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The metaphorical capacity of *future-food*: Enhancing design's role in public engagement with emerging technologies

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ABSTRACT

In an era of rapid technological progress, deepening public engagement with science is crucial. This paper intends to solidify the value of design in this new space of engaging the public with emerging technologies. We first introduce a framework that aligns design competencies with four principles informed by science and technology studies and futures studies. Then we present a case study of 'Future Food in 2040' that engages 97 participants to create design fictions, illustrating the principles. The fictions showcase how speculative food technology metaphorically represents varied social issues under the themes of *Efficiency, Entertainment* and *Ecology*. Recognizing its metaphorical capacity, we propose *future-food* as an effective engaging tool to provide an inclusive and discursive avenue for broader public participants to develop and express thoughts on technological futures. This paper contributes to advancing design's role in fostering a more ethically aware innovation culture and a democratically informed future.

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Introduction

Today's world is flooded with disruptive technologies such as robotics, genetic engineering, and machine learning, which bring concepts and terms that are astonishing and confounding. The widespread lack of comprehension regarding these emerging technologies – both in terms of how they work and their possible effects – results in polarized and extreme public reactions (Joy 2018). Some champion the technocratic belief that technology is the silver bullet solution for complex social challenges like ageing, crime, and transportation woes. Conversely, there is growing unease over a dystopian future, for instance, marked by automation-driven job losses and invasive surveillance

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technologies. This evolving milieu underscores the necessity for a deeper and more nuanced public engagement with emerging technologies (Hagendijk 2004). Effective engagement includes creating and maintaining a continuous, transparent, interactive dialogue between innovation bodies and the public, such as clear communication about project goals and understanding public and stakeholder views (Von Schomberg 2011). Also, it requires fostering public involvement in discussing the future implications of emerging technologies. Embracing holistic socio-technical systems thinking will help prevent 'narrow thinking', such as unquestioning technical solutions, prioritizing efficiency and productivity, and believing technology is a simple fix to complex societal problems (Radoff et al. 2022).

Moreover, futures studies view citizen involvement in future speculation as a moral and democratic obligation (van der Duin, Lodder, and Snijders 2020). Without participatory approaches, there is a risk of excluding average or marginalized social groups from future-making. Therefore, engaging the public in the technoscientific dialogue is crucial for fostering a socially responsible and ethically aware innovation culture and a democratically informed future.

In recent years, participatory formats like conferences, science cafes, and creation workshops have become more widespread (Dijkstra and Critchley 2016; Lehoux et al. 2018). However, critics point to an overemphasis on theoretical concepts and logical argumentation that lack connection to concrete, real-world scenarios. They call for more proactive and innovative strategies, such as creating future scenarios and material and artistic engagement (Craigon et al. 2023; Grove-White, Macnaghten, and Wynne 2000). In this evolving landscape, design methodologies like speculative prototypes and design fiction are becoming popular within science and technology studies (STS) and futures studies (Nabuurs et al. 2023; York and Conley 2020). There is also a growing trend in design, which is towards a more public-centred philosophy that transcends traditional product development. Designers are involved in organizing discussions around novel technologies such as the Internet of Things (Jacobs et al. 2020), mixed reality (Eghtebas et al. 2023), and 3D printing (Pilling et al. 2019). The remarkable efforts of Stuart Candy and his team are for their engagement with large audiences in civic events and festivals in discourse about the role of technology in shaping climate futures (Candy 2018; Candy and Kornet 2019). Responding to the increasing intersectional practices, this paper aims to delineate the value of design in this discourse of public engagement with emerging technologies.

This proposition builds on two design traditions. The first is design's long-standing role in humanizing and demystifying novel technologies that are yet to exist. This began with Critical and Speculative Design, which created provocative artefacts to challenge the status quo (Dunne and Raby 2013). This approach evolved into design fiction, a method that leverages the narrative power in exploring social and ethical dimensions of emerging technologies (Bleecker

2009). The second tradition lies in design's participatory tradition, which has led to the development of rich methods and principles to engage users, stakeholders, and communities with design processes (Sanders and Stappers 2012).

At the intersection of design and the multi-disciplinary practice of public engagement with emerging technologies, there is an imperative to clarify and affirm the role of design as a mediator or enhancer. This paper intends to establish a robust and deliberate link between these domains, underscoring design's unique value and potential in addressing future challenges. Despite numerous practices already operating in this space, there remains an untapped depth to design's involvement, which this paper seeks to articulate.

