mental health, and more [151, 366, 394]. These concerns could be fundamentally distinct from those associated with other technologies and can alter a user's perceptions and interactions with the analogue world [224]. I highlight here several challenges that were brought forward by the experts. **People losing their connection with the real world and becoming attached to their virtual world** was flagged as a key concern for the metaverse [224, 237, 366]. *"That's the part that is a bit problematic – we become tourists of our own reality"* (E2). Besides, this can also lead to emotional disconnect or escapism *"People live in this virtual and metaversal reality*

to escape their true emotions. Over time, they can no longer tell if what they're experiencing is real or if they're living as a puppet in a virtual world (NE1)". Additionally, the filters and features provided by these immersive platforms could have an opposite effect to what we are trying to achieve with this study, disconnecting further the user from their meal *"Do we distance ourselves from our food when we use certain kinds of filters?"* (E7); *"And then to there's a question of personalisation as in everything. The more you start personalising your experiences and enhancing them to the maximum, there's a question of, when will that lead us as a society? Are we going to essentially [...] become addicted to the goods. And are we not going to find join in other things (E5)?"* Exciting opportunities and unique experiences could be afforded by the metaverse as discussed above, however the **overexposure to virtual content might diminish the value and appreciation of real-world experiences**? *"People get bored, you know, you always see people skipping, skipping, skipping through their songs. I wonder how it is going to play here if you have access to almost any experience that you want (E6)?"* This can lead to **technology dependency and addiction** *"I can also see how addictive and powerful this can be as a tool, just by looking at how powerful the simple screen is right now in social media and how it affects your global life. So the biggest concern is the unethical usage of these technologies and the potential that they have (E5)"* and *"it can impose a negative impact on people's behaviour as it can develop a new type of addiction. Moreover, this technology can make people undervalue their self-worth (MF)"*, and "*I started thinking about how, in this day and age, we're constantly seeking dopamine, especially with our continuous consumption of social media. This could be a similar case (NE11)".* Spending hours and days in a virtual world without being physically active or engaging in social activities can lead to **social anxiety, eating disorders, increased feelings of loneliness, and other psychological effects** [27, 151]. For instance, (NE5) raised concerns about eating disorders, stating, *"I believe there's more to consider when it comes to eating in the metaverse. It shouldn't revolve around overeating, like in Mukbangs".* Moreover, the **information overload** that comes with the technology integrated in all our daily activities can exhaust and demoralise us *"I do have concerns about information overload and commercialisation (E5)."*

Data collection and sharing with other parties has wide implications in regards to **privacy**, as highlighted by experts: *"Today, there are things about me that not everybody has. The*

minute when everything becomes digital – the control of it, is gone." (E4). Considering the additional data layer brought by the metaverse, cybersecurity presents a significant threat [224]. Thus, it is essential to determine **who is responsible for data security**, who will protect it from cyber attacks, and what happens in the event of a data violation incident [1, 394]. However, managing and controlling virtual content is more complex and challenging in the metaverse due to the vague line of boundaries between the analogue and the virtual world [1, 394]. *"Ethical aspects in who manages the data might become a concern"* (E1).

Cybersickness is yet another problem which might affect one in two VR users, making these solutions uncomfortable and unusable *"What is the best technology to be used in these scenarios? How do you eat with a headset on? How to design these avatars and visuals without losing the connection and the engagement of seeing the real portion of the food and the hand gestures of your co-diners? Hearing somebody chew into a mic..basically, it's like a nightmare (E3)."* This points to the need of conducting various design investigations in this space, which go beyond paper prototypes, looking into how people perceive these technologies and how they can or cannot be integrated in various food-related activities. There are also **technical challenges**, as the metaverse and virtual worlds are still in development, raising concerns about the convenience of hardware. As (NE5) pointed out, *"Most people in Western cities prioritise quick and convenient options over investing time and energy into selecting food, wearing heavy glasses, and logging in. People in Western cities value convenience."*

A summary of important features to consider, with their potential benefits and risks outlined in the (Table 4.5).

# DICom Framework Dimension	Potential Benefit +	Potential Risk -
1) Multisensory Immersion	Creating rich, sensory experiences for mindful and engaging dining. Enhances emotional connection and imagination.	Cybersickness, overstimulation, and detachment from physical food sensations.
2) Cultural and Contextual Richness	Celebrating diverse cultural practices, traditions, and food narratives. Deepens appreciation and identity.	Risk of cultural misrepresentation or oversimplification. Lack of authenticity.
3) Dynamic Social Interactions	Facilitates storytelling, communal rituals, and connection with friends, family, or strangers.	Potential for exclusion, loss of authenticity, or reliance on superficial interactions.
4) Imaginative Exploration and Creativity	Encouraging fantastical and creative dining scenarios that transcend real-world limitations. Boosts engagement and novelty.	Overexposure to fantastical elements could lead to gimmickry or reduced appreciation for real-world experiences.
5) Food Literacy and Engagement	Promoting knowledge about nutrition, sustainability, and cooking techniques. Enhances awareness and responsible eating.	Information overload or losing the experiential aspects of food in favour of technical details.

Table 4.5: Summary of DICom framework dimensions with their potential benefits and risks.

4.6 Summary

In this research, I adopted a generative approach that emphasised the positive aspects of the metaverse – such as negating physical distances, providing immersive experiences, and serving as a catalyst for creativity and inspiration. By focusing on these positives, I uncovered new opportunities and suggest potential directions within this evolving landscape. My findings highlight key elements and design directions that I hope will inspire designers to create humane solutions for the (food) metaverse.

I believe that sharing this work is timely, given the nascent state of the metaverse. However, I also address the risks associated with the widespread adoption of these technologies, which should not be underestimated. These risks can range from exacerbated body image issues to increased social withdrawal. Therefore, I recognise the need for further investigation into the opportunities and risks of the metaverse, particularly in light of individual differences,

cognitive, affective, and social purposes, and the specific goals people pursue in virtual worlds.

I view technology, including the metaverse, as a tool—much like a hammer that can either build or destroy, depending on its use. It is not the tool itself that determines its function, but rather the intent behind it. I believe that human-centric design can leverage the technologies of the metaverse to foster better connections with food, rather than detracting from our current practices. Through this chapter and my thesis, I envision a positive future that reconnects people with food, enhances appreciation for it, and encourages sustainable dietary choices.

To explore this vision, I employed co-design methods, collaborating with participants from diverse backgrounds to co-imagine how our relationship with food can be shaped in the metaverse. Together, they identified 18 important elements—aspects they value in their daily food practices (RQ1) – and envisioned desirable interventions within the metaverse. I further refined their ideas into a catalogue of speculative concepts (RQ2), which served as conversation prompts with experts and non-experts. These discussions provided valuable insights into the potentials and pitfalls of the metaverse in our food lives (RQ3) and deepened my understanding of the implications and limitations of my work.

Through discussions with experts and non-experts during the evaluation of the catalogue, I identified five key dimensions (RQ4) that constitute the foundation of the DICom framework as presented see in (Table 4.5). These dimensions provide a comprehensive guide for designing meaningful and user-centred food experiences enhanced by immersive technologies.

Building on the findings from these lo-fi prototypes, I will develop a functional prototype that embodies these dimension, allowing for a more immersive exploration of the proposed design concepts in Chapter 5. By involving a broad range of participants, I aimed to explore the value of my early, speculative ideas and the design qualities underlying them. This process enabled me to gain a rich understanding of how both average citizens and experts from relevant fields perceive the transformations the metaverse will bring to our lives and the emerging opportunities for designing a meaningful (food) metaverse. However, I acknowledge the several risks associated with this space, and I discuss these concerns, which are supported by my conversations with experts.

Chapter 5: Exploring the Dynamics of Immersive Eating



Figure 5.1: The physical and virtual setup of the VR eating experience.

5.1 Overview

This chapter builds directly on the empirical insights and conceptual developments established in Chapters 3 and 4. In Chapter 3, the exploratory study of remote dining using AR-enhanced video calls revealed six Design Potentials for Digital Immersive Commensality (see Table 3.4), which highlighted participants' spontaneous behaviours, such as performative eating, playful gestures, narrative sharing, and the desire to engage the senses beyond the screen. These emergent behaviours suggested a need for more immersive, culturally flexible, and socially dynamic environments that support new forms of connection and expression during remote meals.

Chapter 4 responded to this need by exploring speculative future scenarios for food experiences in the metaverse. Through co-design workshops and experts' feedback, five core di-

mensions of the DICom framework were established (see Table 4.5): Multisensory Immersion, Cultural and Contextual Richness, Dynamic Social Interaction, Imaginative Exploration, and Food Literacy and Engagement. These dimensions translated the behavioural insights from Chapter 3 into actionable design principles. Chapter 5 puts these insights into practice by designing and evaluating a Wizard-of-Oz VR prototype that integrates both the DICDPs and the DICom framework dimensions. For example, the prototype's use of scent and environmental transformation reflects "Multisensory Immersion" (Chapter 4) and builds on the DICDP of "Eating and the senses" (Chapter 3). Thus, Chapter 5 operationalises the theoretical findings of the previous studies, testing how these combined insights can create engaging, emotionally resonant, and socially meaningful immersive dining experiences.

This chapter details the development, testing, and analysis of a Wizard-of-Oz prototype, a method chosen for its flexibility in simulating complex interactive systems before full-scale implementation. I describe the iterative design process, informed by insights from surveys and user feedback, which shaped the prototype's features. The chapter also outlines the testing methodology, which included remote trial sessions with 14 participants, semi-structured interviews, and a follow-up survey conducted two months later. The findings are organised around key insights into the feasibility and transformative potential of the prototype. These insights not only validate aspects of the framework but also reveal new directions for enhancing user engagement, fostering cultural appreciation, and reimagining the social dynamics of eating.

5.2 Introduction

In contemporary society, technology frequently intertwines with our eating habits. Many view it as a mealtime intruder, with individuals becoming more absorbed in their screens than in their meals or companions [300]. Yet, the Human-Food Interaction (HFI) community is deeply invested in exploring the multifaceted ways in which technology can enrich, enhance, and transform our food experiences, as shown in a systematic mapping study of HFI research by Altarriba et al. [10]. One of the areas that has generated interest recently is digital or computational commensality [269, 344], which refers to commensality mediated or enhanced by technology. Digital commensality proposes that technology can do more than just coexist

with our dining experiences – it can actively enrich them, fostering deeper connections with our food and fellow diners. Within this technological landscape, immersive technologies stand out, adding layers of complexity to the debate. They promise experiences that could elevate the communal essence of meals, allowing individuals, regardless of their physical location, to be co-located and share the same virtual table. This was partially explored in systems which capitalised on the strong social connotations shared by food and play [340], which used immersive technologies to enrich playful social eating experience (e.g., *You better eat to survive* [23], a VR game that aimed to build trust by creating dependencies around cooperative eating activities). However, there is also apprehension, with some fearing it might further increase our food intake Wang et al. [383] or alienate diners from the authentic touch and feel of traditional meals [344]. Interestingly, there is a spectrum of possibilities in-between these two extremes that has not been explored in depth. Here, my aim is to delve into these uncharted areas through an exploratory study, breaking down the layers of immersive commensality experiences to identify where they can add value and where they might not be as effective.

My approach is grounded in the understanding that commensality is not solely about the shared eating experience; it is equally about deepening our relationship with others and with the food itself. Informed by this holistic perspective, in this study, I formulated the following research questions to guide my investigation:

1. To what extent can immersive technologies foster meaningful social connections and redefine eating rituals, and what are their limitations in doing so?
2. How do users experience food choices, eating habits, and sensory emotional engagement within digital immersive commensality settings, and where might immersive technologies fall short?
3. How successfully can immersive eating experiences authentically represent cultural and culinary traditions?

To better understand the complexities of immersive commensality, I designed a Wizard-of-Oz prototype because paper prototypes, while valuable, proved insufficient in capturing the full depth of user interactions and sensory experiences involved in shared dining. My motivation

stemmed from wanting to address these limitations and create a more holistic approach to studying how people engage with such systems. To design this prototype, I first drew insights from how participants evaluated the paper prototypes described in the catalogue. Through analysis of the data collected in the previous chapter and validation with existing literature, I conceptualised five key dimensions that define the DICom framework, providing a foundation for designing immersive and meaningful dining experiences: Multisensory immersion, Cultural and contextual richness, Dynamic social interactions, Imaginative exploration and creativity, and Food literacy and engagement. Recognising the need to ground these features in user input, I conducted a survey to interrogate users further and refine the implementation of the system. The outcome was a Wizard-of-Oz multisensory prototype for immersive commensality, which I tested with 14 participants. By analysing their interactions, I gained deeper insights into how people experience shared eating environments. Data collection included audio-visual recordings and interviews conducted during and immediately after their engagement, complemented by a follow-up survey distributed two months later to assess the lasting impressions of the experience. This reflexive analysis revealed critical opportunity spaces and offered a more nuanced understanding of immersive, food-centred experiences.

This study and its outcomes were led by myself as the main researcher, with active involvement across all stages from initial planning and design to data collection, analysis, and final write-up. My supervisor, Dr. Alexandra Covaci, provided ongoing support and guidance throughout the process and assisted in analysing the data and shaping the discussion. Developers Khaled Alhasan and Moniem Isa contributed to the design and implementation of the prototype, helped demonstrate the VR sessions, and supported data collection and interviews. Guidance and analytical insights were also provided by Prof. Carlos Velasco and Dr. Ferran Altarriba Bertran, whose expertise informed key aspects of the study. Together, this collaborative team supported the research through technical input, discussion, and reflection.

5.3 Background

This section presents a focused synthesis of literature related to digital immersive eating experiences, with the aim of articulating their interconnections and theoretical implications. While Chapter 2 provided a broad examination of digital commensality in HFI and digital

immersive commensality, the discussion here extends that foundation by critically exploring the progression from conventional tele-dining systems to fully immersive dining environments. The inclusion of this targeted literature review within Chapter 5 is intentional, as it directly supports the conceptual framing and methodological rationale of this study. By engaging with recent advancements in immersive technologies particularly their application in digitally mediated commensality, this section establishes the theoretical grounding necessary to inform the design, implementation, and analysis of the Wizard-of-Oz prototype developed in this chapter.

5.3.1 From tele-dining to immersive dining

While tele-dining systems have paved the way for innovative platforms and tools facilitating shared meals, they inherently impose limitations on the scope of digital commensality. Previous studies, such as KIZUNA [264] and CU-Later [364], have explored digital commensality tele-dining systems based on pre-recordings. These studies revealed the importance participants attributed to the synchronisation of their eating behaviours during screen interactions in order to feel as though they were truly sharing a meal together. However, further research based on live interaction indicates that people require more than just visual presence on the screen while eating. Alhasan et al.[6] showed that both friends and strangers sharing a digital meal, display behaviours emphasising the importance of not only synchronising movements, but sharing spaces and multisensory experiences during the meal. These could be facilitated through immersive technologies.

Indeed, the integration of immersive technologies such as Augmented and Virtual Reality (AR/VR) in the food industry has been receiving attention by multiple stakeholders, with potential to enhance customer experiences, improve training and education, revolutionise product development and marketing, boost operational efficiency, and promote sustainability and consumer awareness (e.g., Dorsey, 2017)[1]. For example, VR and AR are being applied in novel ways, from immersive dining and augmented menus to virtual taste testing and interactive marketing experiences [374]. These technologies also offer practical solutions for staff training, culinary education, supply chain management, and kitchen design, with the

[1] https://techcrunch.com/2017/12/25/how-augmented-and-virtual-reality-will-reshape-the-food-industry/?guccounter=1

added benefit of educating consumers about the sustainability of their food choices. The expansion of VR and AR in this sector is fuelled by technological advancements, reduced costs, and a growing consumer appetite for immersive experiences. Despite varying adoption rates due to factors like consumer acceptance and cost-effectiveness for businesses, the food industry appears to be interested in the transformative changes through the increased application of VR and AR technologies (e.g., [385]).

Here, it is important to mention, though, that the scepticism has gravitated around the idea of how increasing integration of technology in eating and food experiences has the potential to distance individuals from the communal aspects of dining. For instance, the use of smartphones and other digital devices at the dinner table can divert attention away from mindful eating and conversations and shared moments, undermining the social bonding that meals traditionally support [93, 241]. Whilst the specific effects of a given technology in our eating experiences may depend on the way in which it is used, it is nevertheless worth acknowledging that technologies themselves afford action. Moreover, it is essential to consider the specific effects – physiological, psychological, and social – of immersive technologies such as AR and VR on our eating experiences, particularly given the limited research in this area.

Despite the scepticism surrounding immersive technology's potential to distance individuals from the communal aspects of dining, and from the food itself, a small number of studies have looked into the intersection of food and immersive technology, embracing playful approaches. One of these examples is *You Better Eat to Survive* [23], a two-player VR game that involves eating real food to survive and ultimately escape from a virtual island. This study integrated the gustatory sense not just as an additional game input, but as an integral element to the game experience. This highlights the promising direction for future inquiry, as the fusion of food with VR could foster immersive cross-modal gameplay experiences, not only transforming the absence of visual food cues into an engaging game element but also potentially influencing individuals' relationships with food. By exploring beyond conventional methods and harnessing immersive digital platform capabilities, we can craft experiences that transcend reproductions, introducing entirely novel paradigms of shared dining, as suggested by Velasco et al.[369].

Building on these foundations, multisensory VR technologies are increasingly being recog-

nised for their potential in supporting the management of disordered eating behaviours, offering novel interventions that address both overeating and dietary restriction. VR-based cue exposure therapy has demonstrated effectiveness in reducing binge eating episodes and food cravings by allowing individuals to confront food-related stimuli in immersive, controlled environments that promote the development of healthier emotional and behavioural responses [53, 236, 267]. In parallel, research has shown that VR interventions employing body-swapping, avatar embodiment, and virtual mirror exposure can improve body image perception and reduce anxiety associated with food intake in individuals with restrictive eating disorders such as anorexia nervosa [295, 309, 310, 320]. These approaches are further supported by systematic reviews highlighting the efficacy of multisensory VR in enhancing body satisfaction and mitigating disordered eating behaviours through the integration of visual, olfactory, and haptic cues [25, 34, 74]. Collectively, this shows the value of VR not only in shaping more engaging and interactive food experiences, but also in contributing to the development of balanced, ethically informed interventions that support both mindful restriction and recovery from overeating within immersive, sensory-rich environments.

Despite the potential of multisensory experiences in VR and its immersive capabilities, head-mounted displays (HDMs) can significantly constrain the types of food that users are able to consume during virtual dining. The physical bulk of most HDMs often obstructs natural eating motions, making it difficult to bring food to the mouth, especially items that require two hands or involve utensils. As a result, users tend to prefer easily manageable, bite-sized foods that can be consumed with minimal mess and coordination [216, 340]. This limitation not only affects the practicality of immersive dining experiences but may also influence users' food choices and overall engagement with the meal. Research by Velasco et al.[372] further highlights that these physical constraints may alter the multisensory aspects of dining, potentially diminishing the richness of the experience and the perception of satiety.

