Food for Advanced Computational Thinking

Critical and Creative Approaches to Technology at Te Kura Taurua Manurewa

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ABSTRACT

This paper focuses on a participatory activity that is part of an ongoing partnership formed six years ago between teachers and academics to study creative technology approaches to youth participation. By focusing on a food-based activity in an after-school maker space, we reflect on the pedagogical and methodological innovations, and the ethical and aesthetic qualities of food-based activities for participatory design. The session brought together students and teachers to form a generative dialogue around computation and automation while preparing and sharing food. The results suggest opportunities to rethink current curricular, pedagogical, and education policy strategies. Recommendations for organizers to prepare generative activities where food is used as a design material close the paper.

CCS CONCEPTS

• User characteristics ~ Age ~ Adolescents • Human-centered computing ~ Interaction design ~ Interaction design process and methods ~ Participatory design

KEYWORDS

Education, maker spaces, food, coding, generative themes

1 Introduction

This paper refers to a two-year project that is part of an ongoing partnership that started six years ago between a High School and a University in Tāmaki Makaurau (Auckland), Aotearoa New Zealand. A particular type of participatory activity that uses food as a design material in this project becomes the centrepiece to orient here a wider discussion around critical issues in the field of Participatory Design (PD).

The project stems from the launch of the new Digital Curriculum and Hangarau Matihiko recently introduced by the Ministry of Education and is conducted in a “Maker Space” established at Te Kura Taurua Manurewa High School in South Auckland. This after-school space brings together a group of students (ages 13 to 17) with a diverse set of interest, skills, and cultural backgrounds who meet twice a week after school hours to work in projects with no required connection to the formal curriculum. A major insight from its inaugural year was that the most valued element that brings the group together is the sense of whānau (connection and fellowship) based on inclusiveness, freedom, and mutual support – rather than the technologies typically associated with “Maker Spaces”. Such “maker whānau” has been collectively shaped by the students and teachers as an open-door and safe space to pursue student-driven ideas and interests actively supported by the adults and the technology available.

The project seeks to better understand and support the dispositions and competencies related to Computational Thinking in this maker whānau. It is grounded on a strong Youth Participatory ethos [1] where the voices of students are valued and respected. We also adopted an approach of methodological innovation based on design and creative practices guided by ethics and aesthetics of integrating the research with the learning experiences seeking authentic participation. The project received a competitive grant starting in 2020 from the New Zealand Council for Educational Research – NZCER.

The activity presented in this paper uses kai (food) as a material or medium for participatory inquiry with teenagers. This experience helped us understand how learning and research activities embody specific ontologies that often go unnoticed by educators and researchers in this area. The paper continues with a brief literature review on the foundations of computational thinking and maker spaces, and the tensions between participatory approaches in design and formal education. It then presents the project and the activity to study computational thinking in this context and presents the findings from this activity in one session held in November 2020. The paper closes with a critical discussion on how the results of this session inform computational thinking and the co-design of generative activities in this area.

2 Background

A sharp increase of studies focusing on “computational thinking” (CT) is evident in the last decade -a citation report shown in Figure 1 shows a recent tenfold growth in publications. The literature consists primarily of papers in computer science and technology education areas with a dual impetus on teaching children to code (computer programming) and raising their interest to pursue career paths related to software engineering and digital technologies.

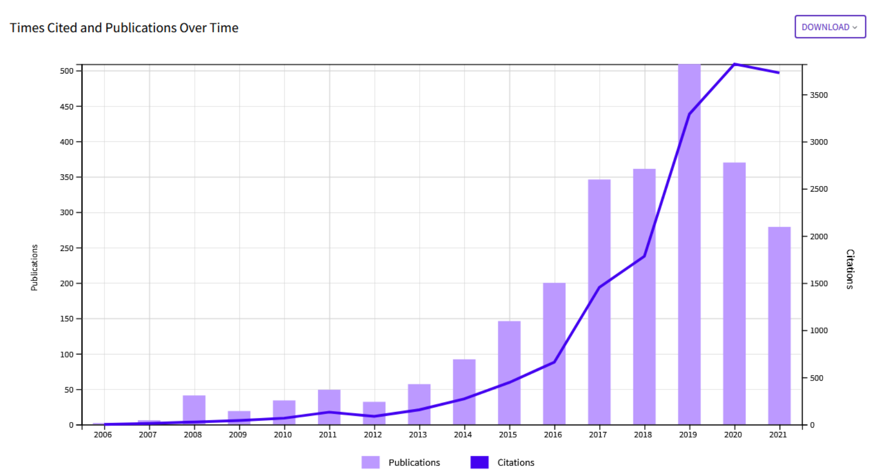

Figure 1. “Computational thinking” Web of Science report. 2,550 publications; 16,245 times cited; h-index = 48

Out of a total of 2,500 papers between 2006 and 2021, only a few are highly cited as denoted by a h-index value of 48 in the field, i.e., the top 48 cited papers have 48 or more citations. Moreover, a third of all citations refer to two papers by Jeannette Wing [2] who is credited with coining the term as used today.

Definitions of CT vary widely across the literature, but most consider one or more of the following competencies related to thinking "computationally": problem decomposition, abstraction, algorithm design, representation, automation, testing (debugging), and generalization. These processes were originally associated with mathematics, science, and engineering problem solving [2], creating an ambiguous basis for what exactly is counted as CT in the field.