Grounding on our investigation, we first present a framework that aligns design competencies with public engagement principles and methods advocated by STS and futures studies. It includes four aspects of familiarity and unfamiliarity of everydayness, concreteness in materiality, crafting critique, and anticipation through diegetic prototypes. This framework elucidates how design's inherent features and skills can embody public engagement principles, thereby amplifying the impact and reach of public engagement efforts. By clarifying design's values, we aim to crystallize its role as a pivotal force in shaping the interaction between society and science. Upon this conceptual framework, we present a case study where 97 second-year engineering university students participated in a design fiction workshop to create future scenarios of food technology in 2040. Despite their non-design background, participants successfully conceived new functions of future food technology and anticipated a broad spectrum of social, ecological, and ethical consequences. Using Causal Layered Analysis (Inayatullah 1998) to analyse the design fictions, we found participants used speculative food technology as metaphors to address diverse issues and concerns under three broad themes of 'Efficiency', 'Entertainment' and 'Ecology'. Through this empirical case, we propose that *future-food* could offer a unique and accessible avenue for broader public participants, to develop and express their opinions and insights about emerging technologies.

Aligning design competencies with the four principles

This section introduces the design competencies that align with the four principles of public engagement in emerging technologies, as informed by STS and futures studies. They demonstrate how design's unique attributes enhance public engagement, aiming to highlight design's crucial role in mediating society's relationship with emerging technologies.

Familiarity and unfamiliarity in everydayness

Policy researchers, recognizing the widening gap between citizen experiences and governmental actions, advocate bridging epistemologies between expert

research and citizen knowledge creation (Gudowsky and Rosa 2019). While acknowledging the need for expert insights into macro societal factors, they also recognize citizens' ability to contextualize impacts on their individual lives. Futures studies have similarly acknowledged the influence of everyday consumption and lifestyle scenarios in signalling individual and societal shifts, foreshadowing broader infrastructural and policy transitions (Neuvonen et al. 2014; Wangel et al. 2019).

The micro-level investigation of everydayness is a space where design excels with the intrinsic focus on human-centredness, user experience, and material culture. Design turns emerging technologies into artefacts, experiences, and scenarios, inviting individuals to immerse themselves in alternative realities as naturally as they engage in their daily routines (García and Gaziulusoy 2021). This process requires a delicate balance between the strangeness and familiarity of mundane objects (Bell, Blythe, and Sengers 2005). Also, the concept of 'perceptual bridge' effectively translates novel and complex technology or speculative concepts into the familiar aspects of everyday lives that are recognizable and meaningful to people (Auger 2013). It highlights the value of being rooted in everydayness to render distant scenarios and related discussions recognizable, personal, and relevant.

Concreteness of material engagement

Building upon the device of everydayness above, we present design's renowned capability to turn abstract, conceptual, invisible content, such as the yet-to-exist future image or vision, into tangible, experiential, material and interactive forms (Candy 2010). The forms, presented as 'packaging' with a multi-media (Markussen and Knutz 2013), encompass intricately crafted exhibit pieces and various media in showrooms, functional prototypes in people's real use settings, and mock-ups in co-design workshops. Also, designers skilfully present speculative concepts in daily items like advertisement posters, commercial product catalogues, and products sold in $0.99 grocery, thus bridging the gap between familiar cultural symbols and futuristic narratives. Apart from material making, a more performative and enactive approach is emerging. For instance, designers organize role-playing speed dating events with the setting that big data would match participants (Elsden et al. 2017) or build a virtual shopping page of a futuristic care robot for people to 'purchase' (Ng, Lee, and Wu 2021).

These engagements, whether in showrooms, design workshops, or everyday settings, offer participants an immersive experience and interaction with the technologies that have yet to be fully realized. Staged by these materials and experiences, people can actively partake in dialogues, provide insightful feedback, and liberate their imaginations concerning the future trajectory of technology.

Anticipation through diegetic prototypes

In order to address the societal implications of emerging technologies, it is crucial to anticipate unforeseen and unexpected consequences (Owen, Macnaghten, and Stilgoe 2012). It is a well-founded anticipation of socio-technical changes, which entails looking into future social, ethical, political, and environmental consequences of technological developments (York and Conley 2020). It asks questions like 'what if, what is plausible, and what is possible'. This anticipatory process requires a systematic investigation of uncertainties that could shape technology in multiple ways, employing methods like scenario planning and horizon scanning.