5.3.2 Rethinking human-centric design in immersive food interaction

Recent work has started to look into identifying the essential elements that would guide the creation of human-centric immersive food experiences, anchoring the dining experience in both sensory and socio-cultural aspects. Studies like [84, 88, 130, 376] serve as initial

guides in this direction. For example, Gayler and co-authors conducted a complex analysis, which involved a systemic literature review encompassing 109 papers that focus on varied dimensions of eating experiences, followed by interviews with 18 professional chefs [130]. This diverse data revealed five key implications for crafting future HFI designs: (i) considering multisensory flavour experiences; (ii) supporting both intrinsic (specific to the food) and extrinsic (associated with the food but not specific to it) sensory stimuli; (iii) establishing a profound connection between flavour and emotion; (iv) integrating social and cultural narratives associated with eating; (v) and orchestrating a dramaturgical climax within the dining narrative. Some of these directions were also supported by Deng et al. [88], who looked at current work in the area of HFI and identified areas of interest such as (i) considering multisensory experiences; (ii) the need to reinforce commensality and social bonds; (iii) promoting better choices for health and the environment. Covaci et al. [84] focused on the emergence of the metaverse and took a user-centred approach, which involved diverse participants in a series of co-design workshops, where they imagined the desirable interactions with technology around food. The study aimed to inform HFI designers about the elements people consider important when it comes to their food lives, and to inspire further research with a catalogue of speculative ideas which imagine food-centred applications for the metaverse. However, while speculative studies like those of [84, 142, 277] offer intriguing insights into the potential of interactions with immersive technologies during meals, they also present limitations. Specifically, the heavy reliance on storyboards and other traditional representational techniques may not adequately convey the depth and richness of immersive experiences in a mealtime context. Storyboards, by their very nature, are static and two-dimensional, often failing to capture the multisensory, dynamic, and immersive nature of eXtended Reality (XR). I argue that immersive eating, as a concept, is intricate and layered. Therefore, to genuinely comprehend its potential and how it changes (or not) users, it necessitates the creation and manifestation of tangible prototypes that require active user engagement for a true understanding. As suggested by Krauß et al. [218] – in a more generic XR context – an active engagement bridges the gap between imagination and reality, allowing users to grasp the nuances that storyboards or other representational tools might miss.

5.4 Methodology in a nutshell

The primary aim of this study was to develop a user-centric prototype for immersive commensality, focusing on understanding user behaviours and identifying engagement and interaction opportunities within immersive eating environments. The goal was to strengthen connections both among participants and with the food itself. To achieve this, I adopted a flexible and creative approach, guided by the research-through-design methodology in HCI, as outlined by Gaver et al. [128]. This methodology values adaptability and innovation over rigid standards, framing design as an iterative, exploratory, and often "messy" process. Gaver et al. also advocate for the use of annotated portfolios to document and share design insights drawn from practical examples rather than abstract theories; the annotated portfolios were adopted through presenting a catalogue[2] of speculative food-related concepts for the metaverse, developed during earlier phases of the research over six months (see Figure 5.2). These were not just abstract ideas but were grounded in participant input and framed as annotated design artifacts that communicate specific possibilities for immersive food interactions. This catalogue was used to guide the design of the Wizard-of-Oz prototype, helping to bridge speculative design with practical experimentation.

This chapter builds upon the foundation established in Chapter 4 Phases 1–3 (see Figure 4.2), which identified key dimensions of DICom experiences (see Table 4.5). To evaluate and refine these dimensions, I developed a Wizard-of-Oz prototype, providing a controlled environment for participants to engage with and explore the framework's features in an immersive dining setting. This approach not only allowed for a practical examination of the framework's potential but also facilitated an in-depth understanding of the opportunities and pitfalls within this emerging design space.

Given that cultural considerations, particularly those associated with Japan and Italy, emerged as prominent themes during Phases 1–3, I made a deliberate decision to focus on Japanese cultural elements as a central aspect of the prototype design. This choice was made prior to seeking additional feedback to ensure the prototype reflected culturally rich and meaningful scenarios. To further refine the system design, I conducted a survey with 32 participants, featuring open-ended questions about desirable interactions and specific cultural landmarks,

[2] `https://bit.ly/metafoodcatalog`

such as the Torii gate, Japanese bride, cherry blossoms, and hot springs. Responses were analysed using semantic thematic analysis [52], and the insights gained directly informed the prototype's development.

After developing the Wizard-of-Oz prototype based on users' feedback, I conducted seven remote trial sessions with 14 participants. These sessions were recorded in both VR and the physical world and followed by semi-structured interviews immediately after the experience. Additionally, a follow-up survey was distributed two months later to capture long-term impressions. These methods were designed to provide a comprehensive understanding of user interactions and address the study's research questions. Both the interviews and the follow-up surveys were analysed using reflexive thematic analysis [49, 51]. The study protocol was approved by the Faculty of Sciences Research Ethics Advisory Group of the University running the study (ref: CREAG009-11-22).

5.5 Methodology rationale

This study is based on a Research through Design (RtD) approach [128], which aligns with the iterative and practice-led nature of HFI research. RtD was particularly appropriate here, as it enabled fluid transitions between conceptual exploration and practical application supporting the speculative, user-driven, and experiential aims of the immersive eating prototype. As the study evolved, methodological choices shifted accordingly; early phases centred on exploratory engagement and idea generation, while subsequent stages involved iterative design and empirical evaluation. Importantly, RtD played a key role in shaping the development of the Wizard-of-Oz prototype [37, 97], which was used to explore and assess the DICom framework's dimensions in action. Unlike the speculative catalogue introduced in Chapter 4, which provided design directions, the prototype made it possible to observe detailed, embodied, and multisensory interactions essential for understanding the dynamics of immersive digital commensality. Compared to more linear or detached methodologies, RtD offered the responsiveness and adaptability required to produce a richer, grounded, and experientially validated design outcome.

The Wizard-of-Oz (see Section 5.6) method was selected to simulate immersive and multisen-

sory features without the need for a fully functional VR system. Given the speculative and exploratory nature of this study, Wizard-of-Oz allowed for controlled, cost-effective testing of user experiences, capturing authentic emotional and social responses through real-time manipulation of environmental cues like scent, sound, and visuals. Alternative methods such as fully developed prototypes or simple enactments were considered but found unsuitable; building a complete system was technically and logistically unfeasible within the project's scope, while enactments approaches lacked the realism needed to study embodied and affective user behaviours. Wizard-of-Oz thus provided the ideal balance between experimental control and experiential depth bridging speculative design with empirical evaluation.

For analysis, I employed reflexive thematic analysis [49, 51] (see Section 5.8.5) to interpret the qualitative data gathered during the prototype evaluation. This approach enabled open-ended, iterative engagement with the data while recognising the researcher's active role in meaning-making. It was particularly suited to this chapter, as it allowed both surface-level (semantic) themes and deeper, (latent) insights to emerge from participants' behaviours, reflections, and impressions. Reflexive thematic analysis complemented the RtD methodology by adding a rich interpretative layer that moved beyond basic categorisation capturing the nuanced, embodied experiences of users within immersive and multisensory dining contexts. In parallel, I applied inductive semantic thematic analysis [49, 51, 52] to conduct a survey responses; which focused on participants' feedback regarding specific design features of the prototype (see Section 5.6.3). This method helped identify recurring descriptive themes related to memory, emotional resonance, behavioural shifts, and usability aspects offering a complementary, surface-level perspective that informed both the evaluation and future refinement of the DICom system.

5.6 Designing a Wizard-of-Oz prototype for immersive commensal eating

Based on the earlier phases discussed in Chapter 4 (see Figure 5.2) and supported by the existing literature (see Chapter 2), feedback from both experts and non-experts on the speculative catalogue revealed recurring themes. Notably, there was a strong interest in experiencing Japanese culture, which consistently stood out in the feedback. Therefore, Japanese

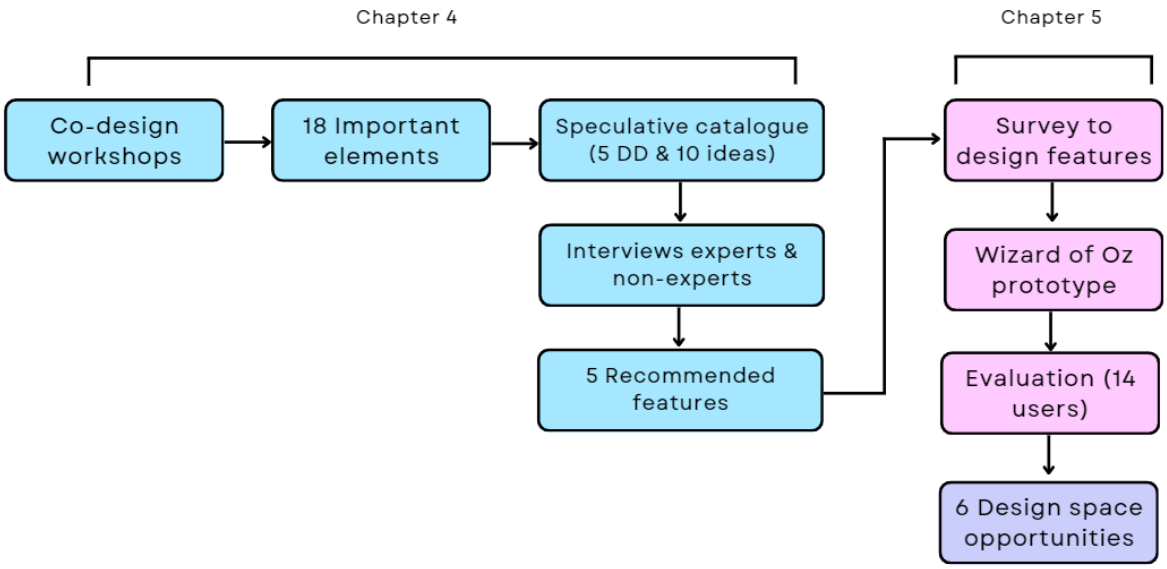


Figure 5.2: The phases of the design process that led to the development of the Wizard-of-Oz prototype.

culture was selected as the foundation for the design. Additionally, the feedback and analysis aligned with the framework dimensions introduced earlier, leading to the identification of five key dimensions that guided the design process: Multisensory Immersion, Dynamic Social Interactions, Cultural and Contextual Richness, Imaginative Exploration and Creativity, and Food Literacy and Engagement (see Table 4.5). These dimensions informed both the thematic focus and the experiential design of the immersive eating prototype. However, to design a VR system that integrates these features in a user-centred manner, it is important to gather further input from users to understand how they envision such a system in practical terms and how they would like these features to be implemented. To achieve this, a survey was conducted to engage participants and gain deeper insights into their perceptions and practical preferences regarding these five features. The following sections provide a detailed explanation of the design process.

5.6.1 Participants

The survey involved 32 participants who were recruited from social media platforms (Instagram and Facebook). There were no specific requirements or inclusion criteria for participant selection, as the aim was to gather a broad range of perspectives rather than target a specific demographic. All participants were briefly informed of the study's purpose and provided informed consent.

5.6.2 Data collection

To map participants' imaginative ideas to specific features and understand how to implement them, I conducted a Google form survey with 32 participants to gather qualitative data on how people envision a Japanese cultural eating experience in virtual reality, as well as how they would want the system to behave. The aim of this survey was to explore these envisioned features in depth and gather practical feedback to inform the design of our prototype. To achieve this, I asked three key questions: 1) Transport yourself to a magical Japanese dining experience in virtual reality. Describe in detail the surroundings, ambiance, and your dining sensations. 2) Transport yourself to a magical Japanese eating experience in VR. Describe in detail how you would like to interact with food and the other elements of that world. 3) What issues do you hope to address through this VR eating experience? Are there specific features that could help you improve your eating habits?

The qualitative feedback gathered from this survey serves as a foundation for translating user expectations into actionable prototype features, ensuring alignment with both cultural significance and technical feasibility.

5.6.3 Data analysis

The survey gathered qualitative insights from 32 participants to inform the design of precise and actionable features for a Japanese cultural eating experience in VR. The responses provided a foundation for mapping participants' imaginative and practical expectations into concrete design elements for the prototype.

Using an inductive semantic thematic analysis process [49, 51, 52], I identified detailed ideas and preferences expressed by participants. The analysis involved four researchers and two developers. I served as the lead researcher. The team began with a week of familiarisation, independently reading and re-reading the data to gain an overall sense and note initial impressions. Each researcher then independently generated data-driven codes such as "cherry blossom", "sharing", "Japanese music", and "eating pace" by breaking the data into meaningful segments. Through immersive engagement and iterative rounds of discussion, the team refined and clustered the codes into overarching semantic themes based on explicit participant

expressions. These themes reflected desires for culturally rich, sensory-immersive environments (cherry blossom, Japanese music), mindful eating (eating pace), and social interaction (sharing). To ensure feasibility and technical accuracy, I worked closely with two developers throughout the analysis, translating abstract ideas into implementable design features while considering practical constraints. The resulting insights directly informed the design of the prototype, as detailed in (Section 5.7).

To ensure inter-researcher reliability during the inductive semantic thematic analysis, I took specific measures to align the team with the methodological stance of the study. Prior to beginning the analysis, I conducted a detailed briefing session with the research team to explain the principles of inductive, semantic-level analysis, drawing on Braun and Clarke's guidance. This included clarifying the importance of focusing on participants' explicit meanings rather than latent interpretations and maintaining a data-driven, bottom-up approach. All researchers were provided with a shared coding protocol and example excerpts to establish consistency in how data segments were interpreted and coded. During the familiarisation phase, each team member independently engaged with the full dataset, and our initial discussions were used to calibrate interpretations and resolve any discrepancies in coding style or focus. Iterative group meetings throughout the analysis ensured ongoing alignment and collaborative dialogue, helping to consolidate a coherent set of semantic themes that remained grounded in the participants' expressed perspectives.

5.7 Prototype features

5.7.1 Multisensory immersion

During the analysis, I observed a notable focus on multisensory elements such as sound, smell, touch, temperature, and taste. This emphasis suggests that these sensory aspects significantly shape user interaction and emotional connection with the prototype. For instance, in discussing sound, seven participants envisioned **natural outdoor** sounds such as **crickets** and six participants mentioned **hot springs water**. Examples include statements like *"I would like to hear the cricket sounds in a Japanese summer (PS1)*[3]*"*, and *"I would*

[3]Data source: PS = Participant Survey.

love to listen to the hot spring water (PS3)". Eight other participants suggested culturally inspired **Japanese music** as background music to establish a relaxing atmosphere, such as *"letting the soothing Japanese melodies of music create a peaceful ambience (PS13)"*. When it came to smell, participants frequently referenced **outdoor scents**, particularly **cherry blossoms**. Nine participants mentioned this, with comments like *"Sakura blossoms can be smelled (PS28)"* and *"I want to be able to smell the cherry blossom and the garden (PS25)."* Taste also held importance, with 14 participants mentioning **eating sushi** *"I would like to eat sushi in this environment (PS30)"*, and 11 participants expressing a preference for the **flavour of matcha**, as illustrated by *" I would enjoy the evening with a Japanese matcha (PS3),"* and *"representations of matcha plants (PS18)"*. Beyond sound, smell, and taste, participants also valued the experience of **temperature**, often associating it with an outdoor setting and the sensation of **wind**. Six participants expressed a desire to feel the wind, as *"I would like to be able to feel the sakura leaves coming onto my face with the wind (PS14)."* Additionally, texture played a role in their envisioned experiences, particularly **the feel of grass** beneath their feet. Three participants shared this sentiment, with thoughts like *"I would love the experience of sitting on the grass and feeling its texture beneath me (PS9)"*.

Incorporating multisensory elements could facilitate a more immersive, semantically rich, and emotionally engaging experience, deepening interpersonal connections [54]. This connection could be further reinforced by combining sensory cues associated with specific themes and familiar elements [129], as PS2 expressed: *"Sharing our senses together in one space will make our conversation more interesting, and I'll feel that we are truly together, not talking from a distance"*. By activating multiple senses simultaneously, participants could become more mindful of the nuances in their environment and the food they consume, heightening their appreciation of its texture, taste, and more. As PS7 remarked, *"experiencing the senses is key here because it enables mindfulness about your food. It's like dining in a dark restaurant; you focus on and appreciate the senses more"*.

5.7.2 Cultural and contextual richness

Given the strong interest in Japanese culture, I posed more targeted questions in this survey to gain deeper insights into participants' perceptions and to use their feedback as a foundation for

my prototype. For instance, I asked participants to describe their associations with Japanese culture and identify specific elements they would like to see in a virtual environment.

The results showed that 23 out of 32 participants preferred experiencing Japanese culture in an **outdoor setup**, particularly within a **Japanese garden** setting. One participant described it as: *"Eating while sitting near a nice view or some nature, like a Japanese garden (PS6)"*. Additionally, when asked about symbols they would like to see in such a garden, participants expressed a preference for specific **Japanese landmarks**. The **cherry blossom**, for example, emerged as the most prominent **natural landmark**, favoured by 21 participants. Participants also expressed interest in **spiritual landmarks**, with 10 suggesting hot springs, 11 highlighting the **Torii gate**, and 8 mentioning a **Japanese bridge**. Culinary elements also played a key role in shaping participants' perceptions of Japanese culture. 14 participants identified **sushi** as the most representative food of Japan, with one participant stating, *"You can't think of Japan without sushi it's ingrained in their culture (PS1)"*. Additionally, 11 participants highlighted **matcha** as an essential element of Japanese cultural rituals, emphasising its significance. As one participant noted, *"matcha is a respected ritual that reflects the principles of harmony, respect, purity, and tranquillity (PS3)"*.

5.7.3 Dynamic social interaction

Participants mentioned an interest in environments that deeply evoke **memories and emotions**. As one participant shared, *"It would be great if the other person and I could travel remotely and share our travel experiences and memories (PS4)"*. Furthermore, seven participants emphasised the importance of incorporating multisensory elements to trigger **stories**, memory-sharing, and emotional connections. One participant explained, *"I think multisensory experiences can create a lot of meaningful memories. For example, smelling something might remind us of a memory we can share, or seeing something in the environment might prompt us to tell a story from our personal lives (PS8)."* This highlights how sensory stimuli can act as triggers for storytelling and emotional bonding. Research by Velasco et al. [375] and Gupta et al. [142] highlights the importance of integrating taste and smell in storytelling due to their cultural and emotional significance.

Sharing a **similar dish** was mentioned by eight participants as a way to foster emotional

connections and build trust. They explained that having the same dish encourages **trust and openness** to sharing **personal stories**, noting, *"eating the same dish fosters trust and encourages a greater willingness to share personal stories which is why it is commonly served at business meetings (PS7)"*. As well, sharing the **same environment** was desired by 16 participants to create a sense of unity and togetherness. One participant elaborated on how this shared setting could strengthen emotional connections during activities like dating, stating, *"I think people nowadays don't just crave food; they crave emotions. When I eat with someone, I want to share the same experience and feel a sense of unity, both of us being in the same environment and experiencing the moment together (PS22)"*.

Socialising with strangers in a immersive setup can be beneficial for introverts and people with disabilities, **providing a low-pressure setting to connect**. A participant noted, *"Many people who are introverted or disabled rely on these experiences to feel free from their disabilities and connected. Sharing this virtual space allows them to practice social interactions comfortably. Using avatars and a 3D world removes the focus on physical appearance, enabling genuine conversations and even dating opportunities (PS22)"*. Engaging in shared meals within a virtual setting can also have **positive effects on mental health** by offering connection and meaningful conversation. As one respondent highlighted, *"This benefits mental health by fostering connection and meaningful conversation. Families who share meals and talk around the dining table tend to bond more closely (PS30)"*. In full scope, when participants were asked about challenges in their daily eating experiences, the social aspect emerged as a significant dimension, with many expressing interest in sharing meals virtually with strangers due to challenges in finding family or friends available, which helps reduce loneliness and fosters connection [190, 239]. Sharing meals virtually with strangers has the potential to offer a low-pressure environment that fosters openness, reduces social barriers [6], and has positive effects on mental health [349], particularly benefiting introverts [149], people with disabilities [203], and those seeking meaningful interactions.

This desire for shared environments and emotional connection extended further, as six participants highlighted the importance of **playful elements** to foster meaningful and playful interactions. One participant shared, *"I would love to date someone and connect with them emotionally. I feel that a virtual setup can help express emotions in unique ways or allow for playful interactions in public without feeling embarrassed, since it's virtual. I'd love to*

explore playful and fun activities that can help uncover this side of me (PS17)". Building on the need for meaningful connections, four participants addressed the challenges of expressing emotions in real-life settings and proposed the use of **avatars** as a solution to help them open up emotionally. One participant explained, *"I think avatars can help people open up more while eating, as it feels like being invisible and less self-conscious (PS18)"*. Having avatars, could create a sense of ease and freedom, enabling individuals to share their emotions more comfortably in virtual environments.

