Modalities of Expression:
Capturing Embodied Knowledge in Cooking

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ABSTRACT

▸ When cooking we negotiate between instructions in recipes and personal preferences to make in-the-moment creative decisions. This process represents moments of creativity that utilise and reveal our embodied knowledge. This paper focuses on the capture of expressions of embodied knowledge by digitally-networked utensils. We present a design process investigating the design of tangible interfaces to capture and communicate embodied knowledge as a proposition for recipe authoring tools for open innovation in food. We reflect upon this process to discuss lessons about the individual nature of embodied knowledge and its expression, and the context of capturing it to make design recommendations. ◂

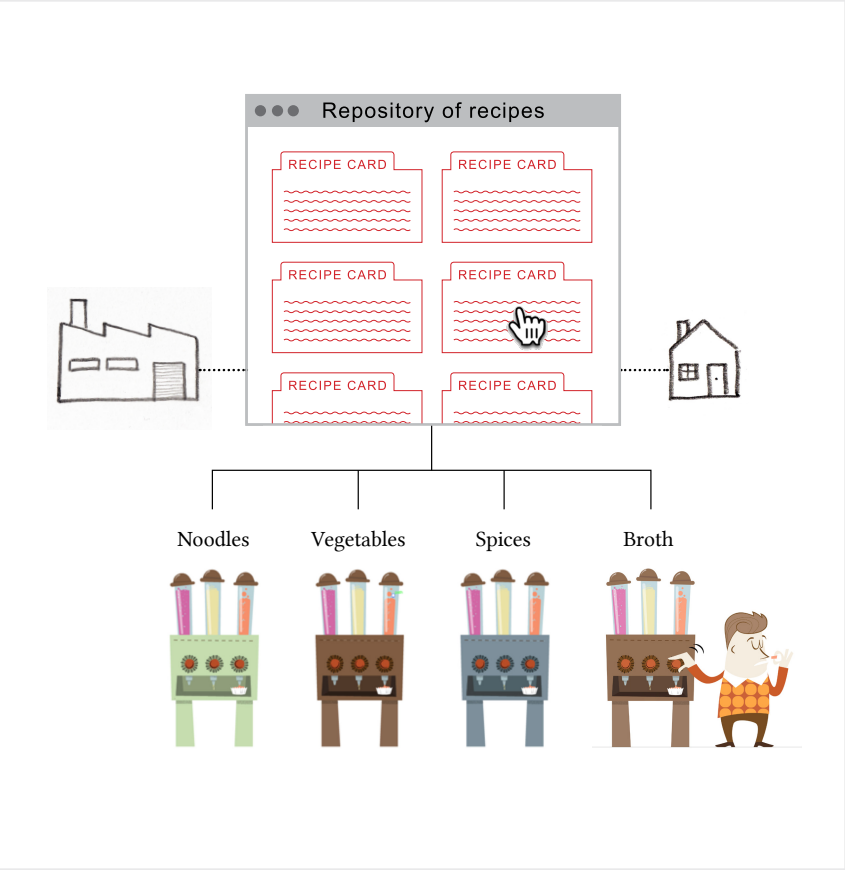
INTRODUCTION

▸ The food industry stands to make significant gains from including consumers in innovation processes, and companies have developed a range of approaches to crowdsource ideas from consumers [12]. One common method is competitions that ask for inventions, new flavours, creative new uses of products, and recipes [12]. These methods often source through online platforms or social media [1], and so rely on people using text to articulate their ideas and preferences, accompanied by photos of the finished 'product' [12 p128].

Outside of formal innovation processes, sharing information about food and recipes online is extremely popular, especially through social media sites that prioritise visual presentation, like Instagram and Pinterest. On established recipe websites, it is common for readers to leave comments below recipes to document their attempts at making it, and to share any changes they made to the recipe [e.g., 3]. This text-based format of presentation is easily shared across media, and accessible by many people. However, a written text recipe can only represent the authors' explicit knowledge [14], which provides a description of what we consciously think we know about our preferences [17]. The type of knowledge expressed in these presentation formats doesn't facilitate accurate expression of how preferences are practically achieved while cooking. There is a gap where physical skill, such as the manipulation of a knife, or the use of the senses to evaluate progress and make adjustments [19] play a large role in determining the outcome. We therefore argue that by prioritising explicit knowledge, these modes of expression miss a large portion of the knowledge that goes into creating a dish.

Imaginative or creative expression is dependent on the cook's embodied knowledge. The translation of instruction and preference into bodily action involves much embodied knowledge accumulated through skill and experience [19]. In cooking or any skilled practice, perception and cognition rely on embodied knowledge, and on "external representations embodied in tools" [9 p606]. Hence, our body and the tools we interact with shape our experience of the world [13, 8]. Through repeated use of a pepper mill, people acquire the embodied knowledge to season their food to their taste without conscious thought. The process of interpreting instructions from a recipe whilst performing actions is reliant on the "mobilization of the mind / body within an environ-

Concept vision starting point



We used illustration techniques as a thinking methodology in order to visualise to ourselves the concept we were working to: A set of digitally networked tangible interfaces – 'Open Kitchen' as a concept platform for 'open innovation' in food - with which people can express subjective sensory preferences in relation to measures and quantities that are expressed in the cooking actions that utilise their embodied knowledge whilst creating recipes. The resulting recipe is uploaded to a web-based open repository of recipes. This repository can be used as a platform for discussion on new food ideas between people and industry.

ment of "objects" which "afford" different possibilities for human use" [19 p91]. As Kirsh [13] demonstrates in a study involving dancers, much of embodied knowledge development relies on practice, rather than on seeing or thinking about the activity to be performed. It is this knowledge that we believe represents crucial elements in crowdsourcing innovation. Because these embodied actions are generated through practice in a particular context, rather than from a plan, they are "impossible to objectify into a set of rules" [19 p92], and therefore communication of this knowledge is extremely challenging.