Three main types of approaches to CT are visible: first, those specifically addressing coding skills; second, those that "focus on the principles of computing" [2] where the intent shifts from teaching children to 'think like a computer' to 'think like a computer scientist'. Third, those that see CT as an addition to the repertoire of thinking abilities "for everyone" and "everywhere" making it, arguably, "instrumental to new discovery and innovation in all fields of endeavor" [2] p. 3270. A dominant rationale across the CT literature is that since digital technologies are becoming pervasive, people need to have the technology skills that prepare them for an ever-increasing digital world, vis-à-vis the threat of automation taking over their jobs. Behind this logic, it is hard to miss the interests of the global tech corporations to increase their consumer base ("the next billion"), extend their reach to every aspect of our lives ("the metaverse"), and guarantee a continuous provision of a skilled and low-cost global workforce.

A related but to some extent separate trend in schools worldwide is the establishment of "Maker Spaces" in K-12 education, including in Aotearoa. The "maker *movement*" (notice the use of pseudo-revolutionary rhetoric) has at least two easily identifiable tributaries: on the one hand, constructionist learning [3] and on the other, the tech-libertarian doctrine of Silicon Valley [4]. These two attitudes toward technology coincided by the late 20th century with the rise of the personal computer and the mainstream adoption of the Internet across the globe. A range of communities and associated practices can be identified in the confluence of these two areas, from *tech entrepreneurship* with a strong profit-making ethos backed by Venture Capitalists to the Free Open-Source projects for technology reappropriation and creation of commons-based tools and solutions.

Only a few scholars have critically analysed the history behind the dominant technology areas. Morgan G. Ames [5] traces the assumptions underlying both "the universal appeal of learning to program computers" and the FabLab or makerspace movement. By foregrounding the youth and early career of its founders, the pillars of the maker mindset become visible: individualistic, pragmatic, capitalistic, and patriarchal. A WEIRD (Western, educated, industrialized, rich and democratic) individualism explains the emphasis of constructionist learning on individual children (mainly precocious boys), its distrust of authority and community, and its entrenched belief that their experience is universal [5]. It also reduces childhood creativity to a technocentric scale explained by innate traits "rather than socially and historically contingent" [5].

Moreover, while digital technologies did have several possible futures open by the early 1990s, their fate was sealed through the policies of the Clinton administration in the US -and the alignment of regimes around the world- that privatized public infrastructure and reverted antitrust legislation paving the way for the rise of Big Tech under the guise of opening access [6]. "Learning to code" campaigns thus began as a promise to upskill a weaning manufacturing workforce, and since then the teaching of STEM (Science, Tech, Engineering, and Math) including coding has been pursued by governments in the service of the tech industry -more recently adding Arts to make STEAM.

A rather unimaginative response in education research and policy today is to update the curriculum and to invest more resources, effort, and studies on training teachers to *adequately* teach computational thinking [7, 8]. This turn towards better curricula and Professional Learning & Development (PLD) programs is often paired with the perceived need for *more* maker spaces in schools, normally locking schools into schemes with suppliers who charge hefty fees for service and warranty, training, supplies, and repairs. This threefold strategy can heavily determine *how* children experience technology in schools in general, and computational thinking in particular: as part of a compulsory and assessable curriculum, perpetuating banking education where knowledge is deposited by experts into the minds of the unlearned, and using expensive equipment to be guarded from *wrong use*. The result of such top-down way of thinking about maker spaces in schools is that they risk becoming places where learners follow tutorials and carry out prescribed activities not too different from the signature pedagogies of traditional woodworking or metalworking labs. [9] identifies two key dimensions in addition to learning activities in youth maker spaces: community and identity. We align our work with this way of understanding maker spaces as student-led communities where diverse individual identities are welcomed, valued, and fostered.

A participatory lens has been applied to the design of and practices in maker spaces [10] including *participatory making* [11]. The idea of *computational empowerment* acknowledges the contextual and societal dimensions of digital literacy in K12 education [12]. Likewise, a *social turn* in this space has been acknowledged where practices are no longer seen as predominantly individualistic and tool-oriented but as fundamentally sociologically and culturally grounded [13]. The potential of maker spaces for learning have been acknowledged [14] and related learning practices identified including supporting independent inquiry, seeking and sharing resources, articulating and expressing intention, and developing skills in tinkering, solving, and creating [15]. Clearly, these and similar efforts seek to challenge the *schooling* practices in maker spaces still dominant today.

Participatory design (PD) and education have shared concerns but also significant challenges to work in partnership: according to the editors of a recent volume, these two areas are not yet engaging in shared dialogue and agreements are lacking as to what PD can bring to learning -and vice versa. [16] p. 235. Many designers, particularly of technology, have yet to recognize the creative agency of people in general and of children in particular. The creator of a computational thinking toolkit states that it is difficult for technology designers to use PD when they want "to come up with new, exciting, great ways to encourage learning of specific topics" and that children can, instead, "come in at different points, to comment on, or use our technology probes in various ways, to make suggestions that we haven't thought of" [17] p. 229. Another HCI expert in the same chapter notes that PD and learning differ in intent: while educators focus on the learning, participatory designers focus on "the artifact" [17] p. 229. Our work departs from such attitudes, first by recognizing the principle of *natality* in every human [18], and second by understanding PD as invested in the codification of generative themes tentatively proposed by adults to children for them to decodify and guide their self-directed learning journey in a process of dialogue and mutual trust [19].

The work presented here aligns well with notions of "setting the stage" or staging in participatory design [20], where an emphasis is placed on the material and the interaction qualities of a participative session. While in this project the aim is not to co-create a designed "solution" to a brief or problem, nonetheless it brings teachers and learners together to collectively imagine and redefine what learning is to them and, more specifically, what computational thinking means to them. The project asks participants to imagine possible future scenarios and to interrogate present ideas and practices, an archetypal "designerly" stance.