5.7.4 Food literacy and engagement

One of the most mentioned interests by the participants was accessing nutritional information. Indeed, by making users aware of the nutritional content, we could prompt participants discussions and understand how this affects their nutrition intake [228]. To explore this feature more deeply, I asked participants to specify the type of information they were looking for, 20 participants expressed that visible **calorie information** could enhance their decision-making process. They found it more immediate and impactful in a virtual environment compared to the often ignored labels and texts in real life. *"I need to have calorie and food data readily available because I dislike reading labels and often overlook the consequences. If this information is more prominently displayed, I might take it more seriously or if I can have direct consequences in the virtual world like losing coins or features or items (PS5)"*. As well as, *"with VR it feels like it's right there on my face NOW! This creates a sense of urgency of making healthier decisions because I'm immersed in this virtual bubble. [..] eating while watching TV or mobile screen, creates a sense of distance. However, VR creates a new immersed reality making me feel more obligated to follow it (PS18)"*.

Another key interest among eight participants was learning more about the food's **recipe and ingredients**. One participant noted, *"I would like to know more about the food's background, recipe, and ingredients (PS17)"*. Beyond knowing the recipe and the calorie intake, nine participants expressed a keen interest in learning about the **cultural history** and traditions associated with the food. This knowledge could add depth and appreciation to their dining experiences. As one participant noted, *"I really want to learn about the history of the dish and its cultural importance. I eat these dishes in many restaurants but often don't know the*

meaning behind them (PS3)". It was also observed through the analysis that four participants were curios not only in learning from their food but also from their dining companions. For instance, as PS1 stated, *"I am constantly curious and eager to discover how people live their lives, and I would enjoy connecting with others by immersing myself in new cultures, such as Japanese culture, to gain understanding and gratitude"*. This sense of immersion and curiosity could encourage participants to **teach and learn from one another** [382], potentially **deepening appreciation and understanding of the food**, enriching the experience with educational value [277].

5.7.5 Imaginative exploration and creativity

When participants were asked to envision their ideal eating environment, 18 expressed a preference for imaginative, fantastical settings over realistic replicas of real-world locations. They described these environments as **magical** or **fantasy-like**, showing an openness to experiences that go beyond the boundaries of everyday life. One participant shared desire of eating in a place where all **elements are oversized**, *"I'd rather dine in a fantasy world because I'm tired of the usual options around here. I've tried many restaurants, and I'm craving something fresh like eating in a place where everything is gigantic (PS9)"*. Similarly, one participant out of two noted an interest to travel to the future in **cyberpunk-style**, *"I'd love to visit a futuristic, cyberpunk-style Japan, similar to what you see in anime (PS5)"*. This magical ambiance can also create **memorable and engaging** experiences; as PS3 mentioned, *"I think dining in a fantasy world would make the experience more memorable and captivating"*. Designing a novel and imaginative environment could evoke **curiosity and a sense of exploration**, as PS10 highlighted, *"dining in a place like Charlie and the Chocolate Factory would bring a sense of wonder and discovery that's often missing in real-life restaurants, where there isn't much to explore"*. Furthermore, sharing a meal in a magical space can **foster conversations** and **bonding**: *"I think dining with someone in a fantasy world would help me connect with them there would be so much to talk about it makes the experience more personal"*.

Additionally, seven participants emphasised the appeal of a **surprise element** in these magical environments, noting that many real-life restaurants feel similar, leaving them longing

for unexpected, unique experiences *"I adore the concept of the unknown, like an eating adventure where I consume without knowing what comes next. It's unpredictable. This is better than dining in restaurants where the experience is almost always predictable and tends to become dull over time (PS4)"*, and *"The unpredictability of what could appears next in the environment while eating could adds an intriguing element of curiosity and surprise. It can foster bonding and mindful eating (PS19)"*. Crafting food experiences as dynamic trajectories with moments of climax and surprise, aligns with research highlighting the importance of such elements [130]. Taken as a whole, incorporating magic into eating experiences offers many benefits by creating immersive, fantastical environments that boost users' engagement [290]. These experiences transcend real-world physics, enabling interactions within surreal, imaginative worlds [290].

5.8 User study

I started by implementing these features into a Wizard-of-Oz prototype. After completing the design process, I evaluated the prototype. To achieve this, I recruited 14 participants for try-out sessions, followed by interviews and a follow-up survey conducted two months later. The following sections discuss more details about the process.

5.8.1 Apparatus

5.8.1.1 Hardware configuration

The core hardware for the experiment consisted of two Oculus Quest 2 VR head-mounted displays (HMDs). These HMDs were used to deliver both auditory and visual stimuli to participants. The Oculus hand-tracking system was chosen to provide a more intuitive and seamless interaction method with the food and the environment.

Dimension	Important Elements	Implementation
Multisensory Immersion	**#8** Food memories represent a sense, **#9** Pay attention to your senses	The prototype includes elements like 3D sound (e.g., the sound of a waterfall, crickets, and Japanese musical instruments), the smell of cherry blossom trees, wind simulation, passive haptic feedback through artificial grass, and the taste of matcha-honey bites.
Cultural and Contextual Richness	**#13** The cultural significance around food	The system integrates elements of Japan, featuring a Japanese garden surrounded by cherry blossom trees, hot spring waters, a Japanese bridge, and a Torii gate. Sushi was replaced with matcha for technical reasons, as matcha is simpler to incorporate into VR eating experiences.
Dynamic Social Interactions	**#1** Culinary collectivity beyond commensality, **#3** Stimulating mealtime conversations, **#4** Seeking surprise encounters over supper	The prototype enables remote eating with another person, allowing both users to see each other and their matcha plates in a shared, immersive environment. This fosters social interaction and collective engagement.
Food Literacy and Engagement	**#6** Engaging in mindful eating habits, **#7** Making and breaking habits, **#12** Searching for food literacy	With each bite consumed, the prototype displays information about its nutritional value and calorie intake. Additionally, it projects a futuristic display on the table, outlining the recipe for matcha and its cultural significance.
Imaginative Exploration and Creativity	**#15** Variety is the spice of life, **#16** Embracing constructive distractions	Users eat in a vibrant cyberpunk setting in Japan, surrounded by vivid colours and gigantic cherry blossom trees. With each bite, a new element of the environment is gradually revealed, adding a surprise with every taste (see Figure 5.3).

Table 5.1: A summary of mapping the prototype's features with Important Elements 4.5.1 and the identified dimensions for implementation.

5.8.1.2 Software and virtual environment

The VR experience was developed using Unity3D[4]. The avatars representing users were created with the Facebook Meta Avatar API[5]. To ensure real-time synchronous communication and shared object interactions, including avatar animations in a multiplayer context, Photon Fusion[6] was integrated. The environment was modeled using Blender3D[7] and further enhanced with Unity Assets. Audio files used for sound effects were sourced from Unity

[4] https://unity.com/
[5] https://developer.oculus.com/documentation/unity/meta-avatars-overview/
[6] //https://www.photonengine.com/fusion/
[7] https://www.blender.org//

Assets.

5.8.1.3 Physical space setup

To ensure a seamless transition between the real and virtual worlds, the physical setup was carefully designed to simulate key elements of the VR environment. A table was set with a plate filled with honey-infused matcha bites. The physical space was further enhanced for multisensory immersion with a grass-like rug on the floor, to reflect the natural theme of the virtual scene (see Figure 5.4). Multisensory enhancements were incorporated using a fan to simulate wind and a cherry blossom diffuser to add an aromatic ambiance. To deepen immersion, the VR environment evolved gradually in synchrony with participants' eating actions. Each time a participant brought food close to their mouth, a programmed command in Unity automatically triggered a new visual or sensory element. For example, as illustrated in (Figure 5.3), the first bite activated the appearance of grass and plants; the second bite revealed the sky and mountains; the third bite introduced a cherry blossom tree accompanied by breeze and scent; and subsequent bites unveiled a waterfall, a Japanese gate, and a bridge.

Additionally, to incorporate olfactory stimulation, a cherry blossom-scented candle was placed on a small table approximately 1.5 meters away from the participants, positioned behind them and slightly to the side. This placement was chosen to allow a gentle diffusion of the scent into the space without overwhelming the participants or interfering with the VR equipment. To enhance the sense of environmental realism, a small fan was also used to simulate wind, manually moved by the session demonstrator during key moments to mimic natural air currents and changing directions. However, no preliminary studies were conducted to determine the optimal position or intensity of the wind and scent diffusion, which remains a limitation. One challenge encountered was the lingering nature of olfaction, which made it difficult to isolate scent-triggered moments or reset the environment between sessions. Therefore, every single day included only one session to allow the scent to fully dissipate and reset before the next day's session. The setup relied on passive diffusion rather than timed or directional delivery systems, which limited control over olfactory timing and precision. This decision was made due to budget and technical constraints, but it was informed by general practices in multisensory media design, as discussed by Murray et al. [259], who reveal the

complexity of managing scent diffusion and its interaction with spatial and temporal variables in immersive setups. Future iterations would benefit from controlled, localised scent delivery mechanisms that better align with real-time events in the experience.

5.8.2 Participants

I conducted the main study to evaluate the system over seven sessions, involving 14 participants representing 11 countries as shown in Table 5.2. Among them, two participants had physical disabilities and used wheelchairs. The participants exhibited a diverse range of familiarity with VR, 71.4% used VR only once or twice before, 14.3% used VR once a week, 14.3% never used VR before. Participants were primarily recruited through targeted social media ads. I sought a diverse group in terms of age, gender, nationality, and VR experience.

Session	ID	Profession	Nationality	Age range	Gender	Condition
1	P1	Digital artist	Qatar	18-24	F	NA
	P2	Digital artist	Bahrain	18-24	F	NA
2	P3	Animator	Bahrain	18-24	F	NA
	P4	Marketing	Lebanon	25-34	F	NA
3	P5	Athlete	Argentina	25-34	M	NA
	P6	Youtuber (Gamer)	UAE	25-34	M	Disabled
4	P7	Chef	Bahrain	25-34	M	NA
	P8	Engineer at Google	USA	35-44	M	NA
5	P9	Traveller	KSA	25-34	F	Injured
	P10	Director	Turkey	18-24	M	NA
6	P11	3D Printing	India	18-24	M	Disabled
	P12	Traveller	Egypt	25-34	F	NA
7	P13	Japanese embassy	Japanese	25-34	M	NA
	P14	Artist	Bahrain	25-34	M	NA

Table 5.2: List of participants involved in the prototype testing sessions and evaluation process, including interviews and follow-up surveys.

5.8.3 Procedure

Pairs of participants, unfamiliar with each other, were invited to partake in the study. They were placed in separate rooms equipped with identical physical setups as detailed in Section 5.8.1.3. Participants were then asked to sit on a designated chair, remove their shoes, and place their feet on the grass-like rug. Before starting the experiment, they received verbal instructions on the system's usage, followed by a hands-on demo where they became more familiar with the system and the hand interactions. Once they felt comfortable, the actual experiment began. At this point, the plate with matcha bites was placed on the table. Participants were then instructed to align this physical plate with its virtual counterpart in the VR environment. Participants were not given any indication about how to engage during the experiment. For this study, all participants gave informed consent at the beginning of the experiment and were informed that they could withdraw from the study at any time.



Figure 5.3: The environment comes to life with each bite. From left to right the elements that appear are - 1st bite: grass and plants; 2nd bite: sky and mountains; 3rd bite: cherry blossom tree augmented by cherry blossom smell (from a diffuser) and breeze (from a fan); 4th bite: waterfall and a Japanese gate; 5th bite: a Japanese bridge.

5.8.4 Data collection

To comprehensively understand the impact of the immersive eating experience, the study employed a multifaceted data collection strategy, encompassing qualitative interviews, audio-visual documentation, and follow-up surveys, as describe below.

- Qualitative interviews: After completing the eating experiment sessions, participants took part in semi-structured interviews conducted by me and other researcher, lasting between 30 to 50 minutes. These interviews featured open-ended questions designed to allow participants to freely express their thoughts, feelings, and experiences. The focus of these questions was to gather insights on participants' comparisons between

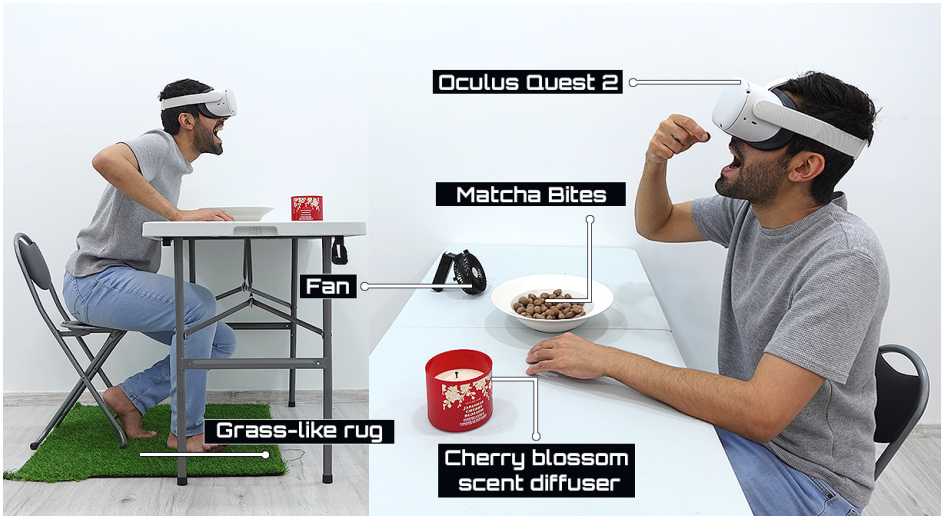


Figure 5.4: The experimental environment, showcasing the integration of VR equipment, eating setting, participant seating, and additional multisensory elements.

immersive VR and real-life eating experiences, their social interactions within the VR setting, and their evaluations of the system's main features. Examples of questions: How did your experience of eating in VR compare to eating in real life? Among the various features of the VR eating experience, which ones did you find most enjoyable or engaging? Could you explain why those specific features were your favourites and how they contributed to your overall enjoyment? Through this approach, I aimed to capture detailed narratives that could reveal the nuances of the immersive eating experience, including aspects like enjoyment, engagement, and the overall impact on participants' perceptions of eating and social interaction. To ensure a rigorous analysis of the rich qualitative data collected, all interviews were transcribed verbatim. Furthermore, to minimise self-reporting bias and social desirability effects during interviews, we assured participants of the confidentiality of their responses and framed questions in an open-ended, non-leading manner.

- Audio-visual data: The study utilised audio and video recordings to document participants' behaviours and interactions during the VR eating experience, as well as their activities in the external physical environment. This dual-environment recording approach provided a holistic view of the immersive eating experience, capturing the nuances of participants' engagement both within the virtual setting and in real-world interactions. The visual data collected from both environments was transcribed and annotated, enabling the identification of key moments, behaviours, and interaction

patterns.

- Follow-up survey: Two months after the experiment, participants were asked to complete a follow-up survey comprising open-ended questions. This survey sought to gather retrospective insights and assess any long-term effects of the immersive eating experience. Participants were prompted to reflect on their memories of the experience, any surprising or unexpected impacts on their perceptions of food or eating habits, and discussions of the experience with friends, family, or colleagues. This longitudinal approach allowed for the collection of qualitative data on the lasting impressions and potential behavioural changes resulting from the study.

5.8.5 Data analysis

Data collected during the sessions was transcribed and analysed through an inductive reflexive thematic analysis process [49, 51]. I employed an iterative, open-ended coding process to identify data patterns related to desires, engagements, opportunities, and challenges. I started this process by analysing the interviews and surveys data. As the main researcher, I led the coding efforts, working closely with two other researchers who spent one week thoroughly reviewing the entire dataset multiple times. This initial review allowed us to build a foundational understanding, familiarise ourselves with the content, and identify information relevant to the research questions. At this stage, we documented our thoughts and took preliminary notes, such as *"Participants engage their senses to foster social connections; Participants show an interest in transforming their eating habits; Technology-induced rituals; Synchronised eating; Participants seek a deeper connection with their food, aiming to eat more mindfully"*; some of these notes informed the development of interview and follow-up survey questions as well as the finalised thematic analysis. As the main researcher, I guided the team through an additional two weeks of systematically labelling the multifaceted dimensions of re-imagining food interactions in the context of immersive technologies. Together, we created succinct codes that addressed the research questions.

Subsequently, another researcher collaborated with me to review and analyse the coded data, integrating and comparing initial codes from all data sources. This analysis was informed by the framework dimensions identified earlier, ensuring that the coding process remained

aligned with the theoretical constructs of multisensory immersion, cultural and contextual richness, dynamic social interactions, imaginative exploration and creativity, and food literacy and engagement. To ensure alignment among all team members, I shared detailed documentation of the initial coding and clustering processes, followed by group sessions for discussion and feedback. This iterative approach allowed the team to determine which codes were most useful for interpreting relevant themes, how they might relate to the framework dimensions, and which could be discarded. Following this, I led the team in grouping related codes into six higher-level themes that encapsulated key insights and captured significant aspects of the data. These themes were evaluated for their coherence, relevance to the framework, and connection to user behaviours and perceptions observed during the Wizard-of-Oz prototype evaluation. This iterative refinement ensured that the themes represented both the framework dimensions and the practical opportunities and challenges of designing DICom systems. The final themes indicate critical opportunity spaces for designing meaningful digital immersive commensality experiences and are detailed in (Section 5.9).

To ensure inter-researcher reliability during the inductive reflexive thematic analysis, I, as the lead researcher, guided a collaborative and transparent process that allowed all team members to align with the methodological stance. This included an initial week of independent and repeated engagement with the dataset by all three researchers to build familiarity and record early impressions, followed by structured coding sessions led by myself. I shared detailed documentation of the coding and clustering steps, and we held group discussions to refine codes, evaluate their relevance, and align them with the conceptual framework. Our collective interpretative process fostered a shared understanding and consistent analytical lens.

5.9 Opportunity spaces for immersive commensal experiences

My exploration builds upon the foundational dimensions of DICom to delve into the multifaceted nature of re-imagining food interactions in the context of immersive technologies. By identifying and analysing opportunity spaces, this study provides a framework for advancing both academic understanding and practical applications in this emerging field. Below, I present these opportunity spaces, each grounded in empirical observations and research findings, and aligned with the key dimensions of the DICom framework in Table 5.1. These

spaces illustrate how immersive technologies can address the complex interplay of sensory engagement, cultural relevance, social dynamics, imaginative exploration, and food literacy. They highlight the potential to enrich the social fabric of immersive eating experiences but also emphasise opportunities to deepen engagement with food itself. By connecting these opportunity spaces to the DICom framework, I demonstrate their role in shaping meaningful and transformative interactions, while offering directions for future research and design.

5.9.1 Revitalising our social eating rituals

This opportunity space aligns with the Dynamic Social Interactions and Imaginative Exploration and Creativity dimensions of the framework. It demonstrates how immersive settings can foster both organic and intentionally designed rituals, enabling participants to connect and interact in novel ways. Additionally, it highlights how imaginative and playful elements within these settings can inspire creative interactions, triggering a sense of wonder in communal eating experiences.