These forms of knowledge may be seen as an important element in supporting people's creative expression and personalisation. Discussing the tendency towards "corrective technologies" [10] that seek to make cooking more efficient, Grimes and Harper signal the need to acknowledge that deviations from the transmitted information through accident, or the expression of imagination in recipes, can result in accidental discovery, new culinary experiences [10], and "personal culinary masterpieces" [10 p470]. To this end, there are research projects that seek to explore possibilities for enhancing or supporting creativity in cooking by providing tools that support this deviation through creative reinterpretation of unusual tools and ingredients [4], or by introducing new tools that inspire new ways of working and making [15].

In this Pictorial, we present the analogue process by which we investigated the design of tangible interfaces that capture and communicate various expressions of people's embodied knowledge for recipe authoring. The rationale for this investigation is based on the gap identified that current open innovation platforms support the communication of explicit knowledge, and therefore a recipe authoring platform that supports the communication of richer information about creativity in cooking in the form of embodied knowledge is needed in order to support mutually beneficial exchanges between consumers and the food industry about product ideas (See left).

Our investigation involved studio-based design ideation and human-centred design methodologies, and starts with a public deployment of a digital pepper grinder with which we tested our assumption that people translate their knowledge into bodily actions, and that these can be captured digitally. In order to explore how people negotiate between recipes and personal preferences to make in-the-moment creative decisions, we hosted a 'paper cooking' workshop amongst the research team, and undertook a series of interviews with, and observations of people cooking at home. We used the insights from these activities to identify five categories of embodied knowledge, with which we designed a range of low-fidelity analogue 'design responses' for digitally networked interfaces and tools and the hypothetical data that would be extracted from their use. We iteratively enacted and tested our proposals amongst the research team. We validated them with design students, which resulted in our main contributions – that the tools prompted people to reveal their own embodied knowledge, and our method signposted a design direction for what is a complex phenomenon. We conclude that it is not possible to design specific tools to capture embodied knowledge as this knowledge is not transferable across contexts, and that a more nuanced approach is needed in the form of video-based tools that would give people agency over the authoring of digital presentations of recipes. ◂

Testing the concept of tangible interfaces for open innovation in food with the *Food Replicator* experiment

▸ To make a start in interrogating our concept vision in a quick and experimental way, we designed the *Food Replicator* experiment, in order to explore the potential of tangible interfaces as a way for people to express subjective sensory preferences.

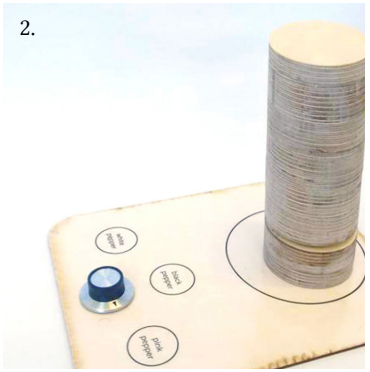
We chose the pepper mill to inform the design of this first input device, as it is a ubiquitous food item, both in terms of the object and seasoning. Using an approach similar to the 'Wizard of Oz' method [2] we developed a digitally networked pepper grinder to capture these expressions of preference by measuring the number of 'turns' people make, and communicating these to a fictional 'food-making machine' – the *Food Replicator* – performed by one of the researchers.

We conducted an informal public test at an open symposium at [5], during which attendees were invited to express their desired level of 'pepperiness' of a risotto dish. Participants were given the choice of communicating their preference to the *Food Replicator* either verbally, visually (sketching on Post-It notes) or bodily (using the grinder).

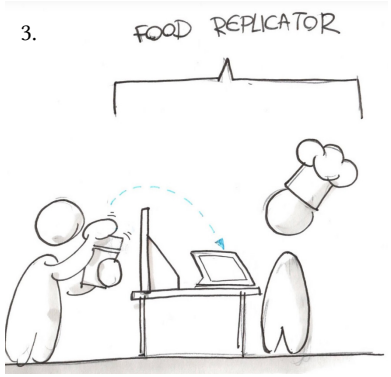
When asking the six participants about their experience, most people were satisfied with the amount of pepper added to their dish. The participants who tried the verbal, visual, and bodily ways of expressing their preferences, reported that the use of the grinder was more intuitive, and that they struggled with describing verbally or visually what they had in mind.

We took this as encouragement for pursuing the development of networked embodied input devices or tangible interfaces. ◂

'Dr Pepper', the *Food Replicator* – a fictional 'food making machine', comprised of a pepper grinder which is wirelessly networked to a tablet, a façade, and a chef (the proxy fabricator). The grinder was comprised of microcontroller and rotary encoder that measures the number of turns.



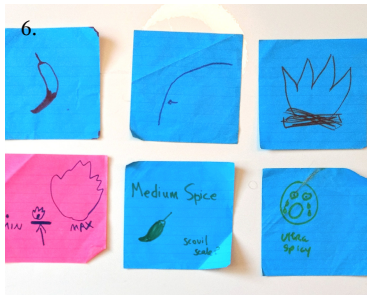
The digital pepper grinder consisted of a pepper mill, and a knob to select the type of pepper (black, white, red). The design intention was to give the sense that this is an interface, not an actual pepper grinder. Hence, the design language was kept at a low fidelity, in line with its intention as a *sketch* that



is open to interpretation, and that can be used to explore ideas [2]. Participants were invited to use the digital pepper grinder to mime their desired level of pepperiness; the number of turns was captured on a tablet (wirelessly networked to the grinder) held by the chef, and presented numerically.

Using this data, the researcher, acting as a proxy fabricator, added pepper to the risotto behind the façade of the 'food making machine'.

The chef then gave the dish to the participant to taste, and asked them to say if it matched the level of pepperiness they had in mind.