In sum, several responses have emerged in recent years to extend the dominant narrow view of computational thinking including those addressing its creative [21], social [12], cultural [22], embodied [23], designerly [24], and maker [25] dimensions. Our work is informed by these views toward a more *advanced* understanding of computational thinking. Our work also recognizes the tensions between participatory approaches to design and learning [16] and seeks to contribute insights for design-based participatory activities for dialogical learning [19].

3 Advanced Computational Thinking in a Maker Whānau

The "Advanced Computational Thinking" (ACT) project is part of an ongoing partnership between teachers from Te Kura Taurua Manurewa High School and education and design academics from AUT University. While others refer to *deeper* CT levels as "cleverer or more sophisticated abstractions" for advanced modelling [2] p. 3270, the term *advanced* in ACT does not imply that once *basic* CT competencies are developed, then learners are to engage with supplementary or more technically advanced dimensions of technology [26, 27]. Rather, ACT sees learners engaging with digital technologies in humanistic and post-humanistic ways right from the beginning, from their initial uses and creation of and with technology. Advanced in ACT thus entails dialogical approaches to learning [19] where the learners' interests, well-being, and worldviews are at the centre when deciding how to engage with computers and what they use them for. Hence our research question in the ACT project is:

How do students and teachers experience engagement with an advanced level of computational reasoning that prioritises ethical, creative, critical, reflective, and community dimensions?

The ACT project emerges in an after-school learning environment driven by students and teachers' genuine interests around digital technologies. Working with those who have already enacted this crossing of a threshold, opens an opportunity to explore how their experiences with digital technologies can enrich their wider experiences of and beyond the school curriculum, as well as their contributions to their communities. The project aims thus to study the dispositions, skillsets, and activities that are relevant to them. A social justice aspiration drives the project to better understand how ACT can contribute to address inequities in educational outcomes.

Applying the six dimensions of the Participation Evaluation (Part-E) framework [28] to the ACT project, its *Objective* is to study and support mind-sets and paradigms beyond coding to support students in making informed decisions about, critical uses of, and meaningful contributions to and through technology in their present and their future. For its *Practice*, we employ novel methodological approaches that are co-created with participants inviting ideas and outcomes beyond those anticipated or desired by the researchers. *Interaction* between project members takes place at the level of exchanges and mutual awareness of contributions as it seeks to align with ongoing relationships, practices, and the culture of the maker whānau. An initial awareness of the *Barriers* included budgetary to support research activities in the space through additional salaries and equipment, and the coordination challenges and logistics between schedules and workflows in the two types of institutions involved. Because of the roles of the people involved in the project, *Representation* is entrusted or delegated albeit dampened by the after-school nature of the space. Lastly, the project seeks a short-term and small-scale *Impact* as benefits a group of students to identify opportunities and advance their learning in design, technology, and creative skills. For teachers, the project seeks to open additional possibilities for teaching and learning and contribute to their professional and personal growth. For the wider Kaahui Ako o Manurewa (Community of Learning, collaborative networks of early childhood centres, primary and secondary schools) this research seeks to benefit these schools in their achievement goals for students through providing a collective focus on innovations in pedagogy and student engagement of digital technologies as well as creative and critical thinking. In the end, the project seeks to provide national benefits with regards the teaching of computational thinking within a holistic and integrated conceptualization of teaching and learning. In addition, schools in Aotearoa may benefit from seeing the possible benefits of implementing advanced aspects of maker culture in their school curriculum.

3.1 "Crit sessions" as a research method

The ACT project formulates "crit sessions" as its main research method. Crit sessions have a long tradition in design education as spaces of dialogue where knowledge is co-created between participants [29]. Adapting crit sessions as a research technique, we seek to encourage a more open-ended and participant-driven alternative to approaches such as focus groups or group interviews. To our knowledge, crit sessions have not been used as part of participatory research methodology in formal or informal learning environments. In recent months, the Manurewa maker whānau had already shaped a culture of working on self-directed student projects supported by other students and the teachers. The research team was welcome to participate in these sessions which helped foster communication with the students and mutual trust. During this early stage, crit sessions were seen as an appropriate format to periodically provide support and feedback to students on their self-directed projects, and to generate data.

All members of the maker whānau are invited to crit sessions outside of the normal hours of the space, to participate in activities, present their work, ask questions, provide feedback, and make suggestions to each other. The crit sessions were deemed as an appropriate way to offer a student-oriented and project-based discussion, and a good alternative to extractive methods centered around obtaining data from participants. A crit session is shaped by all who participate, starting with an open call to plan and prepare each session. All ideas are welcome towards the collective examination of the learning experiences and how these connect to and are augmented by advanced understandings of computational thinking. We originally

planned to conduct crit sessions a couple of times every school term but had to adapt to the recurring interruptions to school activities due to the Covid-19 pandemic.
Data collected during crit sessions include researchers' and teachers' notes; design artefacts and stories shared by students; and designs, models, code, and sketches produced during the activity. No data was produced during the normal hours of the maker whānau, only from the voluntary crit sessions. With informed consent from students and their parents or guardians, we audio and video recorded the crit sessions, and transcribed these recordings for analysis. The data analysis applies a framework for critical qualitative inquiry based on dialogical facilitation [30] guided by the three 'bridging strategies' from research to design formulated by [31] p. 204 as shown in Figure 2. Bridging here applies to addressing the gaps between disciplinary backgrounds within the research team (namely, participatory design, learning philosophy, and teachers) and the gap between research and PD interventions (namely, the crit and the regular sessions in the maker space). As Figure 2 shows, [31] bridging is a way to more closely and naturally connect research phases (data, information, knowledge formation) with design activities, and to support a two-way conversation between stages and members of the team. This is initially applied in the ACT project focusing on generating insights to bridge data to design ideas including activity briefs, prompts, and examples that teachers and students in the maker space can use to support their understanding and practices of computational thinking. This paper presents a specific activity from a crit session in the ACT project, leaving the higher-level theory building for future work pending due to the Covid-19 lockdowns.