To enhance these systematic anticipatory approaches in futures studies, design contributes a micro-level perspective with the concept of a 'diegetic prototype' (Kirby 2010). This term describes a hypothetical object that exists and fully functions in the fictional world. The term 'diegetic' means narrative or plot. And if something is being 'diegetic', it means something *really* exists in that fictional world. This notion extends further into a strategy for world-building where the object is manufactured, used, favoured, and disliked by individuals and impacts various societal groups. Thus, a diegetic prototype is more than being physically functional; it embodies everyday interactions, assumes social roles, and carries normative and symbolic significance. Such conceptualization directs attention to the anticipation of how the object would be experienced, interpreted with meanings, and constructed with norms and values.

Crafting discursive space

Futures studies see the future as a 'learning machine' about the present instead of a concept of time (Berkhout, Hertin, and Jordan 2002). Exploring future scenarios enhances reflexivity in the present, challenges taken-for-granted perceptions, and helps navigate uncertainties and ambiguities of the changing world. Beyond reflexivity, another key idea is projectivity (Mische 2009). It influences people's ability to take action either to change behaviours in the present life or map out pathways to achieve the desirable future. Ultimately, whether these future images shed light on what is to come or the present, they reflect people's core beliefs, values, and knowledge (Polak 1973).

Future as a learning machine is integral to the discursive turn in future-oriented design practice, where the product is not designed to solve problems but to make people think (Tharp and Tharp 2019). Designers morph novel technologies into provocative prototypes and future scenarios. To be discursive, these designs employ strategies rich in ambiguity (Gaver, Beaver, and Benford 2003), friction (Forlano and Mathew 2014) and strangeness (Blauvelt 2003) to defamiliarize the familiar and provoke reflection. When users engage with these prototypes, they reflect

on their use, allowing them to deliberate on and discuss the implications of new technologies and express their concerns and aspirations (Boer and Donovan 2012).

Process and data

Based on the four principles presented above, the authors (also workshop organizers) developed a process to engage 97 participants in envisioning future food scenarios in 2040. The process includes preparatory tasks and a 90-minute in-class creation workshop. And it was part of a creative writing course for second-year students at a Tier-A university in China. All participants studied non-design, engineering majors, and were in their early 20s. From the workshop, 97 pieces of design fictions were created, named from P1 to P97 for data analysis.

Pre-workshop

To sensitize participants to speculation and design, two preparatory tasks were given before the creation workshop. The first task presented ten speculative food technology concepts and asked participants to select their favourite and the most provocative concepts and to articulate their reasons. This task aimed to push the boundaries of imagination and prepare them with speculative thinking. The second exercise was designed to acquaint participants with the fundamentals of human-centred design through an analytical case study task. They were tasked with selecting a food-related technological product from their own experience and then analysing the product using a structured framework consisting of user/persona, context, functional features, value, and potential consequences. This exercise aimed to familiarize participants with design case analysis methodology, emphasizing the user-centric perspective and broader implications of technology.

In addition to the two preparatory tasks, the authors employed scenario planning to develop four future directions (Schoemaker 1995). The initial step involved searching for societal, technological, and design trends related to future eating and food technology in both academic platforms (i.e. ACM digital library) and market and technology trend reports (e.g. Deloitte, Institute for the Future) with keywords ('human-food interaction' OR 'future eating' OR 'future food'). After identifying relevant trends, we developed two pairs of uncertain drivers: 'fun-based' versus 'utility-based' and 'technology manipulating people' versus 'technology empowering people'. The two pairs of drivers led to the development of four distinct future directions: 1, 'Entertainment Economy'; 2, 'Domestic Food Labs'; 3, 'Ultra-Efficiency'; and 4, 'Gastronomy in Ecological Crisis' (Figure 1). Each direction depicted a unique future vision of food culture, production, and consumption, and then presented with a short

paragraph as an inspirational backdrop for participants to create fictions later during the workshop.