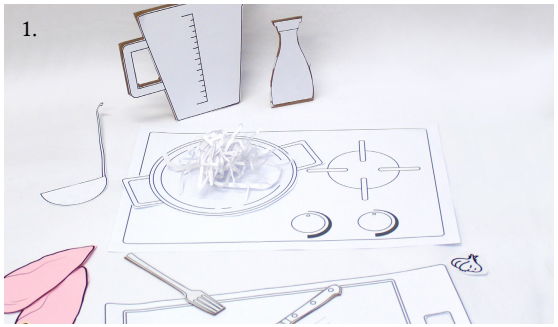
The visual expressions of levels of pepperiness sketched by participants; participants struggled to describe their preferences using visual means.

Exploring and probing instances of embodied knowledge used in cooking: '*Paper Cooking*' workshop

▸ Before embarking on further designs of input tools, we needed to understand how people negotiate between instructions in recipes and personal preferences to make *in-the-moment* creative decisions whilst cooking. We did this in an internal team workshop (right).

At the end of the workshop, we focused our discussions on how we implemented preferences when interpreting cooking instructions, and noted that they all related to estimations of quantities and personalisation of flavour. We observed that we made *in-the-moment* decisions based on contextual factors, and we used tools and our bodies to estimate measurements. As Kirsh [13] observes "the body… can help people project the structure or idea they are most interested in", we thought about the role of the body as the reference point for decisions, and the type of embodied knowledge revealed to inform what might be the adequate dimensions (quantity, size, time), feel (texture, consistency), and movement (speed, direction, intensity, etc.), to achieve a desired and memorable dish which are expressed in five categories:

Material or ingredient dimensions were used to decide quantities, e.g., using the pack size of tofu as a guide to divide it into personalized sized chunks. The ***Body*** was used to measure 'a piece the size of your thumb', and to grip a bunch of noodles. The ***Technique*** of using utensils was used to estimate quantities by using the capacity of a ladle. ***Time*** was used to measure the quantity of soy sauce by measuring by the duration of the pour. ***Memory*** was used as a relative measure to make adjustments to dishes, if it was too salty last time, they would use less salt this time. ◂

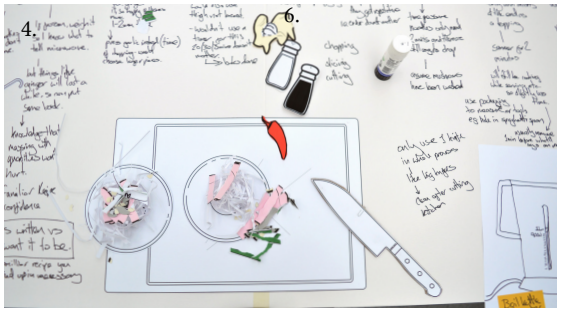


In line with the desire to explore possibilities, and allow opportunity for new interpretations we used paper props [2] with which we enacted real life cooking techniques.

As well as allowing us to conduct the workshop in the studio, taking an embodied cognition approach, this 'distorted model' [13] of the cooking process using paper props allowed us to mime cooking actions we would use in a home context, providing enough physicality to recall and reflect on the embodied knowledge we use while cooking.

During the 'cooking' process participants were asked to follow the recipe, and tear / fold / assemble the paper ingredients and utensils as they would while cooking. One member of each team was the 'cook', and the other was responsible for documenting the process on the tablecloth.

The cook recorded his/her decision-making in-situ by annotating the paper tools and ingredients, so that they could easily be recollected in context. The dishes and utensils then became the record of our decision-making and could be referred to during our discussion at the end.



Following the cooking session, we discussed each team's dish and cooking process using the annotated cooking elements as prompts. The cook in each team walked everyone else through his/her cooking process, and the documenter articulated their observations of the cook's cooking process they had noted on the tablecloth.

Exploring and probing instances of embodied knowledge used in cooking: 'observations of people's cooking practices at home' study

▸ Following the Paper Cooking workshop, we undertook a study interviewing and observing people cooking at home. The aim was to observe how people use recipes, and how they interpret them in order to calibrate them to personal circumstances and preferences, how they made 'in the moment' decisions to interpret the recipes, adapted them according to preference, ingredients and tools, or used their body to estimate measurements.

We recruited five participants. We undertook semi-structured interviews, as well as observations whilst participants cooked a dish in their home kitchens, taking an approach similar to a 'guided tour' [6]. Our observational approach of asking participants to walk us through how they use recipes allowed us to identify instances of embodied knowledge in an unbiased way.

The instances we observed (right), reinforced some of the categories found in the Paper Cooking workshop. Participants used *Technique*, *Body* and *Memory* to adapt recipes according to preference. These adaptations were rarely recorded or annotated, but made while cooking. ◂

Insight relating to using the ***Body*** to measure quantity of "*a pinch of salt*" (P5).

Insight relating to using the ***Body*** to feel nut mixture to measure "*texture and consistency*" (P4).

Insight relating to ***Technique*** of using utensils (favourite small knife) to chop ingredients to measure a specific grade: "*this is finely chopped to me*" (P2).

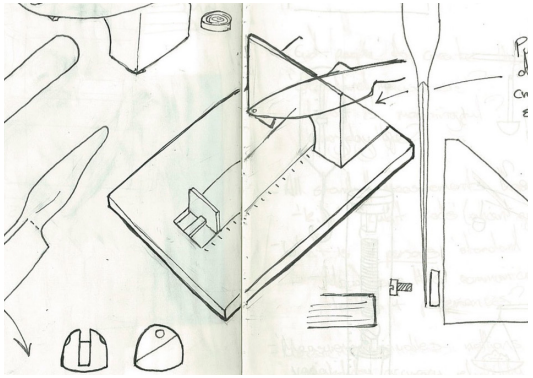
Insight relating to ***Technique*** of using utensils to chop ingredients to measure a specific grade: *"They aren't meant to be too big, because big isn't nice, and not too small, because then you can't really taste them*" (P3).