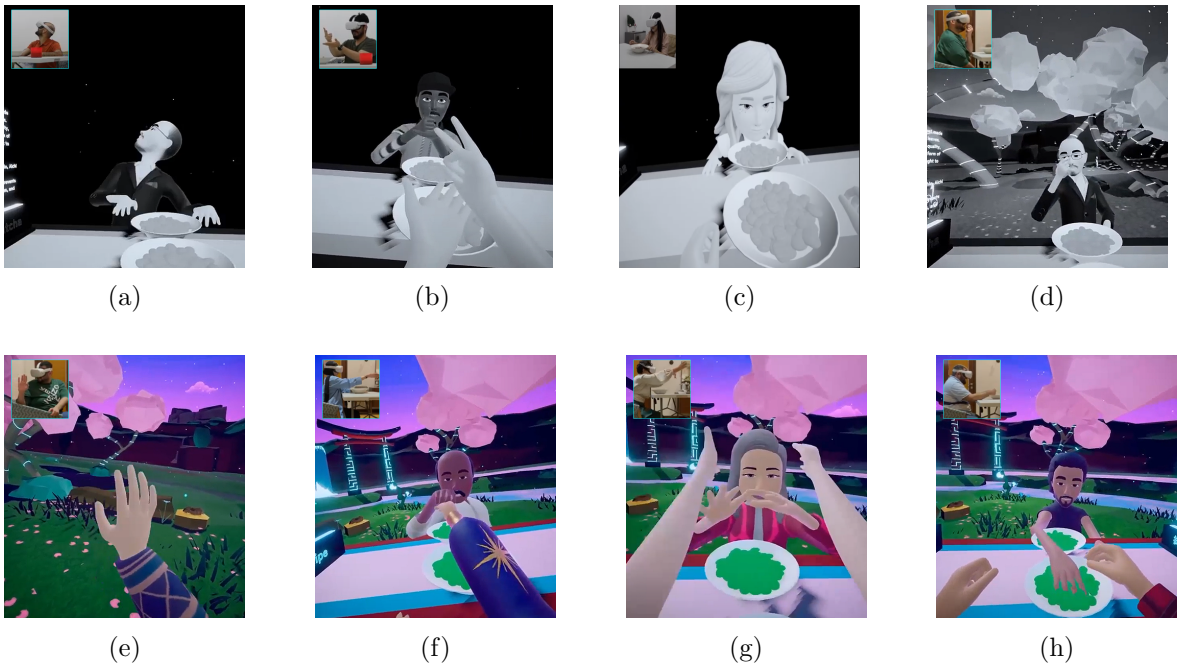
In real-life dining scenarios, rituals evolve naturally, shaped by cultural norms, personal preferences, and social dynamics [31]. For example, when sharing a meal with someone, we may engage in traditional rituals like saying grace or clinking glasses in a toast. However, the introduction of mobile phones has ushered in a new ritual – capturing the perfect food photo for Instagram and sharing our culinary experiences virtually with our social networks. Now, as we consider the integration of immersive technologies into our eating experiences, new rituals can emerge, that would manifest in two distinct ways: both organically and as a result of intentional design. Some may naturally emerge as participants navigate the immersive digital environment, while others may be deliberately crafted to enhance the communal eating experiences. These unscripted moments arise from the immersive nature of the VR environment, where participants feel compelled to interact and connect in novel ways. On the other hand, designed rituals can be intentionally woven into the immersive eating experiences to encourage specific interactions and connections among participants.

In my investigation of eating rituals within the immersive environment, I took a similar approach to [89] and I identified distinct moments that punctuated the entire gastronomic journey. These moments, were also influenced by the deliberate design elements incorporated

into our immersive system. This intricate interplay between naturally evolving interactions and purposeful design features introduces a nuanced dimension to our exploration of modern-day eating rituals. These moments, which I have labelled as *exploration* (i.e., involving looking around, understanding the space and the mechanics of grabbing food and the tactile exploration of it), *synchronisation* (i.e., choosing to synchronise bites to uncover the elements at the same time), and *mutual disruption* (i.e., trying to expand interaction and break social norms) served as touchpoints where the inherent human inclination for ritualistic behaviours converged with the affordances of our technology. Given their emotional intensity and their repetition, I view these step-by-step actions as potential immersive modern-day rituals that could be embedded within the broader secular context of social eating.

During the initial **exploration**, participants exhibited a diverse range of approaches as they familiarised themselves with the system and each other. This phase was marked by playfulness, curiosity, anticipation, and a sense of novelty *"are we in space? or what's the location? (P5)"*, *"what do you think in our plate? (P7)"*. Four of our participants chose to kickstart their experience with a playful game of rock-paper-scissors (Figure 5.5b). This not only served as an icebreaker [341] but also set a lighthearted tone for the subsequent social interactions. Participants were then intrigued by the space (Figure 5.5a), the food itself and the mechanics of grabbing it. They engaged in a sensory exploration where they used their olfactory and tactile senses to try to guess the food's identity (Figure 5.5c). Participants communicated, shared their thoughts, and built on each other's guesses and reactions. This highlights the inherent social nature of eating and how, even in a technologically mediated setting, human interactions remain central to the eating experience. By blending the digital with the tangible, the experience fostered a deeper sense of curiosity, and cultivated a heightened sense of intimacy among participants.

In the **synchronisation** phase, participants demonstrated a shared desire to explore the environment simultaneously, embarking on a playful journey to stay in sync with each other, *"Hey I didn't eat wait for me! (P1)"*, *"Oh sorry! I'll wait (P2)"*, this coordination is exemplified in another instance shown in (Figure 5.5d). As unique elements of this digital environment unfolded progressively, they acted as triggers for deep conversations and the exchange of personal stories (Figure 5.5e), thereby strengthening their interpersonal connections.



(a) (b) (c) (d)

(e) (f) (g) (h)

Figure 5.5: Illustrations of distinct moments that punctuated the immersive dinner. (a) P8 gazes around, exploring the surroundings; (b) P13 and P14 start their dinner by engaging in a rock-paper-scissors game; (c) P3 and P4 smell their food, trying to guess its ingredients; (d) P7 and P8 decide to coordinate their bites to unlock surprises together; (e) P7 and P8 wave to capture the rabbit's attention; (f) P11 and P12 engage in a handshake; (g) P3 and P4 become highly playful, engaging in light-hearted slaps and playful scuffling with each other; (h) P5 and P6 playfully try to swipe food from one another (the images in the top left corner are of the users eating with the ones in represented in VR).

The **mutual disruption** phase was particularly noteworthy for its departure from conventional spatial and cultural norms. Participants engaged in tactile interactions including hand-touching (Figure 5.5f) and playful gestures such as scuffling with each other, *"I didn't know the person but when I got in the VR world, I felt the environment and the setup was welcoming and not formal and serious like the real world. So I forgot about real life and I just thought that okay, I want to do something to her and see how does it feel? something that makes us laugh more (P2)"* as presented in (Figure 5.5g) or trying to steal food from each other's plate (Figure 5.5h), despite potential cultural constraints. The immersive technology was instrumental in enabling these social interactions, such as mutual feeding or utilising food as an interactive medium within the digital realm. These insights reveal the profound impact of immersive technology in enriching eating experiences, fostering a heightened sense of camaraderie that transcends traditional norms. By infusing eating with playfulness and creativity, immersive technology encourages participants to engage in novel interactions, transforming meals into spaces of exploration and shared joy. Within this blend

of play, technology, and social interaction, new eating rituals emerge, enhancing connections and reimagining the essence of communal eating.

While these playful and uninhibited behaviours demonstrate the potential of immersive technology to foster new social rituals, it is important to critically consider the influence of the novelty effect on participants' experiences and self-reported reflections. As many participants had limited prior exposure to VR-based dining or multisensory environments, their heightened enthusiasm and willingness to break social norms may have been partially driven by the initial excitement and curiosity associated with engaging with a new and unfamiliar medium. This sense of novelty can temporarily amplify emotional responses, leading to more positive appraisals and greater openness to experimental behaviours. As such, while the data highlights meaningful moments of connection and play, it is necessary to acknowledge that some of these responses may not reflect sustained or repeatable behaviours once the novelty wears off. Future studies could address this limitation by incorporating repeated sessions or extended observation to better distinguish between novelty-driven reactions and lasting shifts in commensal behaviours within immersive environments.

Designers can derive valuable insights from these findings by recognising the nuances of creating and merging old and new rituals in various social contexts. If we can identify these moments, we can intentionally design and ritualise them to promote enjoyable mealtime [380]. These moments hold significance in a range of social scenarios. For instance the exploration phase, marked by playfulness and curiosity, can be paralleled with scenarios such as team-building challenges in a corporate setting, fostering curiosity, communication, and novelty among team members while the synchronisation phase, where participants seek to stay in sync with each other, resembles a romantic dinner setting, allowing couples to synchronise their eating experiences and deepen their emotional connection. By drawing these parallels, designers can intentionally design and ritualise these moments, enriching mealtime experiences in various social contexts. Further research into the coexistence of these rituals, their implications for social bonding, and their adaptability to various occasions will guide designers in crafting eating experiences that enrich mealtime in its various forms within different social scenarios.

5.9.2 Sensory food experiences elevate social connection

This theme aligns with the Multisensory Immersion and Imaginative Exploration and Creativity dimensions of the framework. It explores how engaging multiple senses in immersive dining contexts can create profound connections among participants, while imaginative and creative elements amplify the shared experience. The data showed that shared sensory experiences—centred around the intrinsic multisensory nature of food—enhance enjoyment, build trust, promote synchronisation and playfulness, and deepen emotional bonds, reflecting the framework's emphasis on using sensory cues to enrich social interactions and inspire creativity in communal dining.

Reflecting on the fundamental principles of eating behaviours, research has shown that our company significantly influences our consumption patterns. Traditionally, when dining with family or close friends, we tend to consume more food compared to when we eat alone or with acquaintances or strangers [315]. Eating in an unfamiliar company usually brings an air of self-consciousness or restraint, stemming from societal norms or potential judgements [160]. Immersive technologies introduce a twist to these traditional eating dynamics. When we enter a virtual eating environment, where we can share the experience of tasting the same food, smelling the same scents, and virtually touching the same textures, the usual boundaries between us and our eating partners blur. This unique setup transforms eating from a routine activity into an engaging and social exploration of new sensory experiences. In this immersive context, participants can connect on a deeper level, despite physical separation. The novelty and shared nature of the experience encourage a sense of discovery and play, fostering a new kind of social bond that is both profound and joyful. One of the users remarked: *"When we started to taste the real food, I felt there was something real in common between us. And that made me connect with her (P4)."* Participants reported no longer feeling isolated users in a physical space, but companions sharing a sensory journey. When asked (2 months after the experiment) what aspects of the experience they recall, all participants mentioned the shared sensory stimulation: *"One of the most unforgettable moments was when the other person joined in, indulging in the same food alongside me. It was truly mind-blowing to experience this shared connection of a common and real taste within our bodies despite being physically separated (P2 - after 2 months)."* P2's reflection, highlights the lasting impact of

shared mouthfeel in immersive dining. Their emphasis on "*a common and real taste within our bodies*" suggests that the tactile qualities of food, such as texture and oral sensation contributed to a sense of connection. This shared mouthfeel appears to have anchored the experience in memory, reinforcing both the emotional and embodied aspects of co-presence. It illustrates how mouthfeel can be a potential design element in creating meaningful virtual commensal encounters. P6, a wheelchair user participant highlighted a particularly poignant aspect of the playful and inclusive nature of this immersive experience, stating: *"Being on that virtual bench, sharing the same food, I momentarily forgot my wheelchair. [..] I cared only about feeling free and similar to the other person (P6)."* This reflects how immersive technologies, through social shared experiences, can level the playing field, allowing for a sense of freedom and equality that transcends physical limitations.

The shared sensory experience centred around food served as a temporary *security primer* fostering a deeper connection and trust through social and playful interactions. That trust emerged almost instantaneously with the initial bites, contrasting with the typical dynamics of social VR [123]: *"I also think the common senses between me and the other person brought us more together, made me trust her more and be open (P8)."* In the latter, cultivating such a depth of connection often demands a more incremental and deliberate approach [123]. The act of users feeding each other (four out of the seven pairs) further illustrated this bond (Figure 5.6a). This gesture, often reserved for deeply intimate settings, underscores the level of trust and connection the experience facilitated. It is an act that not only symbolises care, but also signifies a letting go of barriers or reservations.

This deepened connection manifested not just emotionally but also behaviourally, with participants finding a shared rhythm in their eating patterns, further emphasising the playful mimicry and synchronisation inherent in communal eating scenarios. The immersive sensory bond in the virtual space led to observable shifts in participants' eating patterns, suggesting that even within a virtual environment, our innate human tendency to engage in playful mimicry [159], especially in communal eating scenarios, remains strong – for instance participants, when paired, seemed to find a shared rhythm, consuming similar quantities of food. For example, *"Wait now is my turn to feed you (P14)"*; (P13 opens his mouth and trying to eat from P14's hand) *"yeah nice and gentle (P13)"*, (P14 suddenly shouts playfully) *"JUST OPEN YOUR MOUTH! (P14)"*, (P13 laughing) *"I'm trying!! (P13)"*, *"It's literally getting*

inside your nose (P14)", (both laughing). Similarly, 12 out of the 14 participants exhibited this synchronised eating behaviour.

These findings underscore the substantial impact that everyday activities, particularly multisensory ones like eating, can have on shaping our virtual experiences. Moreover, they highlight the reciprocal relationship, where the virtual experiences can also influence and transform our everyday activities. Consuming the same food and engaging in social behaviour while doing so emerges as a powerful trigger for establishing an immersive shared sensory realm and triggering trust. The fact that immersive technologies can provide another context for eating, one where people draw from their real eating practices while also creating behaving playfully, contributes significantly to this potential.

Drawing parallels to the increased users' interest in re-imaging mundane activities in social VR, such as sleeping [231, 410], my observations indicate that social immersive eating could offer a compelling, interdisciplinary avenue for further research, calling for methodical and in-depth explorations. Moreover, building on results from [205], who showed a significant positive association between commensality and work-group performance in the case of firefighters, it would be interesting to explore how immersive technologies, through multisensory engagement, could potentially enhance cross-cultural commensality in diverse settings. By incorporating sensory cues such as the flavours of regional dishes, the sounds of cultural music, or the visual aesthetics of traditional dining environments, these technologies can recreate the rich, shared sensory spaces that make real-world commensality so impactful.



(a) Early in the experience, P13 willingly accepts to be fed by P14 engaging in a playful exchange. This gesture is later reciprocated.



(b) P3 and P4, building trust, reach out to touch hands after P3's initial hesitation to eat, ultimately being convinced by P4.

Figure 5.6: Participants engaging their senses and breaking the social boundaries through playful interactions

5.9.3 Restoring our sensory connection with food

This theme aligns closely with the Multisensory Immersion dimension of the framework, emphasising how multisensory immersive technologies can reawaken our sensory awareness and deepen our connection to food.

No human activity is more multisensory than eating, yet in many modern contexts, it often occurs in a state of sensory disconnect. For some individuals, particularly those in urban environments or with time constraints, groceries are purchased online or meals are ordered via smartphones, arriving packaged and pre-prepared, often without the chance to see, touch, or smell the food beforehand. In these cases, people may rely more on packaging descriptions than on their own senses to assess food quality. However, this is not a universal experience; many still visit farmers' markets or supermarkets and prepare meals from scratch at home. Paradoxically, data in my study shows immersive technologies could offer a solution to this sensory disconnect. While it might seem counter-intuitive to use technology to bridge a gap that technology itself has widened, participants saw potential in immersive technologies to re-engage our senses in unique ways.

Participants reported that multisensory immersion is particularly potent with food, as it naturally engages several senses at once and, when paired with immersive technology, it offers a heightened sensory experience that is both immersive and value-laden. P8's reflection indicates that the true potential of VR lies not just in its ability to simulate but to add value by complementing and amplifying real-world experiences: *"I engaged my smell, I've engaged light touch, I've engaged in my taste buds. So I think as long as it is something you feel in real life, it potentially could add that value. I think food was a really good one because it captured multiple of those physical senses at the same time (P8)."* The participants reported that while the intrinsic taste of the food remained consistent, the overall eating experience was elevated due to the social exploration of the sensory dimension. The act of consumption became no longer just about taste but also about the multisensory experience and events it can trigger *"But I think the experience kind of changes how you feel about the food. So the flavour, the you know, the enjoyment, the flavour, sort of remains the same, but then the experience escalated, because now when I eat things actually happen (P7)."* The juxtaposition of the virtual and non-virtual created a heightened awareness of the food's texture and flavour. *"What remains*

clear in my memory are the flavours and textures on my plate. The sweetness of the matcha and the vibrant and bright colours of the surroundings gave me a sense of positivity. While indulging the matcha I loved the sensation of the grass below my feet. I don't know but it kinda gave the Matcha an earthy and fresh taste like it's coming from the pretty Japanese garden (P7 - after 2 months)."

The impact of the virtual environment was not only immediate but also had lasting implications on all participants' subsequent real-world culinary experiences, as showed by answers to the follow-up survey. The immersive nature of the eating session appears to have instilled a heightened the social and playful reconnection with the sensory aspects of eating, prompting participants to engage more deeply with the multisensory aspects of food consumption in their daily lives. This is evident in their active attempt to mentally recreate the ambiance associated with our experiment, suggesting a shift towards a more mindful and immersive approach to eating. *"After the VR experience, I started to really appreciate the different flavours of the different types of cuisines. For example, if I get takeout Japanese food, with every bite I take, I try to close my eyes and really imagine myself in a Japanese environment with the sounds of nature, people talking, and even the sound of the food sizzling on the pan in the background and the texture of food. I found myself appreciating more the favours (P2 - after 2 months)."* P8 supports this: *"I found pleasure in the soothing ASMR while consuming the food. The experience left me in the real world more aware of the environment and my sensory perception (P8 - after 2 months)."*

The findings indicate that immersive technologies have the potential to mitigate, or at least counteract, the sensory desensitisation observed in contemporary eating habits, as suggested by this study's data. However, it's important to note that these conclusions are preliminary, and further research is needed to fully understand the impact and efficacy of these technologies. Designers could explore the development of short, immersive sensory experiences that complement traditional eating. Leveraging crossmodal correspondences, these experiences can enrich the sensory perception of eating experiences, introducing social aspects that engage and delight diners in novel ways [81]. Such interventions, by integrating scientific principles with social and playful execution, offer exciting possibilities to elevate the eating journey. This suggests that participants might engage with their meals in a more immersive, mindful, and enjoyable manner. The prospect of enhancing the eating experience through

such social and immersive interventions highlights a promising area for further exploration, underscoring the potential of immersive technologies to deepen our sensory connection to food.

5.9.4 Bites or bytes? Rethinking food *datafication* with immersive technologies

This theme aligns with the Food Literacy and Engagement dimension of the framework. It explores how immersive technologies can creatively convey nutritional information and promote mindful eating practices. By employing multisensory feedback mechanisms and dynamic environmental adaptations, this theme underscores the potential for informing healthier eating habits and greater awareness of dietary choices.

The interaction with the system revealed a challenge for the ones who ate more: recognising when to stop eating. The captivating nature of the virtual environment sometimes overshadowed the act of eating itself. P12 admitted to feeling *"guilty about eating that much food because I was so captivated by the beauty of the place."* Moreover, P6 reported that their *"appetite has been over the roof"* after the digital commensality experience, leading to significantly increased portion sizes. The reasons for such an outcome are intriguing. It is plausible that the immersive eating, by heightening sensory experiences, could have amplified P6's association of pleasure with eating. Another potential reason could be that the intensity of the visual experience distracted P6 from recognising or attending to their body's satiety cues, re-calibrating their perception of fullness. Such accounts highlight potential consequences of disconnecting individuals from their internal satiety cues within immersive experiences.

The digital era has been marked by an increasing *datification of our daily life* [106], with our actions, behaviours, and even our food becoming quantifiable data. Yet, as the experience of the participants suggests, people do not always perceive or value this data consistently. During the eating experience, 13 participants overlooked the real-time caloric information presented to them, a gap between raw data and meaningful, actionable insights. This is in line with research investigating the effects of calorie labelling in restaurants, which has shown that this approach does not reduce average calories ordered [44]. However, P5's account illustrates how specific demographic or lifestyle groups (i.e., athletes) may derive more utility

from such features, especially when this aligns with their real-world needs and habits: *"I liked the calories because it is something that is important to me to know the amount of (P5)."* Yet, given that many individuals bypass calorie counts, it is evident that alternative feedback mechanisms are needed within these digital environments to prevent participants from potential overconsuming.