Creation workshop

Integrated into the school's curriculum, the design fiction creation workshop spanned 90 min, themed 'Future Food in 2040'. It employed a structure with four steps – Why, What, How, and Consequences – to guide participants through a creative process (Figure 2). The workshop commenced with an introduction to Discursive design (Tharp and Tharp 2019), emphasizing five key mindsets – 'remind, inform, inspire, provoke, and persuade' – that served as a foundational guide for crafting future scenarios with a discursive message. In Step 1, the four directions generated from scenario planning were introduced inviting participants to choose one as their entry point. In Step 3, the design case from Pre-task 1 was revisited fostering an object-centred perspective. In Step 4, students were encouraged to consider the perspectives

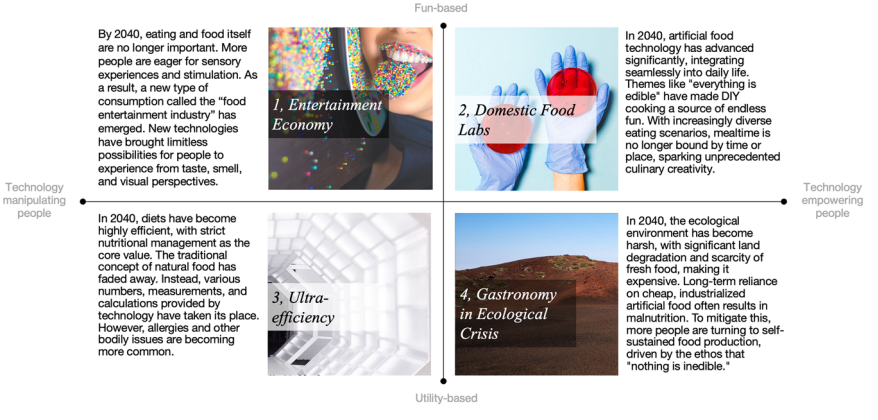

Figure 1. The four directions of future food scenarios in 2040; the images and the texts were provided to students during the workshop; all images are from www.pexels.com.

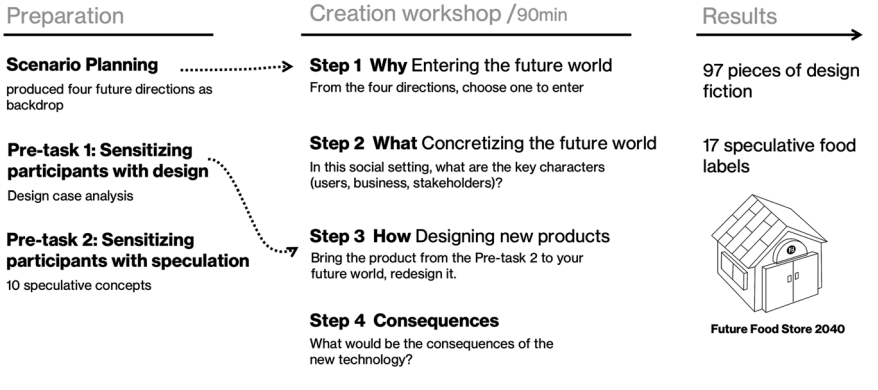

Figure 2. The process of the design fiction creation workshop.

of multiple characters, weigh potential negative and positive impacts, and contemplate dilemmas. Throughout all the steps, participants engaged in peer discussions and were encouraged to make sense of each other's speculations rather than passing judgment.

For the workshop assignment, each student was asked to submit a piece of design fiction, complemented by an optional task of designing a speculative food label for their future food. This additional task aimed to enhance the concreteness and plausibility of their world-building efforts.

In the end, we collected 97 design fictions and 17 speculative food package labels from students. We then selected and developed eight package labels into a speculative webpage for the Future Food Store 2040, designed by a visual designer, showcasing them as part of the workshop outcome (Figure 3).

Data analysis

An iterative analytical process was conducted to analyse the 97 design fictions using thematic analysis (Braun and Clarke 2012). Initially, the transcripts were transformed into 1137 quote statements. Following inductive coding, these quotes were then grouped into three overarching themes: 'Efficiency' ($n = 49$), 'Entertainment' ($n = 27$), and 'Ecology' ($n = 21$). Lastly, each fiction was analysed with Causal Layered Analysis that includes four layers of litany (surface and observable events), social and structural (systematic causes), worldview (norms, standards), and myth/metaphor (collective archetypes, unconscious dimensions) (Inayatullah 1998). The aim was to unpack