Studio-based design ideation to develop design responses to the categories of embodied knowledge

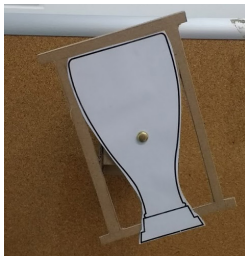
▸ We took these categories of embodied knowledge into the design studio to ideate a range of sketches and low-fidelity models. The aim was to understand the use and expressions of embodied knowledge we had observed, and to design and develop propositions for tools or interfaces that might enable them to be captured and communicated digitally in our concept platform.

We used paper prototyping methods to sketch the physical signifiers of cooking utensils and food, instead of using the real items, as it enabled a quick way to ideate and iteratively test ideas [2]. Each category prompted a design response, which the research team used as a material and speculative manifestation to re-enact instances in the studio, and to discuss them.

Based on the five categories, we ideated interfaces and tools that might support the expression of embodied knowledge, and to imagine how such knowledge might be captured and presented. These are presented in the following pages. ◂



Ideation sketch of knife jig involving mechanisms to pull the vegetable forward in relation to the speed of chopping, which sets the grade.



Soy Sauce Timer

Informed by the ***Time*** category, the 'Soy Sauce Timer' indicates one's preference of quantity of soy sauce.

Embodied data captured: quantity of sauce assessed by duration of pouring, when the bottle is tilted at specific angles (accelerometer).

Data extracted: A numerical value for a liquid measure.

Knife Jig

Informed by the ***Technique*** category, the 'Knife Jig' measures the speed of chopping and the speed of the movement of the ingredient through the jig, in order to measure and communicate different grades of chopped ingredients.

Embodied data captured: the speed of chopping and of the movement of the ingredient through the jig, in order to measure the size of the pieces.

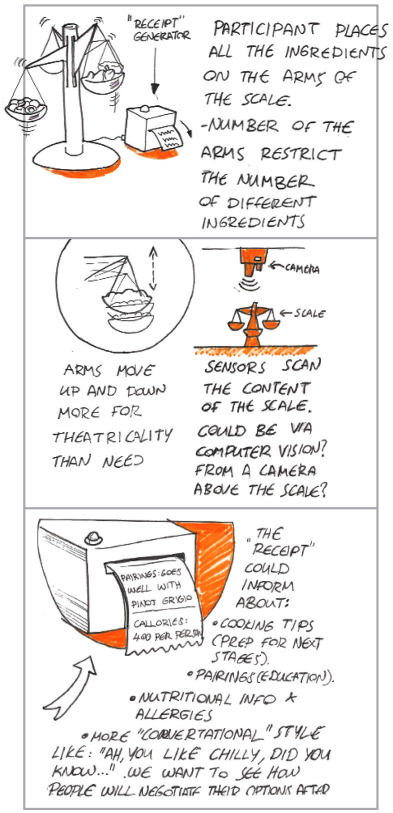
One rig could be set for different grades, such as 'finely' or 'roughly' chopped. Another rig can support different techniques, such a slicing.

Data extracted: Size of pieces (numerical), and interpretation of grade of chopped pieces (finely, coarsely).

Design responses: *Interfaces & tools* to capture embodied knowledge

Relative Scale

Informed by the ***Material*** category, the 'Relative Scale' measures the weight of each ingredient by enabling physical comparisons of ingredient quantities and flavour calibration based on personal preferences, knowledge of the recipe, number of servings.



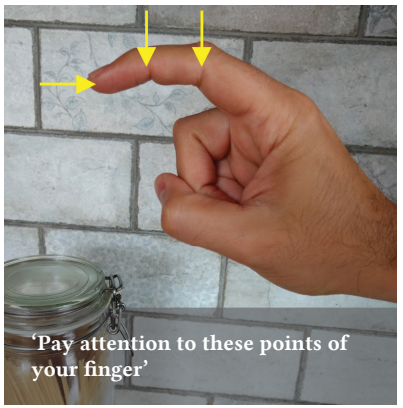
(Above) **Embodied data captured:** Quantities of each ingredient.

(Right) Ideation sketch of the 'Relative Scale'; there are specific vessels for different ingredient types in order to generate weight data for each one.

Data extracted: A list of ingredients, and numerical values of weights for each one.

Glove

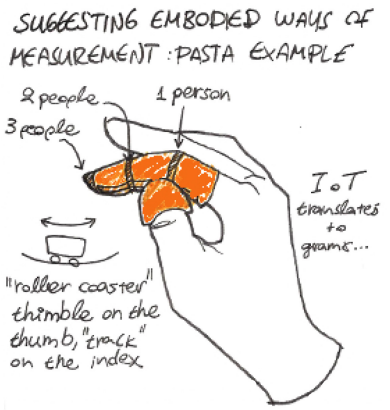
Informed by the ***Body*** category, the 'Glove' records approximate measurement units made using hands through the active coloured areas.



Embodied data captured: Quantity of noodles or spaghetti by gripping bunches between thumb and forefinger.

We translated the empirical rules we observed into the 'Glove' tool to support enacting of embodied measurements.

(Right) **Data extracted:** The point at which the forefinger touches the thumb reveals a numerical value for weight, and number of servings.