Furthermore, participants' feedback showed a playful path forward, suggesting that immersive eating experiences could creatively integrate nutritional information through multisensory feedback mechanisms. One significant opportunity lies in transcending numerical representations in a playful manner and tapping into multisensory feedback mechanisms. As participants like P4 suggested, translating caloric intake into various stimuli — varying temperatures, adapting the story, changing the smell — could enhance awareness and influence healthier choices by introducing a playful and engaging way to make caloric information tangible. *"I just suggest to connect more with the senses. Maybe the choice of food can control the temperature of the environment or if I don't finish my food something happens like bad spirits and smell comes into the place or if I choose unhealthy food it impacts the environment around me (P4)."* Such playful interventions promise to bridge the gap between the sensory richness of dining and the critical awareness of eating habits. By making caloric intake a visible and interactive part of the immersive experience, diners are invited to engage with nutritional information in a manner that is both enjoyable and enlightening. This innovative approach not only addresses the challenge of overeating but also enriches the eating experience by weaving together the joy of eating with the mindfulness of nutritional choices.

This theme underscores the importance of combining education, playfulness, and sensory immersion in fostering healthier eating habits. Immersive technologies can transform food literacy by embedding nutritional education within an engaging and intuitive context, making calorie information and dietary choices more meaningful. Additionally, understanding the long-term impact of immersive dining on eating habits could inform how these technologies are used to encourage sustained behavioural change.

5.9.5 Extending the foodscape extends the behaviour

This theme aligns with the Food Literacy and Engagement dimension of the framework. It demonstrates how immersive technologies can inspire meaningful behavioural changes, fostering curiosity, experimentation, and social connection in both digital and physical realms. Through short-lived yet impactful interactions, this theme shows the potential for immersive eating experiences to enrich culinary practices, interpersonal dynamics, and everyday habits.

The immersive eating experience, on the surface, might appear like a short-lived adventure into a digital realm. Participants plunge into an augmented commensal world, extract value, insights, and emotions, and then retreat back into reality. However, this experience also provided an avenue for self-discovery and shifts in behavioural dynamics through play and social interactions. Much like the ethos of *throwaway technology* – where engagement with the tech serves a specific purpose and then recedes – the immersive eating experience offered participants a brief yet impactful dive into a digital culinary world. After it, they resurfaced with renewed perspectives that influenced various aspects of their daily lives.

Participants expressed deep appreciation for the nutritional insights provided during the immersive eating session. P1 saw significant value in understanding the health benefits and origins of the food: *"it gave me more insights into the food"*, while P9 highlights the educational component's importance: *"I think it will add a lot of value to whatever you're eating, and why you're eating it (P9)."* This newfound knowledge was not confined to the virtual realm. The majority of participants (13 out of 14), reported that these insights had gradually found their way into their daily lives, leading to conscious dietary choices, experimenting with new ingredients, and reconsidering previously disliked ones. P6, for instance, mentioned they experiment more with ingredients *"I have been trying new foods and drinks, even trying to mix and match with ingredients or ready food to see if they work together or not (P6 after 2 months)."* P8 was inspired to purchase matcha tea, recalling its health benefits from the immersive dining session. P6's revelation about matcha's health properties even prompted a reconsideration of personal preferences, suggesting a potential second chance for the previously disliked ingredient: *"I don't like matcha. And reading that it's good for your health. Like what it does for health It's really interesting. Maybe I should give it a second chance (P6)."* These observations together with P5's shift towards using honey as a sweetener, in-

spired by the recipe of the bites, exemplify the power of immersive eating to influence and educate about culinary practices and healthy ingredients.

Yet, the transformation was not solely health-centric. Interactions with the prototype unveiled a theme of adventurous culinary exploration. P10's reflection sheds light on this playful encouragement to venture beyond known tastes: *"For me, I'm a very picky eater, so consuming food is very limited for me, and it's all based on my likings, but the experience made me want to try out new things without having to overthink whatever I'm eating (P10 - after 2 months)."*

Perhaps most strikingly, the immersive eating prototype did more than just inform — it connected. Even within the confines of a digital space, it nurtured a sense of communal eating, breaking down barriers of hesitance and fostering a spirit of sharing. This sentiment of a shared gastronomic journey transitioned seamlessly into the tangible world. P13, inspired by the virtual interactions, began making proactive efforts to share meals with colleagues, regardless of their personal rapport: *"I've noticed that at work I now make an effort to eat with someone from the embassy even if I don't know them personally (P13 - after 2 months)."* This sentiment was echoed by P4, who, in an unforeseen change of habit, shared food with their sibling after the virtual eating experience, underscoring the influence of the immersive eating session on interpersonal dynamics and food-sharing tendencies: *"The most significant change was that I ended up sharing my food with my brother, which was quite an unexpected turn for me (P4 - after 2 months)."*

P6's story adds another layer of playful engagement and social reconnection. Despite the constraints of P6's physical condition, the immersive eating prototype stirred a need for genuine social interaction. The longing to reconnect with the outside world became evident as post-experience, they ventured to a park, seeking to relive the serene atmosphere experienced in the virtual setup: *"Lastly, I was encouraged one day to go to the park and enjoy the relaxing atmosphere as I did in the VR. I realised that I miss going to the park and having my usual tea and chilling with people. This experiment reminded me to go out and socialise more. [..] Especially my mother wanted to try it to understand why I was encouraged to go out but it was difficult to explain it to her without actually experiencing it. However, my best friend tried to do something similar with me. Now we have an online meal every Friday and we eat*

it in a video game. Unfortunately, we can't see our food as in your experiment but still fun (P6 - after 2 months)."

This theme highlights the potential of immersive technologies to act as catalysts for behavioural and social change. Future studies could explore how these technologies influence long-term eating habits, support cross-cultural food exploration, and foster inclusivity in shared dining experiences. By combining playful interactions with educational insights, immersive eating has the power to transform both individual and communal relationships with food, turning every bite into a meaningful journey of discovery.

5.9.6 Embracing cultural fluidity around food

This theme aligns with the Cultural and Contextual Richness dimension of the framework. It examines how immersive technologies can navigate and represent cultural authenticity – both symbolic and objective – enabling individuals to explore, reinterpret, and connect with diverse culinary traditions. By leveraging participatory and dynamic representations of global food cultures, this theme underscores the potential of VR to evoke cultural resonance while fostering deeper appreciation and understanding.

When assessing the virtual environment, participants demonstrated divergent perceptions of cultural authenticity: symbolic and objective [104]. Symbolic authenticity is grounded in social constructs and perceptions and invokes feelings of familiarity by relying on the essence or spirit of a culture to craft a narrative that resonates with certain audiences. For most participants 12 out of 14, the emphasis was not on cultural precision, but rather on the general ambience that felt culturally evocative, even if it did not adhere strictly to reality. Their interpretation leaned towards the enjoyment of an illusion, in line with postmodern perspectives on authenticity. Interestingly, despite the Japanese elements in the environment being somewhat generic – to the point where they could have been representative of another real or imagined place – participants swiftly and predominantly associated the setting with Japan. This suggests that, for many, the essence and feel were enough to evoke a sense of Japanese-ness, aligning with the postmodernist perspectives on authenticity: *"Yeah, I like the Japanese virtual world because it's a culture that you know directly. Like once you see the bridge, once you see the greenery, you understand that this is Japanese culture (P5)"* –

see Figure 5.7a, where participants engage in a lively conversation about Japan triggered by the cherry blossom tree.



(a) Upon seeing the cherry blossom tree, participants instantly declared, 'This is Japan!'

(b) Participants sharing stories about Japan, prompted by the environment

Figure 5.7: Participants exploring the environment, recognising objects and sharing knowledge about Japan.

However, two participants, who had a deeper connection to Japanese traditions, sought objective authenticity. P13 lamented: *"Japanese culture is not just a sakura tree, or the bridge or the torii. People are also part of the culture. And I didn't feel any Japanese vibe other than the Matcha."* Their perspective emphasised the need for more than just visual symbols; it called for an encompassing experience. They yearned for cultural touchpoints that move beyond the generic: from certain greetings in Japanese to the deeply ingrained ethos of addressing customers with an almost divine reverence. These participants undertook the role of guides, enriching the commensal experience by delving into the intricacies of the tea ceremony and discussing distinct regional sounds of Japan, thereby pulling the collective experience closer to objective authenticity. For instance, six participants naturally bowed, used Japanese greetings such as *itadakimasu* or *konnichiwa*, expressed gratitude before eating, and said *sayonara* while bowing before leaving, reflecting how immersive settings can encourage culturally grounded behaviours even among those unfamiliar with the traditions.

This divergence in perspectives illuminated an untapped potential in the VR landscape; to foster more genuine representations of culture, grounded in both symbolic and objective authenticity. While the guiding role assumed by knowledgeable participants in directing others toward objective authenticity was promising, any attempt to generalise or portray "global cultures" must be approached with caution. Cultural representations are complex, context-specific, and deeply personal. Therefore, leveraging crowdsourced content may offer a valuable approach not to define cultures universally, but to support more diverse, situated, and locally

informed portrayals that better reflect the richness of different cultural experiences.

This theme emphasises the importance of balancing symbolic and objective authenticity in immersive experiences. Designers must account for varied cultural perspectives, creating environments that resonate with broader audiences while offering opportunities for deeper exploration. Collaborative tools and participatory content creation can further enhance the richness and relevance of these environments. Future research could investigate how immersive technologies influence cultural perceptions and foster cross-cultural appreciation. By integrating participatory elements and leveraging the collective knowledge of diverse communities, VR platforms can evolve into dynamic spaces that celebrate and preserve the global tapestry of food cultures. Through such initiatives, immersive dining experiences can transform into powerful tools for cultural education, engagement, and sustainability.

5.10 Summary

This chapter explored the transformative potential of immersive technologies in redefining the experience of eating, with a focus on social connection, sensory engagement, and cultural enrichment. To investigate these possibilities, a Wizard-of-Oz prototype was developed and evaluated. This approach allowed for controlled exploration of user interactions and behaviours within a simulated immersive dining environment (RQ1), addressing challenges and opportunities in designing such systems.

The Wizard-of-Oz method was chosen to bridge the gap between conceptual frameworks and real-world application. By using this approach, the prototype simulated features of an immersive dining system without requiring full technological development. While the setup allowed for exploratory interaction and observation of user responses, it primarily served to evaluate the feasibility and experiential value of the DICom framework dimensions. The prototype integrated elements derived from earlier phases of research, including the DICom framework dimensions (Multisensory Immersion, Cultural and Contextual Richness, Dynamic Social Interactions, Imaginative Exploration and Creativity, and Food Literacy and Engagement).

To ensure the prototype design was aligned with user expectations, a survey with 32 participants was conducted. This survey aimed to gather qualitative data about how users envision

an immersive dining experience, focusing on their sensory preferences, cultural associations, and desired interactions. Insights from the survey informed the inclusion of specific features, such as Japanese cultural elements (e.g., cherry blossoms, Torii gates, matcha) (RQ3) and multisensory enhancements (RQ2) (e.g., tactile grass, wind simulation, ambient sounds, and olfactory stimuli).

The evaluation phase involved seven immersive dining sessions with 14 participants from diverse backgrounds. Each pair of participants, unfamiliar with one another, interacted within the immersive environment while physically separated. The study used a combination of audio-visual recordings, semi-structured interviews, and a follow-up survey two months later to capture user behaviours, reflections, and long-term impressions. The qualitative analysis revealed a rich interplay of user experiences with the prototype, offering valuable insights into the design of immersive dining systems. While the themes of revitalised eating rituals (RQ1), sensory engagement (RQ2), and cultural authenticity (RQ3) were developed through interpretative engagement with the data, the broader focus of this chapter was on understanding the feasibility, user responses, and transformative potential of the Wizard-of-Oz prototype as a tool for reimagining food interactions. These findings were closely aligned with the DICom framework dimensions — Multisensory Immersion, Cultural and Contextual Richness, Dynamic Social Interactions, Imaginative Exploration and Creativity, and Food Literacy and Engagement — which guided the design and evaluation process. By anchoring the analysis within this framework, the study not only highlighted key opportunities and challenges but also demonstrated how these dimensions can inform the creation of meaningful and impactful immersive dining experiences. The findings lay a foundation for future work in integrating immersive technologies into social and cultural food practices, while refining and expanding the framework for broader applications.

However, a notable limitation of this study is associated with the simplified and symbolic design choices made in constructing the VR environment, which presented a stylised and somewhat clichéd representation of Japanese culture. Elements such as cherry blossoms, traditional music, and iconic landmarks were selected for their recognisability and multisensory appeal, but this approach inevitably reduced a complex culture to familiar symbols. While this supported the prototype's immersive goals and encouraged playful interaction, it also risks reinforcing cultural stereotypes and overlooking regional and contextual nuances.

These simplifications may have shaped participants' interpretations in ways that limit the authenticity of cultural appreciation. A more critical discussion of these issues and their design implications is presented in Chapter 6 "Cultural contexts and food appreciation" (see Section 6.2), and in "Limitations and Future work" (see Section 6.4).

Chapter 6: Discussion and Conclusion

6.1 Overview

This thesis aimed to explore DICom, focusing on its social potential and the sensory and emotional aspects of virtual communal dining. It examines design opportunities and challenges to inspire technologies that enhance shared virtual meal experiences. Taking into consideration the scope of a single PhD thesis, the research work done aimed to address specific literature gaps that are under the umbrella of the overarching research problem. In specific, this thesis presents three studies on social interactions in digital commensality and the dimensions that shape meaningful connections during virtual meals (Chapter 3, 4), the influence of digital platforms on food choices, eating habits, and sensory experiences in virtual dining settings (Chapter 3, 4), and the opportunities and limitations of using technology to foster social and sensory connections in shared meals within DICom (Chapter 5). Herein, this (Chapter 6) starts with an overview of the studies carried out in this thesis (See Table 6.1). Followed by addressing the research questions from all the studies in Section 6.2. Next, outlining the thesis contributions in Section 6.3. Finally, in Section 6.4 the limitations and potential research opportunities that stem from the work done in this thesis, which could be investigated in the future, are discussed.

Order	Chapter 3	Chapter 4	Chapter 5
Study	Digital Immersive Commensality – Learning from Spontaneous Remote Dining Practices	No Pie in the (Digital) Sky: Co-Imagining the Food Metaverse	Exploring the Dynamics of Immersive Eating
RQs	Addressed RQ1 + RQ2	Addressed RQ3	Addressed RQ1 + RQ2
Method	Mixed-methods study	Qualitative study	Qualitative study
Approach	Analysis of semi-structured interviews, observation notes during sessions and quantitative questionnaire	Analysis of audiovisual recordings, sketches, participants' notes during workshops, and semi-structured interviews with experts and non-experts	Analysis of semi-structured interviews, audiovisual recordings during sessions, and follow-up surveys
Analysis	**Interaction analysis** [182] was conducted to identify spontaneous activities observed during the sessions; **Inductive thematic analysis** [50] was applied to a corpus of data collected from 14 interviews with strangers and 22 interviews with friends, along with video recordings of the sessions.	**Reflexive thematic analysis** [49, 51] was applied to a dataset collected from 50 participants during six co-design workshops, as well as to eight interviews with experts and 11 with non-experts.	**Reflexive thematic analysis** [49, 51] was applied to a corpus of data collected from 14 participants in 7 sessions including audiovisual recordings and interviews; **Inductive semantic thematic analysis** [52] was conducted on 32 follow-up answers to surveys from the design process and 14 follow-up answers to surveys collected two months after the sessions.

Table 6.1: Details of the studies carried out in this thesis.

6.2 Research questions addressed

Each chapter addressed a set of research questions, all of which ultimately aimed to expand knowledge related to the design and deployment of DICom. The chapters explored its social potential in specific, as well as the sensory and emotional dimensions in virtual communal settings. Additionally, they examined design opportunities and challenges in designing meaningful digital dining experiences, aiming to inspire designers to create experiences that leverage technology to enrich shared meals in a meaningful manner. The following subsections summarise chapter-specific research questions and key findings along with implications to those findings.

RQ1: How do social interactions unfold in digital immersive commensality set-

tings, and what factors influence the development of meaningful connections among participants during virtual meals?

In this thesis, I explored how social interactions unfolded during digital immersive meals and discovered ways in which food, technology, and sensory engagement influenced the development of meaningful connections among participants. Through the findings presented in Chapters 3 and 5, I showed how participants leveraged shared experiences, playful behaviours, and sensory engagement to foster emotional bonds and a sense of connection in both video conferencing and immersive VR settings.

Food as catalyst of digital setups. The findings highlighted how food consistently acted as a powerful catalyst for fostering social interactions. As demonstrated in Chapters 3 and 5, food often served as an icebreaker, prompting conversations that started with questions about what others were eating and evolved into deeper discussions about personal stories and cultural connections. I showed that the choice of food noticeably shaped the dynamics of these interactions, with distinct outcomes depending on whether participants brought their own unique dishes or shared the same dish. In Chapter 3, participants brought their own unique dishes, which led to rich and diverse exchanges. These discussions often revolved around individual preparation methods, recipes, and the cultural or personal significance of the dishes. This setup encouraged participants to assert their individuality, providing opportunities for self-expression and discovery through food.

In contrast, in Chapter 5, participants shared the same dish, creating a shared foundation that fostered a sense of commonality and trust. This uniformity helped participants feel more aligned and connected, as it minimised differences and focused the interaction on the collective experience of enjoying the same meal. Sharing the same dish acted as a unifying element, fostering solidarity and a sense of togetherness. Participants often commented on their shared experience of taste, texture, and presentation, which helped build rapport and synchronise their interactions. Importantly, this was a conscious design decision informed by findings from Chapters 3 and 4, where participants expressed a strong desire for shared sensory moments and emphasised the bonding potential of eating the same food. These findings demonstrate how carefully curating the choice of food in virtual dining contexts can significantly influence the dynamics and outcomes of social interactions, tailoring them to

meet specific objectives.

Multisensory engagement. In this thesis, I showed that multisensory engagement plays an important role in enabling meaningful connections in digital immersive commensality. Participants consistently expressed a desire for sensory-rich experiences, emphasising the importance of taste, smell, texture, and visuals in creating authentic and socially engaging interactions. Chapter 4 further demonstrated how participants greatly valued integrating sensory experiences at the dinner table to promote mindful eating and enhance engagement. Chapter 3 showed how participants in video conferencing environments creatively compensated for sensory limitations by describing their meals, bringing food closer to the camera to show its texture, describing or trying to guess the smell, etc.

In contrast, Chapter 5 showed how the multisensory VR environment which addressed some of the sensory gaps present in videoconferencing tools, allowed participants to engage more deeply with their surroundings and each other. This enhanced sensory immersion was attributed to the sensory stimulation provided by the virtual environment and the shared experience of eating the same food. Participants noted that tasting the same dish added an additional layer of sensory connection, as it allowed them to discuss and react to the flavours and textures collectively. It led to behaviours such as holding hands, attempting to hug, and engaging with the sensory details of their surroundings. Participants commented in interviews and surveys that these sensory cues, both from the food and the virtual environment, helped create a more vivid and emotionally engaging shared experience, fostering intimacy and connection that would otherwise be difficult in a virtual setting.

Shared environments. I also showed how shared virtual environments shaped the dynamics of social interactions. In video conferencing setups, participants often shared their individual environments, which fostered some level of intimacy but also emphasised physical separation. In contrast, the shared VR environments in Chapter 5 allowed participants to explore a common space together, enhancing the sense of adventure and collaborative engagement. These shared experiences aligned with participants' desire to "embrace constructive distractions," as noted in Chapter 4, and contributed to a sense of relaxation and enjoyment during meals.