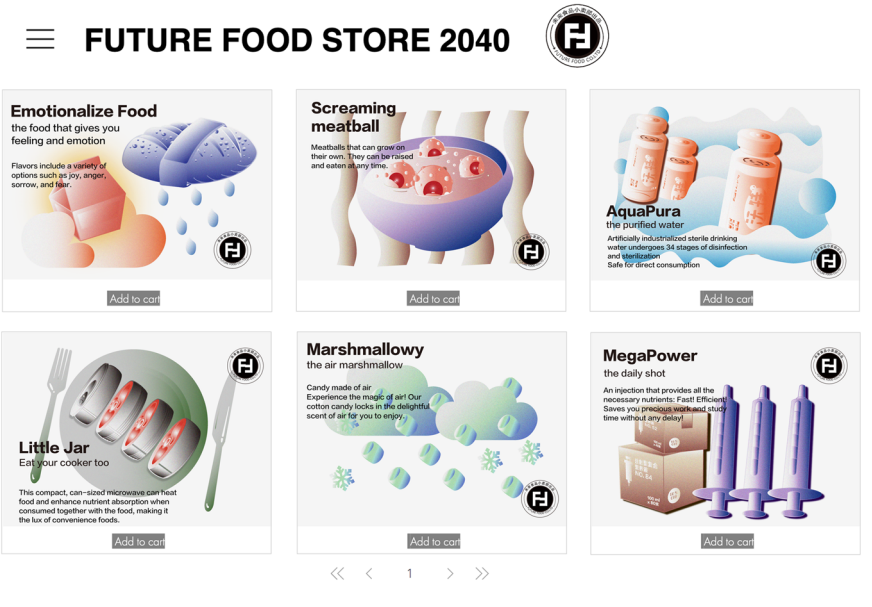

Figure 3. The webpage of Future Food Store 2040 as part of the design fiction creation workshop outcome.

different layers of understanding and assumptions about food, technology, and the future. This analysis revealed the metaphorical value of future food technology detailed below.

The metaphorical capacity of future food

Efficiency

Fictions in this theme ($n=49$) envisioned unprecedented precision and efficiency in food production, delivery, and consumption, coupled with an extreme level of personalization to cater to individual health needs with surgical accuracy. Speculative design concepts ($n=16$) predominantly manifest as capsules, nutrient bars and compact capsules to minimize consumption time. Or the personalization technology of nutrition through biotechnological advancements (e.g. molecular food that breaks down natural ingredients into elemental nutrients) and artificial intelligence seeks to meet individual health requirements. The second most speculated concepts are robotic and automated systems integrated into smart kitchens and food delivery logistics networks ($n=13$). Humanoid robots act as chefs and nutritionists who manage everything from grocery shopping to meal preparation. Below, we present three metaphors that future food stands for in the context of purchasing efficiency.

Future food as a corporate manipulative tool

In this metaphor, food is appropriated by corporations as an instrument to maximize employee productivity. Some fictions depicted companies replacing traditional meals with injection devices to curtail lunch and rest times or using pipes to directly transport nutrient pills to workstations, eliminating the time for walks. The terms 'involution' (内卷), 'corporate slave' (社畜), and '996' are frequently mentioned, reflecting toxic work cultures discussed on Chinese social media. 'Involution', originally an anthropological term, has been widely adopted to a competitive spiral leading to counterproductive results. And '996' denotes a gruelling work schedule (9 AM to 9 PM, 6 days a week) prevalent in Chinese tech companies, sparking debates on work-life balance. It shows these public discussions have influenced students' thoughts and imagination in creating future food scenarios where work cultures worsen and food technology exacerbates this oppression. The concerning aspect is not the food technology itself, but the sociotechnical systems and unethical policies that turn food into a tool for manipulation and exploitation, pushing workers into relentless productivity.

Future food as mechanization of human bodies

In the pursuit of extreme efficiency, food, like encapsulated nutrients, becomes a mere utility. Consequently, the reliance on such technologically produced

and administered food changes humans towards a machine-like state, prioritizing functionality over experience. Some fictions described how human physiology is altered, with declines in physical abilities like chewing and digestion, and reduced size of organs associated with eating. A vision of a cyborg reality also emerged, where the human body and food technology are seamlessly fused to achieve efficiency. The innovations, such as brain-boosting edibles, chargeable implants that turn bodies to a battery, and synthetic digestive systems replacing original stomachs, recreate human bodies to meld with machines.

Food technology with its intimate interaction with the human body and organs and its influence on daily eating behaviours was envisaged to transform humans from ancestral heritage into a mechanized existence. In this future, people no longer experience rich and multi-sensory joys or social connections from sharing. However, the ultimate purpose of efficiency that has caused the shift of fundamental beings is not explained in any of the fiction, as if it is the ghost haunting the collective consciousness or an unquestioned norm.