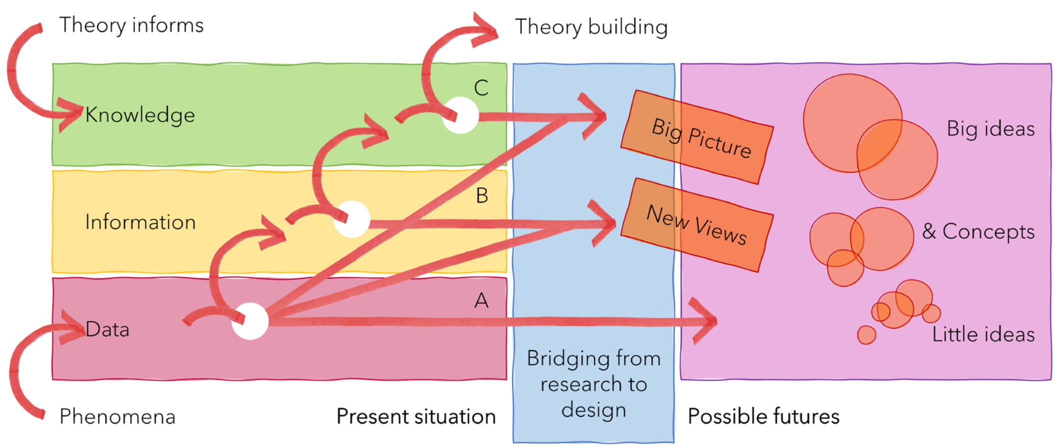

Figure 2. Bridging strategies from research to design in generative design research, redrawn from [31] p. 204

3.2 Crackers for Computational Thinking

A playful food-based activity was prepared for the opening ACT crit session in November 2020, after several months of team members being present in the after-school sessions at the maker space. During that period, the researchers got to know the group, collaborated with them and the teachers, and they also noticed the importance of sharing kai (food) in the space towards the end of the sessions in the afternoons. A "generative theme" as recommended in dialogical education [19] was pursued by the research team to address computational thinking topics in the maker space. The goal was to set the scene to inspire and sustain group discussions around dispositions, skills, and purposes of using and creating new digital technologies.
The team was aware of precedent food activities in this area, in particular the "Peanut Butter and Jelly sandwich" (PB&J) activity widely used in secondary schools in the United States as an introductory session to coding [32-34]. In PB&J the teacher normally brings some sliced bread, a jar of peanut butter, a jar of jelly (jam) and utensils like a plate, knives, and spoons. The teacher acts out the role of a (naïve) robot asking the students to provide clear and precise instructions on how to make a PB&J sandwich. Typically,

students rely on common sense and embodied experience, and they leave some steps out or give unprecise instructions, which create opportunities for the teacher to pretend to not understand or purposefully execute erroneous steps with an overall humorous effect. Although PB&J can be customized in various ways, it does rely on the following principles: it publicly points out errors made by students, it labels their responses as correct or incorrect, it lets more vocal and extroverted students dominate, normally students see the food but do not eat it, and it produces food wastage. In PB&J, the teacher acts "the role of the clueless robot" misinterpreting the students' instructions such as "whenever possible, orient something in the wrong direction" while striving "to strike a balance between erroneous work and making enough progress to keep students interested" [35]. Computation principles covered in PB&J include naming variables, sequencing operations, conditionals, recursion, subroutines, and debugging.

In several ways, PB&J became a counterexample for the team to design our food-based activity, particularly in its pedagogical and ethical orientations which felt markedly out of place in the Manurewa context. First, we sought to shift the power dynamics and make it participatory rather than a performative activity. In PB&J, the 'sage in the stage' is in control while we wanted everyone to directly participate by preparing and enjoying the food. Second, we wanted to challenge the unauthentic act of the teacher exaggerating the limitations of a robot and aspire to a more authentic experience. Thirdly, we aimed to go beyond a narrow theme (algorithm design and debugging) to create a space for generative dialogue that could include these and other themes that students and teachers considered relevant to their computational thinking. Fourthly, we wanted to avoid making fun of students and did not want to base the learning value on their errors or omissions. Rather than seeking cheap comedic value, we wanted to have a playful and memorable yet respectful and constructive time.

The "Crackers" activity was conceived to use food as a design material in a hands-on activity, rather than food being left for a break or at the end of a session. To prepare *Crackers*, the hosts come up with a list of ingredients based on their knowledge of participants and their food preferences and restrictions. Our team made a list that included an assortment of crackers of different types (rice, corn, wheat, and with different seasonings, shapes and textures) and a variety of toppings. Toppings ranged widely from savory to sweet and included food that folk were likely to know and enjoy (tomato, avocado, sliced boiled egg, cheese, olives, sliced fruit, chocolate spread) and others they were unlikely to know or could be challenging for them (anchovies, pate, jalapeños, chili flakes). Ingredients from an assortment of world gastronomies ensured a combination of familiarity and novelty to spark conversations and unlikely combinations for participants to experiment with as they assemble and eat their creations.

A total of 8 students (ages 13 to 17) and 2 teachers joined the crit session. As they arrived, they were welcomed and invited to seat around the table with the ingredients on display and with an assortment of serving utensils including plates, knives, spoons, toothpicks, and napkins. It is advisable to conduct a safety check for food allergens and in Aotearoa a karakia (ritual) opens these sessions. People were then welcomed to help themselves with the food and natural conversations were encouraged. Questions about ingredients were addressed, and everyone was encouraged to try new ingredients and new combinations. The atmosphere naturally became festive and relaxed, and engagement increased as the session warmed up. We included a couple of blindfolds which some participants proceeded to use as they challenged each other to eat what others prepared for them and identify the ingredients.