However, the immersive VR setting also introduced unique challenges. For instance, some

participants noted that distractions in VR occasionally shifted the focus away from deeper conversations, compared to video conferencing where participants remained more directly engaged with one another. These findings highlight the trade-offs between immersive and non-immersive virtual environments in facilitating social interaction.

Playfulness and breaking norms. A key observation in this thesis was the role of playful behaviour in enhancing social connections. As demonstrated in Chapters 3, 4 and 5, participants consistently engaged in playful interactions. In Chapter 3, I observed how participants engaged with digital props, such as virtual food, by grilling, juggling, or performing playful behaviours like slurping noodles and licking sauce from the plate. Chapter 4 also supported playfulness, as it showed participants expressing a strong interest in participating in playful activities while eating. In Chapter 5, participants turned food into digital props, performed magic tricks with it, threw virtual food at one another, interacted with a virtual rabbit, or engaged in exaggerated gestures. Across both studies in Chapter 3 and 5, participants frequently created their own games outside the digital system, such as singing and guessing games. Avatars in VR encouraged playfulness by reducing participants' self-consciousness. While this facilitated greater freedom of expression, it also introduced limitations, such as the inability to convey facial expressions, which are crucial for interpreting emotions. Despite these challenges, the playful interactions fostered bonding and mutual enjoyment, illustrating how food and technology can create a relaxed and socially connected atmosphere during virtual meals.

I observe that in both settings—video conferencing and immersive VR—participants engaged in meaningful social interactions shaped by food, sensory engagement, and playful behaviours. Both environments fostered connections, but the nature and depth of these interactions varied depending on the platform's characteristics. Video conferencing encouraged individuality, personal storytelling, and creative adaptations to sensory limitations, while immersive VR provided a richer sensory experience and a stronger sense of co-presence through shared environments and shared meals. The findings suggest that the choice between video conferencing and immersive platforms depends on the goals of the interaction. Video conferencing is better suited for contexts where individuality, cultural exchange, and conversational depth are prioritised. On the other hand, immersive VR excels in creating a strong sense of unity, sensory connection, and playful collaboration, making it ideal for fostering group cohesion

and shared experiences.

RQ2: How do users experience food choices, eating habits, and sensory and emotional engagement within digital immersive commensality settings?

Digital platforms hold significant potential to enhance sensory awareness and encourage mindful eating. It was shown in Chapter 4 that people are interested in practising and engaging in mindful eating habits. Although these technologies cannot fully replicate the sensory richness of in-person dining, participants in Chapters 3 and 5 demonstrated active engagement with the sensory elements available to them, such as describing textures, aromas, and visual presentations. Eating the same food in immersive environments also intensified sensory engagement, as participants synchronised their focus on flavours and textures. Chapter 5 highlighted how shared meals led to deeper discussions about the sensory properties of food, encouraging participants to analyse and appreciate the subtle nuances of taste and texture that might otherwise go unnoticed. This was particularly significant in VR, where heightened awareness of food's sensory qualities persisted even after the dining session, suggesting a lasting influence on participants' everyday food perceptions.

Cultural contexts and food appreciation. Digital platforms, particularly immersive environments, provide a unique opportunity to connect food experiences with cultural contexts. In Chapter 5, participants immersed themselves in cultural settings, such as engaging with Japanese dining traditions during a VR meal. Activities such as bowing and speaking Japanese greetings, as well as expressing gratitude before eating, highlighted how virtual environments can simulate cultural rituals and encourage participants to explore and respect food traditions. Additionally, participants expressed curiosity about the cultural background of matcha, asking questions about its traditional preparation, significance, and role in Japanese culture.

This cultural exploration extended beyond the virtual experience. Participants noted that such immersive experiences encouraged them to seek out additional information about the cultural history of food and, in some cases, integrate elements of these traditions into their real-life dining practices. For instance, participants reported increased awareness of the significance of food rituals and expressed a desire to incorporate similar moments of reflection

and gratitude into their meals. Chapter 4 further supported this by showing how participants valued the stories and cultural heritage surrounding food, underscoring the role of virtual environments in fostering a deeper appreciation for global culinary traditions.

Mindful eating. In addition to cultural exploration, this thesis showed that multisensory engagement plays an important role in fostering meaningful connections between participants and their food. Participants consistently emphasised the importance of taste, smell, texture, and visuals in creating authentic and enjoyable eating experiences. Chapter 3 demonstrated how participants in video conferencing environments creatively compensated for sensory limitations by describing their meals, bringing food closer to the camera, or attempting to simulate smells through detailed descriptions.

In contrast, Chapter 5 showed how the multisensory VR environment, which addressed some of the sensory gaps present in video conferencing tools, allowed participants to engage more deeply with their surroundings and each other. Eating the same food in VR not only synchronised participants' behaviours but also fostered a shared sensory experience that extended to their perception of flavours, textures, and the overall dining context. This heightened sensory immersion encouraged participants to savour their meals more attentively, enhancing their enjoyment and emotional connection to the food.

Food habits and behaviour change. Digital platforms also influence eating pace and food preferences. Observations from Chapters 3 and 5 revealed a tendency toward mimicry, with participants synchronising their bites and eating pace, mirroring each other's behaviour. This synchronisation may foster more mindful eating, as participants become more attuned to the pace and rhythm of shared dining experiences. Furthermore, immersive platforms appeared to broaden food preferences. Participants reported trying new ingredients and dishes during the studies, with some of these changes persisting into real life. For instance, one participant who initially disliked matcha grew to enjoy it after repeated exposure in the VR environment. These experiences highlight how virtual platforms can encourage picky eaters or hesitant diners to explore new foods and expand their culinary horizons.

Despite the benefits, immersive eating experiences also pose challenges, such as the potential for overeating. Chapter 5 revealed that participants consumed more food during VR dining sessions, likely due to heightened sensory stimulation and immersive distractions, which dulled

awareness of natural satiety cues. However, these experiences also sparked interest in healthier eating habits. Participants expressed a desire for virtual features that provide real-time information on ingredients and nutritional value, translating into increased real-life attention to food labels and meal quality.

Playful interactions with food. Playing with food, typically discouraged in real-life contexts, became a source of creativity and amusement in virtual settings. Participants in Chapters 3 and 5 embraced virtual food as a playful prop, engaging in behaviours such as juggling, throwing food in the air, or interacting with virtual elements like the rabbit in the VR environment. These interactions redefined the role of food from sustenance to an object of entertainment and creative expression. This playful engagement with food highlights how digital platforms can encourage users to rethink traditional food norms.

However, this playful engagement with food raises potential concerns about diminishing the perceived value of food. By transforming food into a tool for entertainment, there is a risk that participants may lose sight of its inherent significance as a source of nourishment, cultural meaning, and mindful engagement. This shift could inadvertently trivialise the deeper connection individuals have with food, particularly when the focus becomes more about the interaction itself than the food being consumed. That said, virtual environments also offer an opportunity to balance these dynamics. For example, playful interactions could be intentionally designed to coexist with educational elements, such as highlighting the origins, nutritional value, or cultural significance of the food being "played" with. Such integration might ensure that while participants explore the creative and entertaining aspects of food, they also maintain an awareness of its intrinsic value and role in their lives.

This thesis reveals that digital platforms can shape food choices, eating habits, and sensory experiences, with video conferencing and immersive systems offering slightly distinct advantages. Video conferencing tools foster mindfulness and analytical engagement, compelling participants to creatively articulate and reflect on their personal food experiences despite sensory limitations. Immersive systems like VR can bridge some of the sensory gaps, providing a multisensory, culturally enriched environment that deepens appreciation for traditions and transforms the act of eating into a collective, immersive experience. The choice of platform ultimately depends on the goals of the experience between introspection and individual

connection to food and a shared, richly interactive dining experience.

RQ3: How can technology enhance the shared meal experience in digital immersive commensality, and what are the opportunities and limitations of creating meaningful social and sensory connections in virtual dining?

This thesis demonstrates that technology has the potential to transform shared dining experiences by fostering deeper sensory, cultural, and social connections. By investigating spontaneous behaviours during remote dining (Chapter 3), exploring user-envisioned future possibilities (Chapter 4), and testing immersive dining prototypes (Chapter 5), this research presents a holistic approach to understanding and designing DICom. The study not only focused on current technological capabilities but also explored how people imagine technology could enhance food experiences, offering insights into the future of shared meals.

"Ingredients" for enhancing tech-mediated food experiences. Chapter 4 identified 18 core elements valued in food interactions, such as sensory stimulation, cultural exchange, and emotional connection. These elements were not only aspirational but were also validated through practical behaviours observed and analysed in Chapter 3 and Chapter 5. This shows that the identified elements are not hypothetical, they are actionable components that designers can integrate into future DICom platforms. The identified elements were further developed into actionable concepts through a catalogue of speculative ideas presented in Chapter 4. This catalogue featured 10 creative and thought-provoking concepts that extended beyond what is currently possible, exploring how people imagine technology could reshape their relationship with food and dining. These speculative ideas were grounded in the 18 elements identified during co-design workshops and mapped to five design directions.

The catalogue served as a bridge between user aspirations and practical design possibilities, inspiring designers to think beyond current technological limitations and consider how emerging technologies like VR and the metaverse could transform dining. Each concept encouraged experimentation with new forms of interaction, sensory stimulation, and shared rituals, aiming to redefine what a meal could mean in virtual settings. The evaluation of this catalogue by experts and non-experts added a critical layer of validation, identifying five key features that could prioritise user needs in designing DICom systems. These features were later integrated into the prototypes tested in Chapter 5, demonstrating how speculative ideas can

translate into real-world applications. This thesis provides a pathway for designers to incorporate these elements into future DICom platforms, ensuring that the resulting experiences are both meaningful and innovative.

Opportunities and limitations for designing future DICom systems Building on the design opportunities and limitations identified in Chapters 3, 4, and 5, this thesis provides a comprehensive roadmap for creating meaningful DICom experiences. The pathways identified, which stem from user-driven insights and speculative designs validated through evaluation, are summarised below.

Desired pathways for designing DICom The findings across the chapters and the evaluation of speculative designs reveal several promising opportunities to transform DICom experiences:

1. **Rituals in virtual dining:** Designing for the emergence and evolution of mealtime rituals in virtual environments offers significant potential to enhance shared meal experiences. Virtual dining platforms, such as DICom systems, provide a unique space for participants to experiment with new rituals, such as synchronised gestures, shared toasts, or group activities, which could foster a sense of togetherness and meaning. These virtual rituals may draw inspiration from physical traditions or evolve into entirely novel practices shaped by the affordances of immersive environments [307]. Understanding how rituals in the digital world compare to physical ones and whether they influence each other is an essential area for future exploration. For instance, will virtual rituals mirror the emotional and cultural depth of physical traditions, or will they introduce new dynamics that challenge existing norms? Such insights could guide the design of DICom platforms to foster engaging, meaningful rituals that strengthen bonds between participants.

2. **Multisensory engagement:** Multisensory engagement holds potential for enhancing co-presence and fostering trust in DICom. By leveraging the interplay between sensory modalities, such as pairing flavours with complementary visuals or synchronised sounds, immersive technologies can create cohesive and engaging environments that feel authentic and emotionally resonant [358, 367]. A key consideration is understanding how crossmodal correspondences, such as matching the crisp sound of food with its

texture or using warm lighting to enhance perceived flavours, can amplify immersion and connection. These combinations of sensory modalities must be carefully studied to identify which are most effective in creating an authentic and cohesive dining experience in virtual settings. For example, how might the interplay of sensory elements influence not only the immediate emotional connection but also users' long-term food preferences or behaviours? At the same time, designers must be cautious of overstimulation or a disconnection from internal cues, such as hunger and satiety, which are critical to maintaining a balanced dining experience [69]. Investigating how multisensory engagement might shape perceptions of physical meals is essential to ensure that virtual dining experiences complement, rather than compete with, real-world practices.

3. **Cultural exchange:** Immersive platforms provide a unique opportunity to celebrate and preserve diverse food traditions through interactive and dynamic representations. By enabling users to participate in virtual workshops or simulations – such as the Japanese dining rituals explored in Chapter 5 – these platforms can foster a deeper appreciation for global cuisines. Such experiences allow participants to not only observe but also actively engage with the rituals, techniques, and histories that shape culinary practices, broadening their understanding of cultural heritage. Crowdsourcing culinary narratives could further enhance authenticity, enabling users to contribute personal stories and recipes that reflect their unique traditions and regional cuisines [328]. This approach raises important questions: How can immersive platforms ensure that representations of cultural food practices remain dynamic and respectful, while avoiding the pitfalls of oversimplification or stereotyping? Moreover, can these virtual engagements influence participants' perceptions of real-world food cultures and inspire greater inclusivity in how traditions are shared and preserved? By exploring these dynamics, designers have an opportunity to create platforms that not only entertain but also educate.

4. **Mindful eating and healthy habits:** Integrating features such as real-time nutritional feedback, sensory cues, and environmental pacing can promote healthier eating habits and mindfulness [74, 143]. For example, subtle environmental changes, like muted colours during pauses in eating Chapter 5, were shown to influence participant behaviour and enhance focus on the meal. This method brings up important questions:

How does prolonged indulgence in immersive spaces affect users' real-world behaviours, especially when it comes to consumption and self-control? And What design principles can be implemented to create immersive experiences that promote responsible behaviour and discourage overindulgence? Designers need to balance these aspects carefully; an overemphasis on sensory pleasure could encourage overindulgence and unhealthy eating habits in pursuit of heightened taste.

5. **Customisation and self-expression:** Allowing users to personalise their dining environments, avatars, and virtual dishes can enhance engagement and satisfaction, as highlighted in references [6, 248]. For instance, Chapter 3 discusses how participants used customisation to match face filters with their clothing, using them as a medium for self-expression. Such customisation not only enhances self-expression but also fosters deeper social connections. Additionally, it raises questions about how can customisation enhance and foster deeper social interactions? And how can customisation promote greater food awareness and appreciation? Designers are thus encouraged to explore options for customising the eating experience, including the food design, environment setting, and avatars, to enrich the virtual dining experience.

6. **Playfulness:** Incorporating playful elements into digital dining can enhance engagement, promote social interaction, and encourage curiosity [11, 17, 38]. Participants in Chapter 3, and 5 embraced playful interactions with virtual food, creating memorable experiences that transcended traditional norms. Questions to consider are how can we design playful elements that enhance social connection? And how can we incorporate playful elements to encourage mindful eating? Designers must ensure that these playful elements complement, rather than overshadow, the emotional and cultural significance of food [11].

7. **Impossible experiences:** Fantastical dining settings, such as dining under the stars or exploring historical cuisines, create unique experiences not possible in the real world [369]. Participants from Chapters 4 and 5 expressed strong interest in these imaginative environments. While engaging, such technologies could set unrealistic expectations and detach users from reality, potentially overwhelming them [84]. By merging physical and digital realms, designers can craft "impossible experiences" that enhance culinary practices through playful interactions beyond traditional senses. This blend of fantasy

and reality could shift culinary behaviour and boost creativity through novel interactions [401]. This poses an important question for designers: how can they design these experiences to avoid detachment from real life while preventing overexposure? By doing so, they can ensure a balance that enriches the culinary experience without alienating users from their real-world context.

8. **Consider throw-away technologies:** The research revealed that even brief digital eating experiences can have a noticeable **long-term effects** on users' behaviour and emotions across cognitive, behavioural, and socio-cultural dimensions, challenging the notion that only prolonged engagements are impactful. These short, intense culinary explorations offer deep cultural, nutritional, and sensory insights, transforming eating habits and well-being while instilling a lasting mindfulness and appreciation for food. The designers should consider strategic use of digital technology in design, not as a constant presence but as a tool for specific enhancements in the culinary journey, particularly beneficial for older individuals lacking social dining skills. Designers are thus tasked with creating immersive setups that are meaningful, engaging, and respectful of their transient yet impactful role in users' culinary and social lives. They must also address critical questions: how can we design these initiatives to ensure sustained engagement and long-term behavioural changes rather than short-lived trends? Furthermore, what strategies can be employed to monitor and evaluate the success of these initiatives in promoting long-term behavioural changes?

Undesired pathways for designing DICom While the opportunities outlined above are promising, several risks must be addressed to ensure ethical and meaningful DICom experiences:

1. **Overstimulation and overeating:** Excessive sensory engagement can dull users' awareness of natural satiety cues, leading to overeating, as observed in Chapter 5. Without careful design, immersive technologies might inadvertently normalise overindulgence, posing risks to physical and emotional well-being [143, 286].

2. **Trivialisation of food's significance:** Overemphasis on playful or fantastical features risks reducing food to an entertainment prop, eroding its cultural and emotional value.

Designers must ensure that immersive elements enhance, rather than diminish, the depth of shared meal experiences [17].

3. **Cultural misrepresentation:** Simplifying or homogenising cultural practices to appeal to global audiences risks alienating users and perpetuating harmful stereotypes [328]. Collaboration with cultural experts and community-driven content creation can mitigate this risk.

4. **Detachment from reality:** Over-reliance on immersive experiences might lead users to develop unrealistic expectations for real-world dining, reducing their appreciation for authentic, physical meals [84]. Designers must strike a balance between virtual and real-world connections.

6.3 Contributions

This thesis offers several contributions to the HFI research community. First, it provides theoretical contributions to the existing literature that extend the understanding of interactions between individuals and food-related behaviours within the framework of DICom. Furthermore, it deepens the understanding of people's daily experiences with food, identifying the opportunities and challenges they perceive in this space considering emerging metaverse technologies. Second, this thesis offers practical contributions that are related to the design and deployment of digital immersive commensality setups using both video conferencing tools and VR. Third, the thesis provides an empirical analysis of users' behaviour within these immersive environments. Finally, it offers conceptual contributions, exploring the intersection of food and technology through user-centric approaches that evaluate potential food technology applications within the metaverse.

6.3.1 Conceptual contribution

1. This thesis introduces the concept of DICom, a novel framework that redefines the practice of sharing meals in digitally mediated or virtual environments. DICom integrates and extends existing theories of commensality, presence, and multisensory interaction, conceptualising how social, sensory, and emotional dimensions of traditional communal

dining can be replicated or enhanced through technology. The framework is not merely a theoretical construct but a synthesis of empirical observations and user-centred studies conducted across this thesis. Through Chapters 3, 4, and 5, this research delineates the core characteristics of DICom:

(a) **Multisensory Immersion:** Leveraging immersive technologies to engage multiple senses such as sight, sound, touch, smell, and taste enhances the dining experience, making it semantically compelling and emotionally engaging [54]. Blending sensory cues with familiar elements associated with specific concepts can further deepen this connection [129]. By engaging multiple senses simultaneously, participants become more attuned to food's nuances, including its texture and taste, fostering a richer appreciation and connection to the meal.

(b) **Cultural and Contextual Richness:** Immersing users in culturally rich settings fosters discussions and connections over shared cultural references, evoking memories and emotions [382]. This can inspire participants to approach food with reverence or curiosity, learning and teaching each other about cultural elements and food preparation [277]. Such culturally grounded interactions enhance appreciation and understanding of food, elevating the experience's authenticity and making it feel more meaningful.

(c) **Dynamic Social Interactions:** This dimension emphasises creating meaningful connections through storytelling, synchronised actions, and communal rituals. Features such as environments that evolve based on participants' eating patterns can encourage social synchronisation and enhance ties between diners. Interactive storytelling mechanisms using food as a central element add depth to these interactions, drawing from the cultural and emotional resonance of shared narratives [142, 375].

(d) **Imaginative Exploration and Creativity:** Encouraging fantastical and surreal dining scenarios that transcend real-world limitations fosters curiosity and creativity. Immersive environments can enable participants to explore new perspectives, unlocking opportunities for creative engagement and the reimagining of food and its contexts. These imaginative setups, such as evolving narrative-driven dining environments, intensify the experiential aspects of food, creating opportunities for

deeper interaction and reflection.