Future food as a symbol of technological-dominant society

This metaphor shifts focus from bodies to a societal paradigm, reflecting the anxiety around technology's pervasive role in every aspect of life. A world was imagined where everything is driven by technology, not only food production processes. This technology-dominated society is single-dimensional, monolithic, and homogeneous. In such a society, the singular focus on technology erases cultural pluralism and the richness of diverse traditions, and it displaces traditional skills, jobs, and industries. The fictions discussed the repercussions of this shift, from the obsolescence of roles like restaurant chefs to the forced adaptation of farmers into food lab scientists. The consequence of future food technology extends beyond changes in employment. It signifies a shift towards a technologically dominated society that eventually narrows to a singular, technocentric dimension of existence.

Entertainment

27 participants envisioned a booming eating entertainment industry, fuelling demand for diverse sensory stimulation and playful dining experiences. The trend is underpinned by technologies such as gastronomic alteration, multi-sensory simulation, and holographic projection. For instance, neural enhancement technologies enable restaurants to offer comprehensive sensory experiences, enriching the traditional dining aspects of taste and olfaction with auditory, visual, and tactile dimensions. Biotechnological firms are marketing products such as 'sadize bread' and 'happilize milk' which are manufactured to elicit specific emotional reactions. Beyond the actual food,

virtual technology offers sensory experiences without actual intake. For instance, one fiction depicts a barbeque restaurant that only provides a set of sensory helmets rather than grilling sauces. This theme reflects a future where food becomes a playground for virtual and augmented experiences in profound ways, with two metaphors of food presented below.

Future food as an addiction

Foods are engineered to deliver gratification that is intense and immediate. Consequently, many participants expressed concern over their addictive quality, comparing them to 'virtual drugs' that people are enslaved to and unable to resist. In the future world, with a burst of success in the food entertainment industry, the government notices the issue of addiction and attempts to regulate the usage of certain food technologies. Yet, despite these efforts, the illegal production and trade of these substances seem only to increase.

The addiction extends beyond food and applies to current digital platforms, such as TikTok and video games. Either in the present or the future, it showcases the powerful technological capability to create and distribute highly engaging experiences driven by neoliberal forces. These scenarios illustrate two layers of conflict. One is the constant negotiation between the powerful external forces of market-driven technology and the individual's self-regulatory abilities. Concurrently, there is a tension between the pursuit of independence from the risk of addiction and the growing desire for joyful experiences which are always ensured by technology.

Future food as an experiential privilege

While some were worried about the addiction issue stemming from the food entertainment industry, others were concerned about the societal disparities that are exacerbated by multi-sensory food technologies. Participants appreciated enjoyable and innovative culinary experiences but anticipated the high costs of research and development that could result in exclusivity. This would be a future where only the privileged few have access to these gastronomic pleasures. And such disparity extends beyond wealth, but to the capacity to experience and enjoy the full sensory spectrum of life that technology affords. This new type of digital and experiential gulf shows the complexities of access in a technologically stratified society. In a society where digital technologies set what people encounter and experience, the disparity is not simply the difference between those who have and those who have not.

Ecology

21 participants envisioned a future marked by ecological strain and resource scarcity, which drives the urgent need for innovative solutions to sustain

human life. Their fictions displayed a broad spectrum of technologies. New technologies allow the transformation or purification of garbage into edible products and the alteration of nutrition. Foods derived from artificially cultured insects are enhanced with beef flavours through genetic editing. Tissue culture technology enables rapid cultivation of lab-grown meat and vegetables. In many fictions, the central government plays a key role in monopolizing food production and distribution. manufacturing uniform 'energy blocks' as standardized nutrition, disseminated equally among the population. This ecologically strained backdrop situates future food as a symbol of regenerative solutions and a sign of the underprivileged.

Future food as a solution of regenerativeness

As mentioned above, future food technologies in this fictional world are developed to repurpose waste into nourishment in addressing resource scarcity. Novel technologies, such as food decomposition technology that breaks down food to its elemental state for reuse, artificial photosynthesis for plant production, and artificial protein generation illustrate a shift towards regenerative food production practices. The device, like 'Meatizer', which turns garbage into edible meat, is not seen as a taboo but accepted as a technological commitment to sustainability. This metaphor portrays food technology as a transformative force, turning degenerative challenges into opportunities for renewal and restoration.