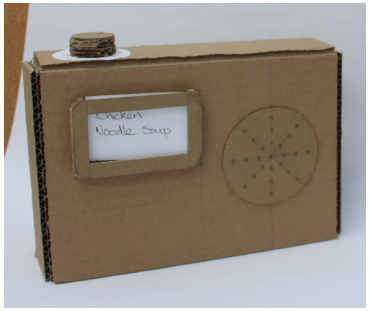
Design responses: Interfaces & *tools* to capture embodied knowledge – *Stories* that contextualise embodied knowledge

Recipe Radio

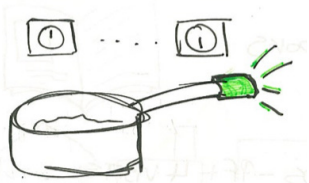
▸ Informed by the ***Memory*** category – we ideated interfaces that would support the articulation of stories to provide background information that contextualised embodied knowledge, and to imagine how such knowledge might be communicated. Some participants in our study of home cooking practices related stories associated with utensils, methods, or ingredients. These stories added rich context that helped comprehension of their cooking process. We designed the 'Recipe Radio' as a way to share stories of recipe generation.

We hypothesised that storytelling would promote people to 'think out loud' about what they were doing, and therefore might be an effective way to prompt people to articulate their embodied knowledge, and background information to it.

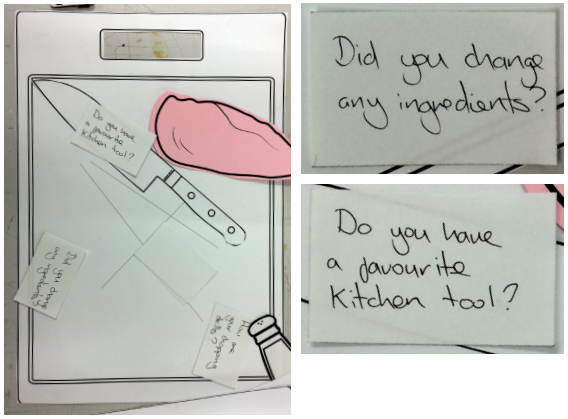
Data captured: Background information that contextualises embodied knowledge – an audio file, which features on a digital recipe card in the repository of recipes. ◂



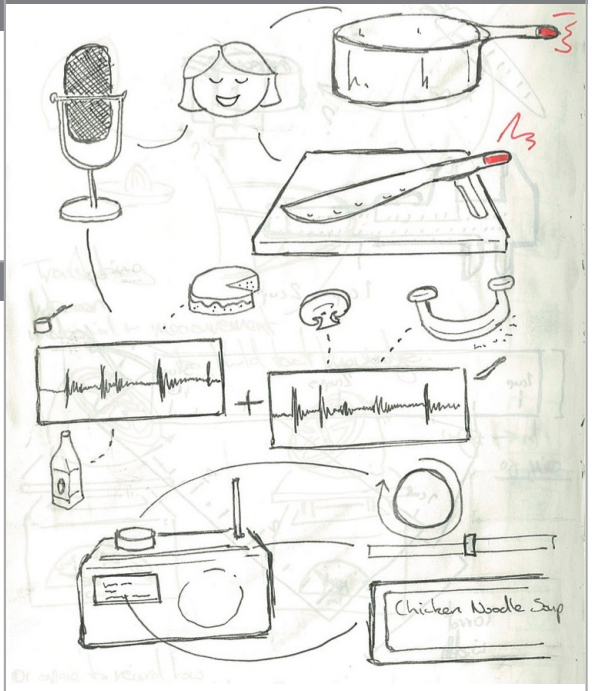
1. 'Connected Cookware' utensil picked up, green light communicates 'ready' to start recording



2. Questions are posed by the platform



3. User records story



4. Future users access story via recipe card

The 'Recipe Radio' is an app that is networked to 'Connected Cookware' and a web-based recipe platform.

The ideation sketches shows the user journey involving the 'Connected Cookware' (utensils fitted with accelerometers) and the 'Recipe Radio'. A recording light is illuminated on the utensils when they are picked up (green to indicate 'ready', red to indicate when 'recording') (no 1). In response, the recipe platform poses questions to the cook, such as "how are you chopping?" (no 2). The cook narrates and records background information relating to their cooking action using the utensil (no 3).

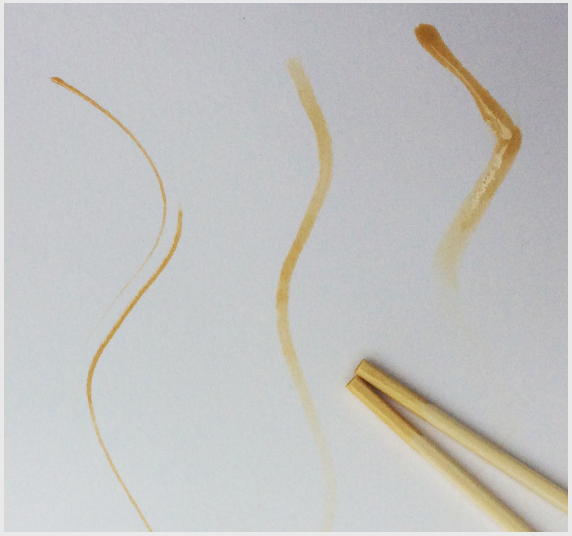
Validating design responses with design students

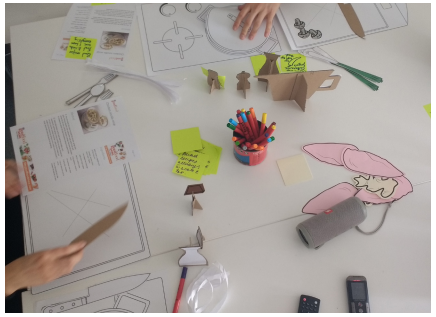
▸ In order to validate our designs, we hosted workshops with design students during which we presented the design responses, and invited them to re-enact the five categories.

Many of the examples people came up with were related to cooking with their families and to their history and culture, for example, measuring rice using hands, and the fact that recipes are not used so much in their culture.