While this took place, the hosts seeded questions in small groups or more broadly about what it takes to prepare a cracker. Connections were highlighted between preparing crackers and computational processes, such as identifying and classifying ingredients by their qualities, assembling ingredients sequentially, iterative testing of flavors, receiving and executing instructions and suggestions from others, combinatorial possibilities, and customization. By analyzing what they and others around them are doing, we invited people to describe and comment on the steps necessary, the challenges, and the strategies to prepare 'finger food' including how to handle ingredients, use utensils, the decision-making processes, and other aspects of the sensorial and social aspects of food intake. The hosts can comment on these themes noticing and asking participants which ones they think are more, less, or not amenable to computation and automation.

With the conversations ongoing, a short video prepared in advanced was shown to the group where different robots preparing food are showcased. Such videos are easy to find online and may range from contemporary robotic arms serving coffee and ice-cream to more futuristic videos that make use of CGI and sci-fi imagery to depict future scenarios of cooking robots. This short video (5 to 10 minutes) seeks to energize the group discussion around what is possible, probable, and desirable when it comes to futures of increased automation. Participants are encouraged to discuss principles of physicality based on what they see in the video and their current experience preparing crackers.

As the video plays, people were encouraged to write down their reactions and ideas about computation, automation, and everyday tasks such as preparing and serving food. Since this group is familiar with ideation processes using sticky notes, we handed these out and encouraged everyone to capture their impressions, questions, and comments to share them later with the group. Figure 3 shows the *Crackers* activity at two stages as organized in this crit session: the group preparing and enjoying their creations (left) and watching the videos on a screen at the end of the table (right).

The crit session closed with a well-known retrospective technique that uses a sailboat as a visual metaphor to help groups identify risks, challenges, opportunities, and goals. Participants are invited to talk about the crit session of that day and to reflect more specifically on their maker space projects. Taking turns, people attach sticky notes on a board commenting on the potential or hidden risks (icebergs), the challenges or things that hold back or slow down work or ideas (anchors), the processes and things that work well (wind), and visions for the future (land).

Figure 3. *Crackers* activity: preparing and eating food, and watching videos of robots preparing and serving food

4 Findings

The findings presented here emerged from iterative analysis carried out by members of the research team including the facilitators of the maker space who participated in the *Crackers* session. The main goal of this bridging phase was to understand if and how a food-based activity like *Crackers* could help produce meaningful conversations that reveal how students experience digital technologies in their maker space projects. The data produced (images, transcriptions, video, audio, and researchers' notes) was shared between members of the team, who gradually over a dozen weekly sessions worked to bridge these data into design insights [31].

A variety of experiences during the *Crackers* activity became evident from the participants' contributions. The ways in which they experienced food were markedly diverse across the group, albeit the evidence speaks of a lively space of enjoyment, reflection, and dialogue created by participants. Some of them chose ingredients and combinations they were familiar with, while others enthusiastically asked about the new ingredients and tried them and in different combinations. Some people encouraged others and recommended their newly found flavors to their colleagues. Challenges between participants emerged to try unusual toppings or to try crackers prepared for each other. Inspired by the unusual (to them or to the group) crackers created by some participants, some copied or tweaked what they saw being enjoyed around them. As these different experiences took place, a convivial atmosphere was observed by the researchers in which this group of students who have worked together for the last two years explored and assessed new possibilities in a large combinatorial space. Conversations naturally spilled over beyond the apparent realm of crackers and toppings, with people building connections to wider aspects such as their openness to new experiences, their preference or aversion to challenge their own expectations, and their strategies to learn from others by imitation and alteration. One participant shared their cautious exploratory approach as follows:

"I started with things I knew I like already. Then I thought it was safe, and then I started experimenting a bit more with things. More adventurous; I had never tried or I thought I didn't like."

Upon watching the video of automata preparing food, the same participant reflected upon how introducing a cooking robot would likely impact on their personal approach and response to novelty and failure. They imagined how they would react to the robot preparing an unfamiliar cracker which they may not like, turning their attention toward the critical theme of trusting technology:

"Whereas if it was a robot, and I didn't like it, I don't think I would like to try anything it gave me afterwards, possibly."

The responses to the videos of the cooking robots can be organized in three main clusters: first, questions about what the robots are actually capable of doing vis-à-vis seemingly simple tasks; second, negative responses pointing out disadvantages of using robots to prepare food and potential problems; and third, positive responses highlighting advantages and future possibilities.

4.1 Questions about technology

Questions expressed by participants were dominated by "How" questions indicating their curiosity about how a robot may realistically achieve everyday tasks and the way algorithms need to be designed to account for a practically infinite number of possibilities. One student wrote in a sticky note:

"Just: How?"

And further elaborated when sharing with the group:

"How can a robot pinch salt like *that*?"