Future food as artificiality, a sign of the underprivileged

In the context of crisis, again, the issue of societal gap raised the concern. However, this time, the future food recycled from waste and artificial substances becomes a signifier of the underprivileged. While natural and unmodified food, untouched by advanced recycling technologies, becomes a luxury, reinforcing social divides through dietary access and quality. Compared to other metaphors that future food stands for, this metaphor positions nature, such as natural crops, beyond the reach of technological advancement. It indicates a more profound yearning for a lost harmony with nature, which technology, for all its advancements, cannot fully emulate or restore.

Future-food as an avenue of interfacing with emerging technologies

An inclusive and discursive device

Having analysed the varied metaphorical meanings of speculative food technologies, we propose that *future-food* serves as an effective tool for engaging the public with emerging technologies, instead of merely a topic or a theme. Next, we will demonstrate why *future-food* is an effective medium for enabling people to imagine, narrate, and critique emerging technologies, aligning with the four principles discussed earlier in this paper.

Firstly, *future-food* inherently aligns with the first two principles of everydayness and concreteness due to the universal nature of food as a daily item. Everyone has their own lived experience and embedded social-cultural reality related to food. It enables each participant to create future scenarios with richness. This helps overcome the challenge of imagining yet-to-exist vague and abstract future images. The tangible nature of food items offers a solid foundation for concreteness that manifests on three levels: physical, experiential, and semiotic. The 97 fictions showcased a wide range of speculative elements, including functionality and experience also expanding to services, business models, branding strategies, institutes, and job types.

Secondly, the metaphorical capacity of *future-food* demonstrates and enriches its role as a diegetic prototype in the third principle of anticipation, where the food-related technological product or system tells stories of the broader world, such as addiction or disparity. Fictions have shown that food serves as a profound symbol, narrating the relationship between culture and nature, artificiality and authenticity, the body with the environment, and the agency of self and social structure. As a value, *future-food* is narrative vessels that enable participants to form discussions and critiques on a wide array of topics, spanning technology, ecology, health, culture, or state, whichever matters to them personally and locally.

Thirdly, the design fictions created serves as a learning machine in the fourth principle of enhancing reflexivity in the present, providing insights into participants' thoughts and the social realities shaping their perceptions. The 'Ultra-efficiency' direction resonated with half the students (49 out of 97). Influenced by media and societal discourse on work ethic in contemporary Chinese society, they expressed their worry or resistance by imagining future food as manipulative and explorative. Also, you might notice that the initial four directions condensed into three themes after data analysis. It is not a methodological weakness but rather a reflection of students' lack of experience or interest concerning domestic cooking, which led to their disengagement with the 'Domestic food labs' direction. This design fiction outcome reflects the characteristics of participants. Different social groups will produce different future images, highlighting the role of *future-food* as the learning machine that represents people's deep hopes, fears and values related to technology, the future, or the present (Adam and Groves 2007).

Key strategies

The *future-food* tool for engaging the public with future technologies was developed from a pedagogical case study involving university students. Its application would be equally effective in structured educational settings, such as STEM education in schools. The structured process, including preparatory tasks and guided writing steps, is better suited for well-organized and

strictly structured events with the necessary resources and support systems. Thus, the tool can be applied to educational programs, events, and camps organized by institutes like schools or science museums.

Below, we highlight several key strategies and considerations to support the use of the *future-food* tool. The first strategy involves providing a backdrop or prompts as a 'perceptual bridge'. We suggest that researchers and facilitators systematically explore societal, technological, and environmental trends in the local region, such as scenario planning. Descriptions of future directions should weave together elements of both the familiar and the unfamiliar, providing a logical extrapolation for understanding how current realities (the familiar) might lead to various future states and imaginative speculation (the unfamiliar). For instance, the 'Entertainment' direction (Figure 1) was crafted to blend the trend ('there was the growing experiential economy, which prioritizes immersive simulation and instant gratification as technology becomes increasingly integrated with the human body') and fictional projections ('new technologies have brought limitless possibilities').

The second strategy is sensitization. It is crucial to walk participants through sense-making activities before the creation step, such as analysing speculative concepts (pre-task 1) and design cases (pre-task 2) to prepare them for speculative thinking and design analysis. These steps ensure that participants can effectively and creatively engage with the future world. Lastly, we recommend starting with tangible and experiential objects to facilitate concreteness in speculation. Participants begin with familiar artefacts from their daily experiences (pre-task 1) and then extend to the imaginaries of more conceptual elements of the social and publics. This grounded approach helps them develop more relatable and plausible speculative scenarios and thus provocation.