The main outcome was that the process prompted them to reveal their own instances of embodied knowledge (right).

Drawing in soy sauce (below) inspired a sixth category of embodied knowledge - *Traces* – which looked at how to represent embodied knowledge data. The design response appears on the next page. ◂



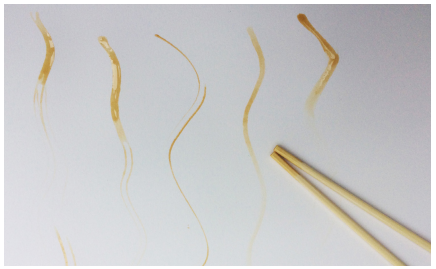


We hosted two workshops, each one involving five students. We asked students to capture their own instances on Post-It notes and to append them to the models.

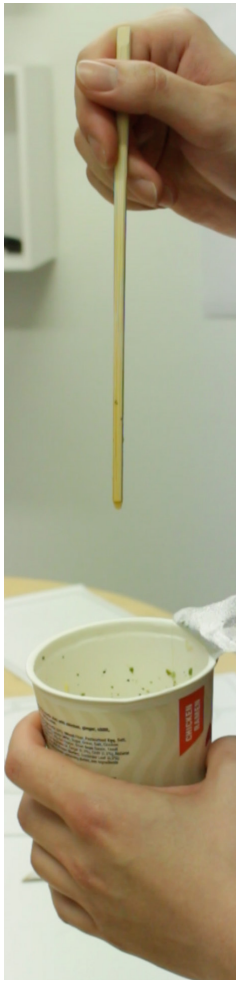
This is a portion of rice for one. This aligns with our category of **Body**.

Using a hand to ensure the right ratio of rice to water. This aligns with our category of **Body**.

Wrapping a cut strip of cabbage around fingers is one mouthful. This aligns with our category of **Body**.



(Left) Assessing the quantity of soy sauce to add by drawing with it on a plate to assess its level of concentration. This aligns with our category of **Tools**.



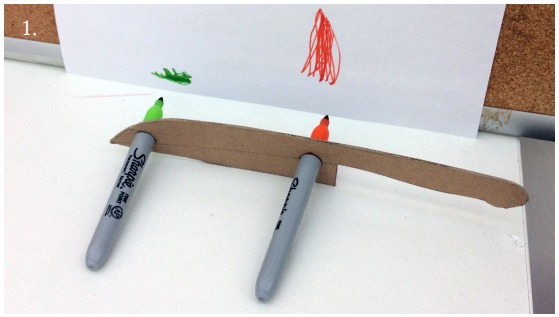
Using a chop stick to assess consistency of soup. This aligns with our category of **Time** and **Technique**.

Design responses: Interfaces & *tools* to capture embodied knowledge – visual *Traces* of embodied knowledge

Embodied Recipe

▸ Building on the idea of 'Connected Cookware', the concept of ***Traces*** imagined the utensils producing marks or drawings that visually communicate the traces produced by the use of a technique (chopping with a knife), or of quantity (pepper, soy sauce, oil).

The character of the embodied action is visualised in the mark/drawing, so that we can conceive representations of recipe data that better communicates embodied expressions in terms of techniques. ◂



The 'Knife Jig' was adapted to include marker pens to capture the marks of chopping techniques; different techniques to achieve different grades of chopping produce different *marks*.

We undertook enactment of these chopping techniques in a kitchen with real utensils and ingredients and filmed them.

We enacted the actions of chopping, pouring, and stirring involved in making a noodle soup broth. We experimented with post-production techniques to reveal traces produced by the movements of actions. For example, we created a *ghost* effect by duplicating and overlaying the clip, while adding transparency and a slight delay. This effect enhanced the sense of movement.

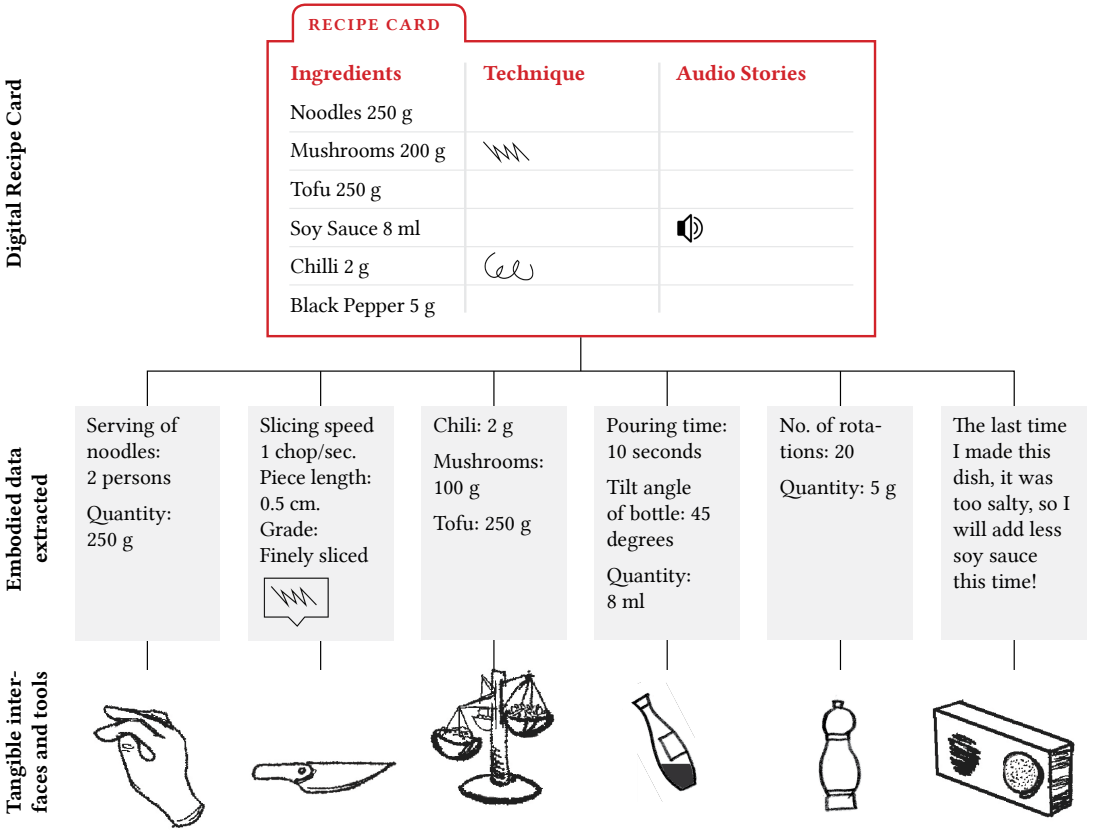
Extracted data: From these effects, we designed a set of pictograms to represent the movements of actions; the actions of roughly chopping garlic and chilli were represented with a more rounded shape, in contrast to finely slicing mushrooms, which required a sharper, consistent and accurate cutting style, which we associated with a sharper visual shape. We used the pictograms to propose how visualisations could be used to construct an embodied presentation of techniques in recipes.