This type of questions prompted different reactions in the group, ranging from ideas about the inner workings of computers to perform these tasks to expressions of disbelief and mistrust of the videos. In all cases, the conversations in the group showed a high level of sophistication and criticality that can be characterized as "cautiously optimistic". Their contributions indicate an eagerness to suspend disbelief to imagine what is possible, matched with an awareness of the difficulties and the tendency of commercial videos to exaggerate and deceit. This shows that this group of students is demonstrably more than capable to see through the tech propaganda in the same way experts in robotics warn against choreographed "demos" that deceive a gullible public [36]. "How" questions also addressed issues and challenges that are hard problems in the field of robotics, such as how the robots may be able to sense the world and their own actions to feed back the consequences of their movements and decisions. For example, referring to a robot shown cracking an egg over a pan, one participant asked:

"What about eggshells? Because *I know* when I crack eggs, and the robot will not notice and just keep going"

Themes of errors and their role for learning prompted multiple questions during the *Crackers* activity. Some videos show scenes where robots make mistakes such as overflowing a container or misplacing it and spilling its contents. In such videos, the robot remains unaware of its own mistakes and the effects, and it just proceeds with the steps as programmed. A participant noted in this respect:

"Much more work is needed to create a machine that can learn from its mistakes"

Such observations and questions are a significant part of activities like *Crackers*. Recall that the PB&J is based on students trying to define an algorithm sufficiently and unambiguously ("prepare a sandwich") given a small set of well-defined ingredients. The teacher's role in PB&J is to point out the flaws and errors that students make by pointing out and exaggerating the ways in which their instructions would fail to compile. *Crackers* turns the tables to make palpable the complexities of preparing food including the dexterity and motor skills these students have and may take for granted, their decision-making processes, and their advanced awareness and proprioception capacities that are so hard to model computationally. Other more profound "How" questions were posed by participants about how people may relate to and interact with robots. The group discussed the consequences of digital technologies being unable to follow individual preferences or, even worse, getting 'stuck' with what people already know and like -thus depriving them of new experiences and learning. The conversation also included questions of how robots may change how humans experience food, ancillary roles, and the work done behind the scenes before and after the tasks shown in the videos. One of the videos shows a robot preparing "grandma's recipe", prompting a participant to ask:

"Who is grandma? And whose grandma's recipe?"

The discussion raised multiple questions about how technology changes how we perceive other humans, their labor, and their acts of care. Some participants asked who is meant to wash up, who is supposed to prepare ingredients, and who is supposed set up the space and implements for the robot to cook. And, referring to perishable food, participants wondered who would be responsible for ingredients to be pre-mixed, kept fresh, and be safe to eat. These questions demonstrate a sharp eye by participants to see beyond the immediately apparent and their questions are reminiscent of "fauxtomation": the hidden human effort behind pseudo-automated work [37]. Questions of cost were also posed by the group with a concern that cooking robots would increase the disparities between those who afford them and the rest. Two exemplars asked by participants are:

"Will it (robot) cost lots of money and will it be affordable?"

"Is it really better?"

4.2 Negative and dystopian views

Conversations exploring the negative views of digital technologies in everyday life included four main themes: fear, skepticism, effects, and costs. Participants referred to films and literature to address the possible scenarios of automation. Some of these included explicit feelings of concern and fear such as:

"As cool as it would be, I have a fear. Has anyone seen WALL-E? This just makes us way more lazy. Having the activity doing it ourselves is better than the robot doing it for us."

Statements of skepticism were also raised by participants. These ranged from disbelief of what the videos showed as discussed above, to noticing the essential limitations of digital and mechanical agents that cook yet are unable to neither understand nor sense what food tastes like:

"Impossible! Nah… wow, that seems impossible"

"Not gonna happen! When I saw it pinching salt, it didn't sell me anything. It feels fake."

"Robot cannot taste the ingredients"

Long-term and indirect effects were also identified in the conversations to formulate negative statements about the computerization of food activities. These included astute observations about the potential obsolescence of cooking skills, risks of technological dependency, and the impossibility of capturing all the complexities of cooking to computation:

"Con is that people won't (know how to?) cook if robots do it"

"No experimenting; when people cook they like to experiment"

Lastly, participants noted the hidden costs and labor, a range of contextual limitations that may impede the role of robots in the kitchen, and even the emotional responses that people may have to such robots:

"Can't do it (robot) all by itself and needs food preparation first (by humans)"

"The (robot) will take a lot of room in the kitchen area"

"I didn't feel the same when the robot dropped the ice cream as if it had been a human"

4.3 Positive and abductive views

Conversations about computation and everyday food intake also included a variety of positive statements about future possibilities and ways in which robots and humans may appropriately interact and collaborate in this area. Many of these statements demonstrate an *abductive logic* enacted by participants who creatively imagined ways forward. The first type of positive comments included various ideas for more specific food scenarios, rather than all-purpose cooking robots:

"Yoghurt robot, good programming: ice cream from one side, sprinkles from another, and then access to move it is simpler and easier for a robot. So, ice cream would be an easy job for them (rather) than the omelet robot"

"Maybe for the elderly when they can still able to move"

"It could help employers with overcrowding customers"

A second type of positive views were related to a perceived freedom of social judgement and the possible use of time freed by technology:

"Yoghurt robot: ok, that could work. It's a relief for all overboard lovers. Great for people who love overdoing things: just punch in a number and there is *no-one judging you* for it. Unlimited sprinkles"

"Unless you don't like that part (food preparation), you are busy, and you prefer to spend that time with your kids."

A variety of creative ideas for future developments of this type of technology were shared in the conversations, including:

"It could be a Netflix situation: recommendations of new flavors based on what you like"

"Could have a database of what people are picking. It could be a possibility. If you have algorithms and people evaluate the combinations."

"You could say "Apples" and it could tell you what goes with it."

"If you had a robot that looks like a person. Then you may feel connect with them. Those (robotic) arms, I'm not feeling anything."