(e) **Food Literacy and Engagement:** This dimension highlights the importance of understanding food beyond its immediate consumption, including its nutritional, cultural, and sustainable aspects. Providing insights into nutritional content, as well as contextual information about ingredients and preparation techniques, fosters educational discussions and deeper engagement [228]. By linking food to broader narratives, participants develop a nuanced appreciation for what they consume, making dining both an enlightening and reflective experience.

Among the five dimensions of the DICom framework (see Section 4.5.3), Multisensory Immersion and Dynamic Social Interactions stand out as having the greatest potential to transform digital immersive commensality into a socially and emotionally resonant experience. These two dimensions directly address the core limitations of current digital dining systems, which often fail to capture the sensory richness and fluid social dynamics that previous systems have been unable to effectively support.

Multisensory Immersion offers a powerful means of deepening presence and emotional connection by engaging multiple senses. Across the studies, participants expressed a strong desire for sensory cues such as smells, ambient sounds, and food visuals, that could bridge the physical distance and evoke a shared atmosphere. The VR prototype in particular demonstrated how layering multisensory elements onto eating interactions enhanced emotional engagement, increased attentiveness, and created a more embodied and memorable experience. In parallel, the dimension of Dynamic Social Interactions emerged as highly promising, offering the capacity to foster responsive, co-constructed, and playful exchanges. While it partially reflects traditional commensal behaviours, it also enables the formation of novel social rituals that are unique to virtual environments. Participants frequently engaged in practices that differed from conventional dining norms, such as role-playing, synchronised gestures, and spontaneous improvisation, thereby creating interactions that were more fluid, expressive, and socially engaging. These behaviours highlight the potential of this dimension in enriching digital commensality beyond the mere replication of physical practices.

Together, Multisensory Immersion and Dynamic Social Interactions form a foundational pair for designing DICom systems that move beyond functional connectivity toward

meaningful, culturally rich, and emotionally resonant shared meals in digital spaces.

2. Building on the DICom framework, this thesis conceptualises **meaningful food experiences** in digital and immersive settings. It focuses on the interplay between technology, social connection, and sensory engagement to define dining interactions that go beyond basic sustenance. Meaningful experiences are characterised by:

   (a) **Social presence:** Technology's ability to enable participants to share emotions, stories, and rituals, fostering a sense of "being together" despite physical separation.

   (b) **Sensory engagement:** The enhancement of dining interactions through simulated sensory elements (e.g., aroma, texture, visuals), creating immersive environments that connect participants.

   (c) **Cultural and emotional resonance:** Integrating culturally significant practices, traditions, and storytelling to reinforce identity and shared understanding.

6.3.2 Theoretical contributions

1. This thesis contributes to the understanding of commensality by exploring how digitally mediated environments reshape the dynamics of shared meals. Drawing on Spence et al.'s work on digital commensality [344], the research provides evidence of how video-mediated communication (Chapter 3) and immersive technologies like VR (Chapter 5) enable participants to create and sustain social bonds in remote settings. While not proposing a formal theory, the findings reveal how sensory and social elements in virtual environments can bridge physical distance, supporting shared rituals and emotional connections. The work highlights the potential for immersive technologies to introduce new practices of commensality that complement traditional ones, contributing to the evolution of dining as a social and cultural activity.

2. Through empirical studies and prototype evaluations, the thesis demonstrates the role of multisensory design in enriching shared dining experiences. By integrating sensory elements like aroma, texture, and visuals, the research highlights how these aspects can enhance user engagement and emotional connection. While the findings build on principles of multimodal interaction [283], the primary contribution lies in showing how

these concepts can be practically applied to digital dining scenarios. This research offers actionable insights for designers seeking to create systems that enhance the sensory and emotional dimensions of remote dining.

3. The thesis examines how digital technologies transform traditional dining norms while enabling new social behaviours, such as performative eating and collaborative storytelling (Chapter 3, Chapter 5). By documenting these behaviours, the research contributes to understanding how digital environments support the emergence of novel social rituals. These findings provide practical guidance for designing virtual dining systems that balance innovation with the preservation of cultural and social values. The research situates its observations within existing discussions of mediated interaction and ritual affordances in HCI (e.g., [117, 136]).

6.3.3 Practical contributions

1. Chapter 5 demonstrates the practical implementation and evaluation of a Wizard-of-Oz multisensory VR prototype, showcasing how theoretical insights from the research process can be translated into a tangible, functional system (see Section 5.6). By detailing the design, testing, and refinement of this prototype, the study provides a practical example of how immersive technologies can be designed to enrich digital eating experiences. This work highlights the potential of such systems to foster meaningful connections with food and others, addressing a previously unexplored area where such immersive systems had not been demonstrated or evaluated (see Section 5.3.1).

2. The thesis delivers in Chapters 3, 4, and 5 a comprehensive series of design guidelines and actionable insights for HFI designers to craft human-centric food experiences. These guidelines, grounded in extensive empirical research, provide a practical toolkit to inspire and direct the development of technologies that prioritise social engagement, sensory richness, and cultural inclusivity in digital immersive eating contexts. Specifically:

    - Chapter 3 introduces six digital immersive commensality design potentials (see Section 3.4).
    - Chapter 4 presents a list of 18 important elements, five design directions, and five

recommended features (see Section 4.5.1) for designing a prototype that enhances social dynamics.

- Chapter 5 provides six design opportunities (see Section 5.9), emphasising pathways for creating immersive and socially engaging eating experiences.

6.3.4 Empirical contribution

1. This research, detailed in Chapters 3, 4, and 5, provides a novel analysis of users' behaviour in DICom setups. Through both video conferencing tools and VR technologies, it explores the dynamic intersection of food and technology in shaping social interactions. The analysis uncovers the nuanced ways participants engage with these virtual immersive environments, capturing how they adapt their behaviours, emotions, and interactions to create meaningful shared dining experiences. This empirical contribution offers valuable insights into the potential of digital tools to foster connection and enhance the socio-emotional richness of remote eating, providing a foundation for future research and design in this evolving field.

6.4 Limitations and Future work

6.4.1 Limitations

The work conducted in this thesis had several limitations that must be acknowledged. Firstly, all three studies faced constraints related to sample size. In the first study, detailed in Chapter 3, affective responses from a limited number of participants were captured and analysed during video-mediated communication sessions. Similarly, Study 2, discussed in Chapter 4, involved a limited sample size in its workshops, and Study 3, outlined in Chapter 5, included only 14 participants in VR eating sessions. These **sample sizes** are relatively small compared to large-scale datasets in terms of participant numbers and session frequency. However, it is worth noting that similar studies in digital immersive commensality often involve small sample sizes due to the complexity of experimental setups, the approach of the qualitative reflexive thematic analysis, and the exploratory nature of the research (e.g. [23,

215, 262]). Niewiadomski et al. [270] discussed the challenges and methodologies in studying social food preparation and consumption within human-computer interaction, highlighting the tendency towards small sample sizes in such exploratory studies.

Additionally, all studies faced limitations related to **participant demographics**. The findings may not be generalisable to under-represented groups, such as individuals with disabilities or older adults, without further investigation. Previous studies suggest that older individuals engage with technology differently than younger generations [213, 215]. Furthermore, the cultural demographics of participants presented a limitation, as the studies represented only a narrow slice of the cultural diversity inherent in commensality practices. Finally, economic status further constrained generalisability, as participants were predominantly from technologically advanced and economically privileged societies. This group is more likely to be early adopters of emerging technologies, potentially excluding those with limited access to such tools.

Despite these limitations, the findings of this thesis provide valuable insights and inspiration for future research and design. Future studies could prioritise larger, more diverse participant samples, including individuals from under-represented groups and varied cultural and economic backgrounds. Investigating cross-cultural differences and using advanced methods for broader data collection will enhance the generalisability and applicability of the findings.

Secondly, while commensality traditionally encourages groups of people to share meals and foster collective interactions (see Section 2.4), the practical constraints of this research limited the exploration to one-on-one social dynamics. Specifically, the experiments in Chapter 3 required the use of video-mediated applications, and the experiments in Chapter 5 required a VR setup. These technical and logistical complexities made it impractical to simulate group interactions within the scope of this study. Consequently, the thesis did not examine **group-based scenarios**, which constitutes a notable limitation. Without exploring how social dynamics operate in a multi-participant context, the broader implications of commensality in digitally immersive environments remain under-explored. Future research could address this gap by designing studies that incorporate group interactions, allowing for a deeper understanding of collective behaviours, shared experiences, and the nuances of larger social dynamics within digital immersive commensality.

Thirdly, the findings presented in Chapters 3 and 5 are closely tied to the **specific design characteristics** of the systems studied. It is crucial to recognise that the particular features and implementations of the selected applications played a role in shaping the identified design opportunity spaces. For instance, in Chapter 3, the analysis focuses on Facebook Messenger Rooms, which include a feature enabling users to apply AR filters. This feature likely influenced the observed interactions and emergent opportunities within the system. Similarly, in Chapter 5, the prototype's features were pivotal in shaping the findings related to immersive commensality and user engagement. Had alternative systems been selected or the designs altered, it is possible that different opportunity spaces would have emerged, or other aspects of the digital immersive eating experience might have been highlighted. This underscores the context-specific nature of the results, which are inherently tied to the design decisions and technical implementations of the studied systems. Consequently, the findings may not be directly transferable to other digital immersive eating contexts that incorporate distinct features, functionalities, or design choices. Instead, these insights should be understood as reflective of the systems examined within this research. Future research could build on these findings by exploring alternative system designs and features, investigating how different technological implementations shape user experiences, and identifying additional design opportunity spaces. Such studies could provide a broader understanding of the social dynamics of digital and immersive systems and their potential for enhancing interaction and engagement in diverse contexts.

Fourthly, acknowledging these limitations, it is important to note that both studies discussed in Chapters 3 and 5 did not investigate the long-term effects of video-conferencing communication applications and VR immersive setups. The study described in Chapter 3 focused on **short-term engagement**, as participants were assessed only during their 30–40-minute sessions. Similarly, the study in Chapter 5 observed participants for brief periods, specifically 15-20 minutes during their sessions, and followed up only after two months. These time-frames provide valuable initial insights but are insufficient to understand the enduring impact of digital immersive commensality. A more comprehensive, large-scale, and longitudinal study is essential to systematically examine the potential long-term consequences of digital immersive commensality. Such research could shed light on whether these setups may have adverse effects over extended periods and how they might shape the social dynamics

and behaviours of participants in their everyday lives. Future investigations should prioritise exploring these aspects to gain a deeper understanding of the enduring influence of digital immersive commensality on HFI, ensuring that both its benefits and potential risks are thoroughly evaluated.

Finally, all the studies presented in this thesis, particularly Study 2 in Chapter 4, emphasised the need for a more thorough and detailed examination of the potential **negative impacts** associated with the use of technology during eating, especially in contexts such as the metaverse. Similarly, Study 3 in Chapter 5 did not extensively explore the possible negative implications of eating in VR. While these concerns were mentioned in Chapters 4 and 5, a deeper exploration is essential to provide a balanced and comprehensive perspective. One practical limitation observed in Study 3 in Chapter 5 relates to the **type of food** that can be consumed while wearing a head-mounted display (HMD). Participants were unable to see their real plates or hands clearly, which restricted the types of food that could be used in the study to non-messy, bite-sized items that could be eaten by hand without requiring precision tools like cutlery or chopsticks. This significantly narrows the range of culturally diverse and realistic food experiences that can be meaningfully represented or conveyed in immersive settings. As discussed in Chapter 2 and in Chapter 5 (see Section 5.3.1), shared meals in many cultures involve multi-component dishes, sauces, or utensil use factors that introduce complexity when visual access is limited. This highlights a notable design constraint in VR dining; the physical act of eating must be adapted to fit the limitations of the medium, potentially affecting immersion, authenticity, and user comfort.

Future research could focus on an in-depth analysis of the effects these technologies may have on mental and physical health, considering both short-term and long-term consequences. Furthermore, their environmental implications, including energy consumption, waste generation, and sustainability challenges, warrant close evaluation. Additional factors such as ethical considerations, potential socioeconomic inequalities, and unintended societal consequences should also be examined to ensure a holistic understanding of the broader impact of these technologies.

Despite the above limitations, these constraints do not diminish the important value of this thesis as an inspirational resource for future designers and developers. The outcomes pre-

sented here lay the groundwork for advancing the next generation of HFI, offering insights that extend far beyond food consumption and technological use. This thesis represents an important step in reimagining eating experiences, demonstrating how technology can be leveraged to not only enhance users' connections with others but also foster a deeper, more meaningful relationship with food itself. Moreover, the findings provide actionable guidelines for designing user-centred systems that are attuned to the emotional, sensory, and social dimensions of dining, ensuring they meet users' needs in a thoughtful and impactful manner. This work has the potential to inspire innovation in immersive and multisensory design, shaping the future of HFI toward more inclusive, engaging, and culturally resonant experiences.

6.4.2 Future work

The concept of DICom introduced in this thesis provides a foundation for understanding and designing shared virtual dining experiences that emphasise social, sensory, and emotional connections. Building on the findings and insights developed through the studies presented in Chapters 3, 4, and 5, several opportunities emerge for advancing this framework. These directions aim to refine, expand, and apply DICom as both a theoretical and practical tool in designing the next generation of digital dining systems.

1. **Expanding the DICom framework:** While this thesis establishes a foundation for DICom, future work could refine and expand its theoretical and practical applications. This includes:

    - Exploring how DICom scales to accommodate group interactions beyond one-on-one dynamics, examining the social complexities of larger shared meals.
    - Investigating the long-term impact of DICom experiences on social habits, sensory perceptions, and relationships with food.
    - Designing and evaluating new multisensory features or technologies to deepen the emotional and cultural resonance of DICom environments.
    - Addressing ethical considerations, such as accessibility, cultural representation, and environmental sustainability, to ensure DICom systems are inclusive and responsible.

By pursuing these directions, future research can extend the DICom framework as both a conceptual lens and a practical tool, inspiring innovative approaches to digital dining that resonate with the diverse needs, values, and aspirations of users.

2. **AI companions in DICom settings:** Future research could explore the integration of AI companions within DICom environments, examining how these agents can simulate or enhance social connections. By engaging users in meaningful dialogues about food, culture, or personal experiences, AI companions could reduce feelings of loneliness and foster emotional connections, especially for individuals dining alone. These studies could investigate the role of AI in co-creating the DICom experience, examining how such companions might mimic human-like interactions, adapt to user preferences, and contribute to multisensory and emotionally supportive dining scenarios. Incorporating AI into DICom systems offers an opportunity to explore how these technologies reshape the boundaries of companionship, sociability, and identity in virtual dining.

3. **Exploring emotional dynamic and co-presence** All the studies presented in Chapters 3, 4, and 5 highlighted a significant interest from participants in personalising and customising their dining experiences. Building on this finding, future research could explore how DICom serves as a platform for individuals to express and shape their sense of self. Virtual dining spaces offer unique opportunities for self-reflection and identity exploration, enabling participants to experiment with their self-presentation through personalised food choices, customised dining environments, and interactive virtual engagements. These environments allow users to express preferences, showcase cultural or personal values, and explore aspects of their identity that may not emerge in traditional dining settings. For instance, individuals might design virtual dining spaces that reflect their aesthetic or cultural heritage or curate meals that symbolise their values or beliefs. Furthermore, DICom could play a role in fostering self-validation, as participants seek affirmation and social approval from others in these settings. Future studies could investigate how these interactions in virtual dining contexts contribute to participants' sense of self-worth, belonging, and social identity. This includes examining how digital immersive dining facilitates self-expression through food-related behaviours, visual representations, and conversational dynamics. By focusing on the intersection of self-identity and DICom, future research could uncover how virtual dining platforms en-

courage self-discovery, shape personal narratives, and redefine the relationship between food, identity, and social interaction in hybrid and digital spaces.

4. **Enhancing sustainability from virtual to real-world practices:** DICom presents significant opportunities to foster sustainability both in virtual and real-world contexts. Future research could investigate how immersive dining experiences encourage environmentally responsible behaviours, such as mindful eating or reduced food waste. For example, DICom systems could integrate features like virtual farming simulations, educational games, or sustainability trackers that raise awareness about ecological impacts. Studies could also explore how community-driven initiatives supported by DICom platforms inspire collaborative action, such as promoting sustainable agriculture or reducing carbon footprints. By embedding sustainability into the DICom framework, this research could align technological innovation with broader environmental goals, bridging the gap between virtual engagement and real-world impact.

6.5 Final reflections and conclusion

This thesis presented a foundational contribution to the evolving field of HFI, with a particular focus on Digital Immersive Commensality. Through a synthesis of theoretical examination, participatory design, and empirical evaluation, it advanced an understanding of how immersive technologies can be leveraged to enhance remote shared dining experiences. Through the development and application of the DICom Framework, the research demonstrated how multisensory, cultural, and social dimensions can be meaningfully integrated to foster more human-centric, emotionally resonant food interactions. It is hoped that this work will inspire continued exploration into the design of technologies that not only support eating as a functional activity, but also reinforce social bonds and deepen individuals' connection with food.

Within the DICom Framework, which was developed to guide the design of immersive dining systems, five key dimensions were proposed. Among these, Multisensory Immersion and Dynamic Social Interactions emerged as the most impactful and promising. Multisensory immersion was critical in restoring sensory richness in digital dining contexts, an aspect often lost in remote or screen-based food experiences, while dynamic social interactions enabled

playful, co-created moments of interaction that enhanced the sense of presence and togetherness. These two dimensions appeared to play a pivotal role in shaping the affective and relational quality of immersive commensality, suggesting their potential as anchor points for future design.

Building on these findings, I became particularly excited about several directions I hope to explore further in my future research. One area that stands out to me is the dietary potential of immersive dining, especially how these environments might support picky eaters or individuals with food-related anxiety by making eating more playful, exploratory, and socially supported. I'm also deeply interested in the therapeutic possibilities, particularly in enhancing eating experiences for people with disabilities or those experiencing loneliness and social isolation. These topics strongly align with my passion for designing inclusive, well-being-oriented digital experiences. In addition, I'm curious about how immersive dining might influence the development of identity in virtual environments, specifically, how repeated engagement could shape personality, self-perception, and social behaviour across physical and virtual contexts. I'm also eager to study how AI and virtual avatars could serve as dining companions or hosts, and how this might reshape interactions, hospitality, and cultural storytelling. At the same time, I believe it's important to critically investigate the long-term psychological and social impacts of these technologies. As I continue this work, I hope to contribute to the responsible and human-centred development of immersive food technologies.

In conclusion, this thesis provided both a conceptual framework and a design-based methodology for reimagining shared meals in digital contexts. The DICom Framework is not intended as a fixed solution but as a generative tool one that can evolve with technological advances, cultural shifts, and the growing body of knowledge in HFI. As immersive commensality continues to grow as a field of research, there remains significant opportunity to refine, expand, and apply this framework to support richer, more inclusive, and socially meaningful food experiences.

Appendices

Appendix A

Study 1: Participant Information Sheet

Eating Buddy experience - Evaluating user perceptions on augmented reality enhanced platforms for assisting remote eating experiences.

You are being invited to take part in this research project. Before you decide to do so, please take your time to read this information sheet carefully. Your participation is entirely voluntary. Thank you for considering participating in this study.

What is the purpose of the study?
This project aims to explore how existent digital platforms transform the dining experience with a focus on single-person households. This research will help us understand perceptions on using technology (such as Augmented Reality - AR) to assist remote eating activities as well as possible benefits associated with remote dining. AR is an interactive experience where different parts of users' physical world are enhanced with computer-generated input. For this study, we will employ one emerging AR technology (SnapChat filters) that uses the front-facing camera and overlays a user's face or surroundings with digital features that might totally transform the appearance of the users or of their surrounding space.

Why have I been invited?
You were invited because you are at least 18 years old and live alone during the Covid-19.