CONCLUSION

▸ At the beginning of this work, we recognised that embodied knowledge was an important but overlooked aspect of how people express preferences when cooking, due to the difficulty of communicating it. Following the phenomenological approach of Merleau-Ponty [18], embodied knowledge refers here to the kind of knowledge that the body holds, and that is not clearly explicit, conscious, or verbally articulated. Indeed, communication of this knowledge is extremely challenging, particularly given its situated nature. To attempt to overcome this challenge of communication, we took a material approach to catalysing physical manifestations of embodied knowledge, by designing tools to capture and communicate this knowledge as it is expressed, and which doesn't require explication through language. We designed this set of tools and interfaces in response to our observations of people's use of embodied knowledge whilst cooking. Some of these tools involved simple additions to ubiquitous kitchen utensils, e.g., the addition of an accelerometer *collar* to a soy sauce bottle for the Soy Sauce Timer, others are adaptations, e.g., the Relative Scale and the Knife Jig, and others are new interventions in the kitchen, e.g., the Glove.

We tested our tools with an ethnically diverse group of design students during validation workshops. Of the design responses we presented, participants preferred the Recipe Radio as a valid proposition, as the *stories* could be listened to in the background without interfering with their cooking pace. They were less clear about if or why they would use the other tools. The main outcome was that they recognised the use of the body, tools, and time to estimate measurements of ingredients, which prompted their memories and stories of their own instances of embodied knowledge, which were bound up in their culture and history. They illustrated their own instances using props and utensils, and recorded them using sticky notes.

The insights from these workshops reinforce the role of the body as the reference point for decisions, and the type of embodied knowledge revealed, informing what might be the adequate dimensions (quantity, size, time), feel (texture, consistency), and movement (speed, direction, intensity, etc.), to achieve a desired and memorable dish. Here, our prototypes were effective in terms of prompting participants



In our **revised concept vision** for a set of digitally networked tangible interfaces takes the use of the tools to their logical conclusion using the hypothetical data extracted – a set of numerical values to express quantities and measures, and of chopping speed and rotations of a pepper grinder; pictograms to represent the movements of actions of chopping; and audio files of background stories to embodied knowledge – to produce a digital recipe card.

to describe their own embodied knowledge, and less in terms of being adopted as finished tools.

This is one of the main contributions of this paper: that our design process prompted people to reveal their own embodied knowledge. What started as sketch models of ideas to capture and communicate embodied knowledge, evolved into a method for the production of cultural insight, personal tricks and the collection of food-related anecdotes.

The prototypes, as physical examples of embodied knowledge, offered participants the physical grounding to understand the subject of our inquiry [7], and enables the participants to visualise, test and reflect on how they might use their own knowledge while cooking, and where that knowledge comes from. Hence, the prototypes acted as a material bridge between tacit and explicit, as they provide an external scaffolding for their cognitive tasks [13; p18]. By using their own bodies and the prototype tools, participants were able to simulate their cooking actions and, while doing so, articulated and registered their movement patterns that reveal traces of their underlying embodied knowledge. The fact that participants worked with sketchy (prototype) tools was important as it allowed flexibility to use them as triggers to their embodied knowledge, whilst not becoming attached to the tools in themselves. As Kirsh [13] observes "the body, or physical models more generally, can help people project the structure or idea they are most interested in." (p. 3:5). This can help people to manage their attention and focus in ways that are better than when actions are performed accurately. "Sometimes working with a simpler thing, even if it is imperfect, is better than working with a perfect thing." (p. 3:5).

This was an effective method for us to identify instances of embodied knowledge that might otherwise be difficult to spot, or to disentangle from the continuous process of cooking. During our discussions, the lack of resolution allowed it to transform into a tool that embodies and communicate one's personal chopping style.

The insights from these workshops reinforce the research/prototype character of our tools as a method to signpost a design direction for a what is a complex phenomenon, which is our second contribution. Our insights indicate that it would be necessary to design tools or interfaces that are *tailored* to a whole range (and an ever increasing one) of instances of embodied knowledge, or open enough that they would allow for flexibility in use, as we found that people adopt their own techniques and practices over time and through experience with tools that are ubiquitous to the kitchen, as well as with their body. This would lead to the development of tools or interfaces that might align with the cooking practices of one person, but constrain "expressing their creativity through cooking" [10 p471] of others.