4.4 Debriefing

Upon completion of the *Crackers* activity, a group reflection debriefing took place with all participants to collectively assess the session and its fitness with the work and ethos of the maker space. Words used by participants in closing the crit session to describe the activity and the maker space work included: "Out of comfort zone; Learning; Amazing; Connections; Fun; Engaging; Adventure; Experimenting; and Socially active". Positive aspects that they identified about the maker space included people having and bouncing off creative ideas; a space that is open to newcomers; treating everyone like family; a fun and creative place for collaboration; no negative "vibes" and a sense of whānau. Challenges that the group identified about the maker space included not having enough experience; being new and finding it difficult to learn some new things; malfunctions and overcrowding of machines; need for more space; and insufficient external recognition of the work done here. The teachers also noted the challenges ahead to connect the learning that takes place in the space to the curricular classes.

In all, the findings confirm and illustrate the qualities of a food-based activity like *Crackers* to surface a diversity of lived experiences. This hands-on and multi-sensorial activity breaks expectations of the role of food in a session usually treated as ancillary to the research. It also showed to yield high levels of engagement and to foster a convivial atmosphere where personal/cultural beliefs, traditions, and preferences are recognized and celebrated. Forming, informing, and sharing ideas while participants experience food preparation and degustation helped bridge the hypothetical realm of abstractions that characterize learning (classroom) experiences. Participants were not *told about* the joys and challenges of preparing food, they were also not limited to *watching* how technology may or may not be used for daily tasks such as preparing food, more crucially, they shared first-hand meaningful experiences that allowed them to connect their own understanding of bodily, cognitive, and social dimensions with how they understand and would consider appropriate ways of engaging with technology and with other people.

5 Discussion

The activity "Crackers" uses food as a design material and is part of a participatory approach based on "crit sessions" that we use in an ongoing project where students and teachers experience engagement with an advanced level of computational reasoning. *Crackers* was the result of collective creative work by a team of teachers and researchers between January and November 2020. We argue that it presents an alternative to widely used approaches in this area, such as the "Peanut Butter and Jelly sandwich" (PB&J) [32-35]. The PB&J activity to introduce coding is successful at providing an interactive and entertaining means for people to understand that computers need complete (exhaustive) and clear (unambiguous) instructions. However, the way this is done can be unsuitable, insensitive, or ineffective for some people and some contexts. PB&J presents ethical, political, cultural, and potentially environmental tensions that we analysed in this paper and which we sought to address by changing how power is enacted, how food is experienced, and how ideas are shared. With *Crackers*, we also sought to go beyond right/wrong responses and a deterministic lens that reduces a rich and complex human experience such as eating food to a sequence of steps readable by machines [38]. *Crackers* proved effective to think more expansively and deeply about computational thinking defined as "having the knowledge, skill and attitudes necessary to be able to use the computers in the solution of problems" [39]. Advanced computational thinking means that that knowledge, those skills, and those attitudes go beyond instrumental "problem solving" and require from the beginning a commitment to "problem naming".

Used in participatory contexts, food-based activities like *Crackers* reveal qualities that are worth analysing and learning from. We use the Participatory Evaluation framework, or PartE to analyse *Crackers* here along six dimensions derived from the study of participatory projects: *Objective*, *Practice*, *Interaction*, *Barriers*, *Representation*, and *Impact* [40]. For each dimension, PartE presents a series of attributes, but these are not linear scales increasing in value or desirability, and they are not mutually exclusive. The attributes in PartE can be and often are experienced simultaneously by individuals or groups, by different stakeholders at different times, or longitudinally during a project.

Initially, *Crackers* was prepared as a participatory learning activity to set the scene for generative conversations connecting food preparation with computation and automation topics. As hosts, we anticipated such potential links in the spirit of generative themes [19] including the sequencing of decision-making processes (first a cracker, then topping *a*, if suitable then topping *b*) and detailed instructions to replicate dexterity and fine motor skills. *Crackers* could have been a more 'designed' activity with more specific instructions for students such as the common "give instructions to another person on how to prepare a cracker", but we felt that that would go against the ethos of this group and would shape the experience closer to a "banking" pedagogy of transmission of knowledge. Instead, *Crackers* was formed for participants to freely explore the landscape and point out their thoughts and dispositions about the algorithmic possibilities of a meaningful and enjoyable activity of sharing food socially. In the end, the `Objective` of *Crackers* exceeded our prefigured ideas and intentions showing highly sophisticated ideas about what it would take, what is possible, and what may be the effects of an increasingly digitized life for these students and teachers. Their questions and statements point towards a "cautious optimism" that combines a drive to push the boundaries of what is known and what is possible, while bringing a critical awareness of what is feasible and the potential consequences for the future.