Limitation and beyond

The *future-food* tool developed from the education setting has several limitations and challenges in broader applications. As an accessible tool capable of engaging a broad audience and addressing a relatively wide range of technologies, it might be inadequate for engaging professional audiences or addressing specific technological topics. Thus, *future-food* is more suitable as an entry point for public engagement programs to spark interest and participation from newcomers. Also, the tool requires high levels of engagement and commitment from participants, which can be challenging in settings where motivation or commitment is low. The tool's structured process may not be easily adapted to less organized or informal settings. However, there are various levels of participation in the creation process (Farias, Bendor, and Van Eekelen 2022). For example, the 'Future Food Store 2040' in our case could be further developed into an engaging platform to invite people to

'purchase' or suggest new food products. In this way, various forms of participation are supported, including the structured type of creative writing and playful, experiential and performative ones. Finally, although our participant cohort was culturally homogenous and did not experience conflicts, the food theme's affordance in upholding culturally sensitive or politically charged topics should not be underestimated. Especially when the *future-food* process encourages provocation, contingencies, and ethical judgment, there is a chance of conflicts and offensiveness in group discussions. In a multicultural context, facilitators need to be prepared to manage conflicts and ensure respectful dialogues.

Returning to the objective of this paper, in forging design's value to bridge society and science, skills and techniques alone are insufficient for the broader application. The journey ahead calls for designers to build new collaborations and partnerships across a spectrum of societal sectors (Mejía et al. 2023). These alliances are essential for embedding design activities, like the design fiction creation workshop, into enduring and strategic civic participation programs, anchoring them firmly within the fabric of public life. We advocate for fostering collaborations within fields where design's influence is already acknowledged, like STEM education in schools and universities (Cox 2021; van Grunsven, Stone, and Marin 2024). Moreover, societal institutions such as municipalities and community organizations would be fruitful grounds for civic participation and public dialogue on novel or contentious technologies, like the Next Nature Network's with healthcare institutions (Nabuurs et al. 2023) and Stuart Candy's civic-oriented events with podcast partners (2018).

Conclusion

Design history reflects design's dynamic interplay with evolving technologies, shifting ideals, and diverse entities it serves. In its formative years, influenced by the Bauhaus movement, designers integrated approaches from art, craft, and new production means to design functional, affordable products accessible to the wider population. In post-war Europe, designers were committed to social-democratic ideals, creating utilitarian and affordable goods to rebuild the society from the ravages of war. Recently, the rise of ubiquitous computational technologies has witnessed design pivot to serve the interests of technological corporates, fuelling the prosperity and expansion of the global capitalist system. Designers have leveraged their expertise to create compelling user experiences to deepen the connection between users and brands through interactive devices and interfaces.

What does the future hold for innovative product design, and which technologies and ideals will it interact with? In exploring the evolving landscape of design, this paper has identified a compelling new domain: public engagement with emerging technologies. By presenting a framework of four

principles and a case study on 'Future Food in 2040', we illustrate design's ability to navigate this complex area. Concerning the principle of everydayness, design bridges the familiar with the unknown, making speculation both recognizable and thought-provoking. In the second principle of concreteness of materiality, design turns intangible and abstract ideas into tangible and concrete materials for people to interact and experience. Moreover, in crafting critique, design creates discursive space with rich strategies of friction, ambiguity and sites of showroom, design workshops and reflection. Lastly, design introduces the object-centred strategy of world-building to anticipate the social construction of yet-to-exist technology.

However, the process towards creating engaging, provocative, and discursive future scenarios about yet-to-exist technology is fraught with challenges (York and Conley 2020). From the insights gained in our empirical study, we advocate for *future-food* as a tool that can offer an accessible and discursive avenue for the broader public to imagine, discuss, and express opinions and concerns towards emerging technologies. It is accessible because food is the most daily item that allows any human to wield their lived experiences to the creation. Its discursive power lies in the metaphorical capacity of food, which offers a platform to examine a broad spectrum of issues. Moreover, such future scenarios created by a certain societal group, which are young university students in our case, serve as a lens to enquiry into the collective consciousness and concern for a social problem and technology's place within it, such as the fictions on the '996' work culture.

In establishing design's value to bridge society and science, this paper serves as an initial foray, offering conceptual and methodological insights into the roles design might play. We anticipate further efforts in fostering new partnerships across various societal sectors. With these collaborations, we are envisioning a future where designers work within civic participation programs and policy schemes towards cultivating an innovative culture that is more socially viable and ethically informed and a future that is more democratically informed.

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