Our emphasis on the tools through which embodied knowledge is expressed was problematic in that it assumed that this knowledge was transferable across contexts. Through discussions amongst the research team about our observations, we understood that this was not the case. Firstly, we realized that reducing an action to numerical values and pictograms that can be digitally transmitted to a recipe card, captures only one dimension of the embodied knowledge within it. People's embodied knowledge is bound up in both their past experiences, and the material and environmental context in which they cook. As such, these tools can only provide a partial picture of that knowledge, which may not be meaningful to another person in a different context.

Moving forward, we look to step back from a focus on isolated tool use, and to instead provide an environment where embodied practices can be established, shared, and observed in non-intrusive ways in an 'Open Kitchen' concept – a public-facing kitchen for open innovation in food. By focusing on allowing the conditions for all types of cooking knowledge to be expressed, and by building tools to record the expression in context, rather than the capture of isolated expressions, an open access kitchen might allow for the sharing of more creative aspects of cooking.

We do not claim that the phenomena in an 'Open Kitchen' will be an exact replica of what happens in home contexts, but that by not prescribing instances of knowledge, it might help people to adapt and transfer their knowledge. The dynamic aspects of embodied knowledge are reflected in our six categories. We suggest that these categories can be the lens through which aspects of embodied knowledge can be materialised, and thus approached, and understood. The Recipe Radio concept suggests a step away from the descriptive uses of language we find in recipes, towards a figurative and subjective one that does not aim to replace, but to complement embodied knowledge. We therefore offer an initial framing for the development of digital technologies that can support and enhance them for the open innovation concept of the 'Open Kitchen'. This would support a range of activities for social good, including conversations about food - and related issues of health and nutrition - between producers of food and consumers, support learning and knowledge exchange between participants, and by extension build communities of interest.

We conclude that we need a more ubiquitous set of tools that enable people to capture and record their actions that don't interfere with their natural cooking pace in the kitchen - to "imagine designs that celebrate aspects of human behavior" [10 p471]. Building on the concept of the Recipe Radio, we propose a video recording interface comprised of digitally connected ubiquitous utensils that prompt people to capture and narrate their cooking actions in non-intrusive ways and at their own natural kitchen pace, and an editing function, to produce a digital recipe card that can be shared in the 'Open Kitchen' repository. ◂

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REFERENCES

[1] Maria Busse & Rosemarie Siebert. (2017). The role of consumers in food innovation processes. European Journal of Innovation Management. 10.1108/EJIM-03-2017-0023

[2] Bill Buxton. 2007. *Sketching User Experiences: Getting the Design Right and the Right Design*. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA

[3] Mary Cadogan. Chicken Noodle Soup. Online. Available at: https://www.bbcgoodfood.com/recipes/1869/chicken-noodle-soup. Last Accessed: 05/12/2019

[4] Minsuk Chang, Léonore V. Guillain, Hyeungshik Jung, Vivian M. Hare, Juho Kim, Maneesh Agrawala. (2018). RecipeScape: An Interactive Tool for Analyzing Cooking Instructions at Scale. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems. Paper No. 451

[5] Crossing Over: The Art & Science of Multisensory Perception: https://www.rca.ac.uk/news-and-events/events/crossing-over-art-science-multisensory-perception/ Last Accessed: 05/12/2019

[6] http://www.designkit.org/methods/46 Last Accessed: 05/12/2019

[7] Jonathan Edelman, Larry Leifer, Barmy Banerjee, Neeraj Sonalkar, Malte Jung, & Micah Lande. (2009). Hidden in plain sight: affordances of shared models in team based design. In DS 58-2: Proceedings of ICED 09, the 17th International Conference on Engineering Design, Vol. 2, Design Theory and Research Methodology, Palo Alto, CA, USA, 24.-27.08. 2009

[8] Shaun Gallagher. 2005. How the body shapes the mind (pp. 173-178). Oxford: Clarendon Press

[9] Charles Goodwin. 1994. Professional vision. American anthropologist, 96(3), pp.606-633

[10] Andrea Grimes & Richard Harper. (2008). Celebratory technology: new directions for food research in HCI, Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, April 05-10, 2008, Florence, Italy

[11] Alexandra Juhasz & Anne Balsamo. Online. FemTechNet – A Distributed Online Collaborative Course (DOCC). Available at: https://adanewmedia.org/2012/11/issue1-juhasz/. Last Accessed: 05/12/2019

[12] Sarah Kemp. 2013. Consumers as part of food and beverage industry innovation, in Open Innovation in the Food and Beverage Industry. Ed Marian Garcia Martinez. Woodhead Publishing

[13] David Kirsh. (2013). "Embodied cognition and the magical future of interaction design." *ACM Transactions on Computer-Human Interaction (TOCHI)* 20, no. 1 (2013): 3

[14] David Kirsh (2009). Knowledge, Explicit vs Implicit. Oxford Companion to Consciousness:397-402

[15] Moran Mizrahi, Amos Golan, Ariel Bezaleli Mizrahi, Rotem Gruber, Alexander Zoonder Lachnise, Amit Zoran. (2016). Digital Gastronomy: Methods & Recipes for Hybrid Cooking, Proceedings of the 29th Annual Symposium on User Interface Software and Technology, October 16-19, 2016, Tokyo, Japan

[16] Joshua Palay & Newman. (2009). SuChef: An in-kitchen display to assist with "everyday" cooking. In CHI '09 Extended Abstracts on Human Factors in Computing Systems, April 04-09, 2009, Boston, MA, USA

[17] Michael Polanyi. (1967). The Tacit Dimension London: Routledge & Kegan Paul

[18] Merleau-Ponty, M. 2012. Phenomenology of Perception. Trans. D. A. Landes. New York: Routledge

[19] David Sutton. 2006. Cooking, Skill, the Senses, and Memory: The Fate of Practical Knowledge. In: Elizabeth Edwards, Chris Gosden, Ruth Phillips. Eds. Sensible Objects: Colonialism, Museums and Material Culture.