Do I have to take part?
It is up to you to decide whether or not to take part. Your participation is entirely voluntary. If you do decide to take a part, you would be asked to sign a consent form prior to any further procedures.

You are free to withdraw from the research study at any time and without giving any reason.

Am I eligible to take part?

In order to take part you must be 18 years of age or over. These are the criteria to be able to take part:

1. Age 18+
2. Fluent in English
3. You have access to mobile
4. Living alone

What are the possible benefits of taking part?

We cannot promise that this study will provide any immediate benefits to you, however the information we get from this study will help to inform the research community about possible benefits of remote dining. Many people enjoy participation in research, particularly expressing their views during in-depth interviews.

What are the possible disadvantages and risks of taking part?

The researchers believe that there are no risks involved in this study. Nevertheless, as the study involves discussions of personal experiences you can withdraw at any point if you feel uncomfortable.

What will happen to me if I take part?

You will be asked to attend four virtual sessions during a period of three weeks including interviews before and after the session. The first session will last 15 minutes, the other three will last 30 minutes. In the first session you will be given an introduction into installing and using the AR-enhanced video platform chosen for the study. The duration of this session is approximately 15 minutes. After this first session, you will be asked to attend a another session experiment on different day over an interval of three weeks. In each session, you will be randomly paired with another participant in an AR-enhanced video call and asked to eat in front of your computer while interacting with each other. You will have the freedom to choose the way you interact with each other. The meeting rooms will be locked by using passwords and requiring authentication. The duration of a session will be approximately 30 minutes. The researcher will also take part in the call - without controlling or interfering with the session i.e. with her or his microphone off - in order to record the interaction.

Will my taking part in this project be kept confidential?

All information obtained in this study will be handled in confidence by us. All data will be stored on encrypted computers. Video-recordings and interviews will be transcribed, coded and the results anonymised. Screenshots from the eating session or quotes from interviews may be used, but these will also be anonymous, any faces, names or identifying features will be removed. The researcher will keep data for less than 12 months before destroying all data.

What will happen to the results of the study?

When the study is completed, we would analyse the data we collect and report the findings. It would be reported in an appropriate journal or presented at a conference. You will not be identified in any report or publication. If you wish to receive a copy of any reports resulting from the research, please ask us to include you in our mailing list.

Contact Details:

If you have any enquiries, please feel free to contact

Researcher: Khawla Alhasan

Address:

Email:

Mobile:

Appendix B

Study 1: Informed Consent Form

Study of Towards Digital Immersive Commensality – Learning from Spontaneous Remote Dining Practices

Name of researcher: Khawla Alhasan

Participants Identification Number:

1. Taking part in the study

I confirm I have read and understand the information for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

Yes : No

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.

Yes : No

2. Use of the information in the study

I understand that my responses will be anonymised before analysis. I give permission for members of the research team to have access to my anonymised responses I understand that the data could be used for publication.

Yes : No

I understand that my responses as well as photos and video recordings will be anonymised before analysis. All the faces on the photos and videos will be blurred out before analysis.

Yes : No

I understand that my response will only used for research purposes. I give permission for the research team to archive my anonymized responses for future research and make them available to other researchers in line with current data sharing practices.

Yes : No

I agree to take part in the above research project.

Yes : No

Name of participant:

Signature:

Date:

Name of the researcher:

Signature:

Date:

To be signed and dated in presence of the participant

Appendix C

Study 1: Semi-Structured Interviews

Interview 1: Study of Towards Digital Immersive Commensality – Learning from Spontaneous Remote Dining Practices

Opening remarks: Thank you for agreeing to give this interview. During the interview, we will mostly discuss your experience of the remote eating. Most of my questions will be about your experience, your feelings, and your thoughts during the eating. Kindly answer the questions with reference to the shared eating experience that you undertook. The interview would last between 30 - 35 minutes. Feel free to ask me to clarify if required. I will be audio and video recording the interview. If you have any questions or suggestions, we can take them at the end.

Q1. Please tell us your general impression of your remote eating experience. How have you felt during the session? Was there something that stood out?

Q2. How are you usually having lunch or dinner? Alone or with someone else? With or without technology?

Q3. How is today's experience different from your usual meals? How is today's experience different from the times you share meals with others in the same space?

Q4. How would you compare the benefits of eating remotely with the benefits as eating with someone in person?

Q5. How did the digital technology influence the social aspects of dinning? Give examples.

Q6. What do you think of the other participant who shared their meal with you? Did you build connection with him or her? What did you learn from him or her?

Q7. What is unique about the platform in your opinion? Is there a specific feature helped you to create the connections with the other person? Which feature would you keep or remove?

Q8. If you can keep a memory from the session, what would you chose and why?

Q9. If we would like to create a platform that is dedicated to virtual eating, what we should include in it?

Q10. Have there been any issues or challenges? If so, please tell me more about them. What can we improve to make the experience better?

Interview 2: Study of Towards Digital Immersive Commensality – Learning from Spontaneous Remote Dining Practices

Opening remarks: Thank you for agreeing to give this interview. During the interview, we will mostly discuss your experience of the remote eating. Most of my questions will be about your experience, your feelings, and your thoughts during the eating. Kindly answer the questions with reference to the shared eating experience that you undertook. The interview would last between 30 - 35 minutes. Feel free to ask me to clarify if required. I will be audio and video recording the interview. If you have any questions or suggestions, we can take them at the end.

Q1. We observed you engaged in X type of behaviour (here we described briefly the behaviour the person was involved in). Did this type of play have any impact on your gastronomic experience?
Q2. Could you think of other types of play you might find appealing in the context of these remote dinners?
Q3. How is today's experience different from your usual meals? How is today's experience different from the times you share meals with others in the same space?
Q4. Do you remember any past dining experience where you had fun? Why did you enjoy it?
Q5. Do you think some of these elements can be brought in a remote dining experience to make it more enjoyable?

Appendix D

Study 1: General Instructions for Eating Experience

Dear [Participant Name],

Thank you for registering for the Eating Buddy experience; we really appreciate your interest. We hope to have fun and enjoy the experience.

Please have a quick look at what is required for the eating session below:

1. Updated mobile version of Facebook Messenger Room App + Facebook account.
2. Bring any meal you would enjoy and share with the other participant.
3. Put your mobile in a position where you can show your face and your delicious meal.
4. Please speak English during the session.

How will the experiment work?

1. One hour before the dining, the researcher will provide you the link for the virtual room. When you click on it from your mobile, it will immediately start with the other participant sharing your meal with her or him.
2. The researcher will not communicate with you during the session. He or she will disable the Audio and Video to observe the experiment. You can enjoy talking to the other participant who will also bring her or his meal to join you.
3. The researcher will not interrupt the session only when the time is up, around 20-35 minutes.

Appendix E

Study 1: Digital Commensality Questionnaire

Please indicate how much you agree or disagree with the following statement:

Q1. Eating or drinking with others online helps me feel closer to them.

Q2. Eating or drinking with others online makes our meet-up more interesting.

Q3. Eating or drinking with others online makes our meet-up more fun.

Q4. Eating or drinking with others online helps me feel as if we were actually together.

Q5. Eating or drinking with others online helps me feel less alone.

Q6. I only drink online with others I'm very close with.

Q7. I eat or drink with others online because dinner time is the only time I have to meet them.

Q8. Eating or drinking with someone else online makes me appreciate my food more.

Q9. If I eat or drink alone I get bored, that's why I eat or drink online with others.

Q10.I eat or drink online because someone else asked me to, but it makes me uncomfortable.

Appendix F

Study 2: Participant Information Sheet

Research title: No Pie in the (Digital) Sky: Co-Imagining the Food Metaverse

Thank you for considering participating in this study. You are being invited to take part in this research project. Before you decide to do so, please take your time to read this information sheet carefully. It is important that you understand the reason why this research is being carried out, and what your participation will involve. Please take as much time as you need to decide whether to take part.

What is the purpose of the study?

This project aims to explore the design of remote dining experiences which leverage Virtual Reality technology.

Who is running this study?

The project is being run by the members of the University of Kent: Khawla Alhasan

Why have I been invited?

You have voluntarily agreed to participate in this experiment.

Do I have to take part?

It is up to you to decide whether or not to take part. Your participation is entirely voluntary. If you do decide to take a part, you would be asked to sign a consent form prior to any further procedures. You are free to withdraw at any time: this includes the right to withdraw your data from the study after it has taken place. If you decide not to take part, or to withdraw at any stage, you will not be asked to give us any reasons.

What do you want me to do?

You will be asked to attend one workshop. The session will last approx. 3 hours. During the workshop, you will collaborate with other participants in a group to help us to design an enjoyable shared remote eating experience using Virtual and Augmented Reality. The experimental stage consists of four main activities to let you engage in different forms of design/ideas/art making/enacting these can include:

1. Phase one: Getting to know about our project, sharing stories and playing fun games around food.
2. Phase two: Brainstorming ideas.
3. Phase three: Making collaborative artwork(s) and enacting preparation to find ways of representing your ideas.
4. Phase four: Demonstrating your enactment to deliver your ideas.

There will be 5-10 min breaks in between these stages.

With your consent the workshop will be recorded via a camera/audio-recorder by the researchers, so it can later be analysed for the purposes of the study.

How will you protect my confidentiality and anonymity?

All information obtained in this study will be handled in confidence by us. All data will be stored on encrypted computers. Video-recordings of the workshop will be transcribed, coded and the results anonymised. Screenshots from the workshop or quotes from interviews may be used, but these will also be anonymous, any faces, names or identifying features will be removed and blurred. The researchers will keep data for less than 12 months before destroying all data. The researchers will keep the data for 12 months for analysis purposes and destroy it after the research outputs have been completed (up to 5 years). You are free to withdraw at any time without giving any reason and request the deletion of any data.

What are the possible disadvantages and risks in taking part?

The main cost to you will be the time needed to take part in the study which is not more than three hours. However, due to the nature of VR, some people might experience dizziness or disorientation during or after the experience. To prevent this from happening, you will be given some time to try

the technology. If you feel uncomfortable using VR, a flat screen version of the developed software can be alternatively presented. You can withdraw from testing the software at any point.

Am I eligible to take part?

In order to take part, you must be 18 years of age or over, you must be fluent in English and you must not have any food allergies.

What are the possible benefits?

We hope that you will find the study interesting, and will take satisfaction from helping to develop knowledge of this important topic. In addition, you will be given a £10 Amazon voucher.

What will happen to the results?

We will write up the results and will publish articles on our research. We will provide information on these publications upon request.

Contact Details:

If you have any enquiries, please feel free to contact

Researcher: Khawla Alhasan

Address:

Email:

Mobile:

Appendix G

Study 2: Informed Consent Form

No Pie in the (Digital) Sky: Co-Imagining the Food Metaverse

Name of researcher: Khawla Alhasan

Participants Identification Number:

1. Taking part in the study

I confirm I have read and understand the information for the above study which is stated in the Participant Information Sheet. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

Yes : No

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.

Yes : No

2. Use of the information in the study

I understand that my responses as well as photos and video recordings will be anonymised before analysis. All the faces on the photos and videos will be blurred out before analysis.

Yes : No

I give permission for members of the research team to have access to my anonymised responses and data.

Yes : No

I understand that the workshop will be recorded, and generated data could be used for further application development and publication/conferences. This includes anonymised images and stills from video documentation.

Yes : No

I understand that my anonymised response and audio-visual data featuring me will only be used for research purposes. I give permission for the research team to archive my anonymized responses and

audiovisual data for future research.

Yes : No

I agree to transfer the copyright of my recorded materials related to this project to the University of Kent, represented by the research team. I understand that the research team will retain non-anonymised video recordings for up to 3 years after the data collection.

Yes : No

I confirm that I don't have any food allergies.

Yes : No

I confirm that I am at least 18 years old.

Yes : No

I confirm that I am fluent in English.

Yes : No

I agree to take part in the above research project.

Yes : No

Name of participant:

Signature:

Date:

Name of the researcher:

Signature:

Date:

To be signed and dated in presence of the participant

Appendix H

Study 2: Semi-Structured Interview

Study of No Pie in the (Digital) Sky: Co-Imagining the Food Metaverse

Thank you for agreeing to participate in this interview. Today, we will primarily discuss your feedback on the catalogue of ideas. Most of my questions will focus on your thoughts about the future of eating in the metaverse; what you liked, what you disliked, and your overall impressions. We kindly ask that you reference the speculative ideas in the catalogue when responding to the questions. The interview will last approximately 30 to 35 minutes. Please feel free to ask for clarification at any point if needed.I will be recording the interview in both audio and video formats. If you have any questions or suggestions, we can address them at the end.

Q1. What do you find exciting in these ideas?

Q2. What are your concerns?

Q3. What do you find missing and how would you take these ideas further?

Q4. What are your thoughts about eating in the metaverse?

Appendix I

Study 2: Workshop's Sketches

The following sketches as shown in (Figure 1), created by participants during the co-design workshops, played an essential role in inspiring the artists and designers who illustrated the speculative catalogue.



Figure 1: Workshop's sketches

Appendix J

Study 3: Participant Information Sheet

Research title: Exploring the Dynamics of Immersive Eating

Thank you for agreeing to consider participating in this research project. It is important that you understand the reason why this research is being carried out, and what your participation will involve. Please take as much time as you need to decide whether or not to take part.

What is the purpose of the study?

Our aim is to provide an experience that can provide insights into how food is perceived through Virtual Reality, what sort of challenges and opportunities the users might face in a remote immersive eating? and how to enhance the dining experiences in the future. In addition, this study intends to create a blueprint and guidelines for future designers and developers. For this, we built two prototypes where people can eat (alone or with someone else) in an immersive setup. Our aim is to evaluate these prototypes.

Who is running this study?

The project is being run by the members of the University of Kent: Khawla Alhasan.

Why have I been invited?

You have voluntarily agreed to participate in this experiment.

Do I have to take part?

Your participation is entirely voluntary. You are free to withdraw at any time: this includes the right to withdraw your data from the study after it has taken place. If you decide not to take part, or to withdraw at any stage, you will not be asked to give us any reasons.

What do you want me to do?

You will be asked to attend a user-testing session that will last approx. 60 min. During the session, you will help us test the developed prototype, which we designed for future eating experiences using immersive Extended Reality technologies (such as VR). The testing session will consist of three stages. First you will be introduced to the study and teach you how to use the prototype. After that, you will test the VR prototype. Then, you will be asked to do a 15-20 minute semi-structured interview, to give more in-depth information regarding your experiences, as well as feedback on how the prototype could be improved. With your consent the session will be recorded via a camera / audio-recorder by the researchers, so it can later be analysed for the purposes of the study.

How will you protect my confidentiality and anonymity?

All information obtained in this study will be kept strictly confidential. The data collected from you will be anonymised. We will not include your name, and we will remove any other potentially identifying information about you. The researchers will keep the data for 12 months for analysis purposes and destroy it after the research outputs have been completed (up to 5 years). All information (including audio and video recordings) will be kept strictly confidential and stored on the University of Kent One Drive. Only members of research team from the University of Kent will have access to it. You are free to withdraw at any time without giving any reason and request the deletion of any data.

What are the possible disadvantages and risks in taking part?

The main cost to you will be the time needed to take part in the study which is not more than 1 hour. However, due to the immersive nature of VR systems, some people might experience dizziness or disorientation during or after the experience. To prevent this from happening, you will be given some time to try the technology before trying any developed software. If you feel uncomfortable using VR you can withdraw from testing the software at any point. As the user-testing session will take place in-person therefore poses risk of COVID-19 transmission. To mitigate the risk, the research team will take necessary steps like wearing the mask and sanitised equipment (such as VR headsets) before and after each use. We will also provide face coverings and hand sanitiser to participants during the study.

What are the possible benefits?

We hope that you will find the study interesting and will take satisfaction from helping to develop knowledge of this important topic. You will also get a £10 Amazon voucher at the end of the user-testing session.

What will happen to the results?

We will write up the results and will publish articles on our research. We will provide information on these publications upon request.

Contact Details:

Researcher: Khawla Alhasan

Address:

Email:

Mobile:

Appendix K

Study 3: Informed Consent Form

Exploring the Dynamics of Immersive Eating

Name of researcher: Khawla Alhasan

Participants Identification Number:

I confirm I have read and understand the information for the above study which is stated in the Participant Information Sheet. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

Yes : No

I understand that there might be some side effects from using VR headset (e.g. dizziness), I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.

Yes : No

I understand that my responses will be anonymised before analysis. I give permission for members of the research team to have access to my anonymised responses. I understand that the user-testing session will be recorded and generated data could be used for publication.

Yes : No

I understand that my response and audiovisual data featuring me will only be used for research purposes. I give permission for the research team to archive my anonymised responses and audiovisual data for future research.

Yes : No

I don't have any food allergies.

Yes : No

I agree to take part in the above research project.

Yes : No

I understand that I will be audio and video-recorded and I give consent for being recorded anonymised.

Yes : No

Name of participant:

Signature:

Date:

Name of the researcher:

Signature:

Date:

To be signed and dated in presence of the participant

Appendix L

Study 3: Semi-Structured Interview

Exploring the Dynamics of Immersive Eating

Thank you for agreeing to participate in this interview. Today, we will primarily discuss your feedback on the try-out session. Most of my questions will focus on your thoughts about the eating experience in VR, what you found interesting, what you found challenging, and your overall impressions. We kindly ask that you reference the eating experience when responding to the questions. The interview will last approximately 30 to 35 minutes. Please feel free to ask for clarification at any point if needed. I will be recording the interview in both audio and video formats. If you have any questions or suggestions, we can address them at the end.

Q1. How was eating in VR compared to real life eating? What doest VR add or take from your eating experience?

Q2. How did you feel while eating in VR?

Q3. What did you like about eating with VR? What you didn't like and find challenging?

Q4. Which of the features were your favourite? and why?

Q5. What context do you think would better describe a situation where you would like to eat in VR?

Q6. What do you think is important to take into consideration when it comes to designing immersive dining experience? (suggestions)

Q7. How often would you like to eat in VR?

Q8. What do you think about dining virtually with someone else? Do you prefer eating alone?

Q9. Do you feel the real food in the experience added any value? or it could be better removed?

Q10. What do you think in general of the multisensory elements?

Q11. Did you feel closer to the other participants? or it felt very awkward?

Q12. Do you prefer to be in the virtual environment as an avatar or your actual (real) self?

Q13. Do you prefer fantasy place or real? how wold you design your own experiment?

Appendix M

Study 3: Participant Survey

Study of Exploring the Dynamics of Immersive Eating

This form will serve as inspiration for designing a prototype for our virtual reality dining experience. Should you have any questions, please feel free to contact us.

Contact Details:

Researcher: Khawla Alhasan

Address:

Email:

Mobile:

Q1. Transport yourself to magical Japanese dining experience in virtual reality. Describe in detail the surroundings, ambiance, and your dining sensations.

Q2. Transport yourself to a magical Japanese dining experience in virtual reality. Describe in detail how you would like to interact with food and the other elements of that world.

Q3. What issues do you hope to address through this virtual reality eating experience? are there specific features that could help you improve your eating habits?

Appendix N

Study 3: Follow-Up Survey

Study of Exploring the Dynamics of Immersive Eating This form will help us understand how you perceived the immersive dining experience and will contribute to shaping future eating experiences. Should you have any questions, please feel free to contact us.

Contact Details:
Researcher: Khawla Alhasan
Address:
Email:
Mobile:

Q1. Do you find yourself reminiscing about the VR eating experience you participated in? if yes, what aspects of the experience do you often recall? Tell us about your most memorable moment during the VR eating session.

Q2. Where there any unexpected or surprising effect on your perception of food or eating habits that you noticed after participating in the VR experiment? Please share any noteworthy effect on your relationship with food that you may have observed.

Q3. Since the experiment, have you discussed your VR eating experience with friends, family, or colleagues? if so, how did they react to your account of the experiment?

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