Crackers uses a well-known practice in this after-school space: sharing food in a convivial atmosphere of lively and natural conversations. However, it is re-purposed by bringing it to the core of the session rather than being left to the end and by introducing a mix of familiar and unfamiliar ingredients. Setting up the tables, the screen to show the videos, the board, and the sticky notes, as hosts we had a general idea of how the activity should feel: closer to a picnic than a research session. The session was designed as *generative* at least in two senses: for participants to create objects of their interest with materials provided [31], and for them to re-appropriate the themes tentatively suggested to them [19]. In the end, the `Practice` of *Crackers* mixes tradition (reciting a karakia to open the session) and familiarity with emergent and novel aspects that set the scene for the group to orient the activity in their preferred direction(s).
The interactions in *Crackers* start with the provision of food for all to enjoy and express themselves, and with the exposure to ideas and latest examples of technology through the showcase of cooking robots in the videos. The session feels less like a lecture or a test however playful like the PB&J, and more like a space set up for the expression and exchange of ideas. Choosing the ingredients relies on relational practices; unlike the standard ingredients used in the PB&J, here the hosts know and care for the participants and choose ingredients that they recognize and like but also ingredients that are likely to be new, unexpected, and even challenging for them. Crucially, the activity does not aim to build for deliberation and consensus. Instead, it creates an open-ended space for radical plurality where divergent views are welcome and valued as they contribute to diversity and spur new ideas [41]. In the end, the `Interactions` of *Crackers* support collaborative contributions among participants, who share and build upon the views and knowledge of each other.
The main challenges and risks in organizing *Crackers* are related to providing food particularly where participants handle and prepare their own. These include the cost of food, the logistics to purchase and prepare the ingredients, and an appropriate space to run food-based activities. Food hygiene, allergies, restrictions, and preferences are a priority, and a familiarity with the space and the participants is key to minimize risks. Informed decisions need to account for the prevention of food wastage, the proper disposal of packaging materials, and the use of non-disposable tableware. In the end, the `Barriers` of all activities addressing computational thinking also call for teacher and researcher reflexivity to examine our own practices, beliefs, and experiences with technology, and how they may incidentally shape what we expect from students.
Crackers is shaped, to an extent, by where it takes place: the school grounds. The adults in the session (teachers and researchers) are employed by institutions, supported by funders, vetted by the police, and authorized by an ethics committee, after all. Nonetheless, the voluntary participation in this after-school space brings some autonomy to the project and to this activity. It worked well in this context because the teachers welcomed, oriented, and led the research team for several months. The hosts spent time at the space and their presence was familiar to the students. Also, the cultural dimensions of food helped people to express themselves and connect with others during this collaborative hands-on activity. In the end, `Representation` in *Crackers* spans from self-appointed and delegated due to the institutional context to direct autonomous as members of the group express their own views. Ongoing work seeks to further this by inviting and supporting students to design their own "crit sessions" in the space.
Crackers was positively assessed by participants in closing the session and in the following days students made suggestions and requests for future activities putting food at the centre of the session. The week after this session took place, teachers chose to run *Crackers* with another group of students as they considered it an effective and lively atmosphere for learning. The research team also drew several insights from it both in relation to advanced computational thinking and to the organization of food-based participatory activities. In the end, the main `Impact` of *Crackers* for the area of computational thinking (CT) is to challenge the common (and reasonable) idea that a new curriculum and more and better Professional Learning & Development (PLD) programs are necessary and sufficient to prepare teachers to teach CT to their students. Instead, the scope and depth of the dialogue observed in this session shows that teaching an advanced version of CT is of a different nature from teaching textbook topics where knowledge is reasonably well-established like algebra or photosynthesis. Instead, the area of digital technologies is still in an early stage

of formation where its foundations, possible uses, and the consequences of an increased computerized world are only gradually being understood and collectively shaped.

Rather than thinking of training teachers to code so that they can enact banking pedagogies to pass these skills to students, this research highlights the benefits of a focus on resourcing and support teachers to co-create with their students the ways they will engage with computation and automation. And rather than seeing coding as a problem-solving skillset, teachers and students need spaces to identify, frame, and name the type of situations they choose to problematize when using digital technologies.

This shift inferred from the participants' contributions in the *Crackers* session has profound implications for teacher education, pedagogical practices, and education policy. Under the current paradigm, the way teachers and students engage with and learn digital technologies is determined by the tech industry largely shaped by the dominant doctrine from the Global North [4]. This is subsequently embedded in the curriculum and schools become an efficient source of skilled and low-cost workforce for Big Tech primarily. The alternative is for students and teachers to engage with digital technologies in their own terms. *Crackers* shows how computational thinking is far from resolved, but requires collective processes to be reimagined in convivial and *troubling* approaches [41].

Crackers also strengthened our initial hesitation with the term "computational thinking" and the inference that using, working with, and developing computer programs require a particular mode of reasoning of a different kind to how we think in other facets of life. As with the term "design thinking", the appeal with an essentialist reduction to brain functions is indicative of attitudes from the Global North, whilst alternatives are needed to open other ways of understanding how people engage with and learn in this area. The conversations in *Crackers* rather point toward a holistic view to merge together how people feel, think, and create with digital technologies in communal dimensions. Future work for our project includes co-design with teachers and students' activities and resources to support CT experiences in maker spaces.

For the design of participatory food-based activities, we recommend a critical view of widely used and off-the-shelf activities to identify their ethics, politics, and cultural biases. Their fitness to the local context can be assessed by questioning how they enact power and how they make people feel -including a diversity of people. For example, a common learning task in schools around the world is "The Egg Drop" where children to build a structure that protects an egg from breaking when dropped from a height of several meters. This activity is commonly used to teach STEM topics but in doing so it normalizes a perverse ethics of food wastage that is not only distasteful and insensitive in most contexts. Notwithstanding, the Egg Drop continues to be widely used by teachers in Aotearoa. We recommend paying attention to local culture and how students from different backgrounds may perceive things, and the messages they may derive from these activities.

Consultation is valuable in the preparation of "generative themes" [19], and we recommend a *slow* approach to designing participatory activities for example by spending time and sharing experiences with the group before suggesting an activity. It is possible to re-purpose existing practices but only after a respectful appreciation for local traditions. An inclusive mindset is important to design activities that welcome all regardless of race, gender, demographic, and personality styles. Reflection in and on action is also advisable as well as bringing many perspectives together to propose, critique, and debrief new activities. Improvisation and adaptation during a session should be welcome and in response to organizers noticing or participants suggesting what works and what is not working well. Documentation of process during an activity, while important, should be done in ways that obstruct as little as possible with how participants feel, think, and act.

5.1 Conclusion

The fields of Participatory Design and Learning have yet to identify synergies to better understand and support teachers and learners in their roles as co-creators in dialogic spaces. This paper presents a participatory activity that, while not aimed at designing "solutions" to a brief or problem, nonetheless is informed by design in how it sets the stage [20] and invites people to jointly reflect and imagine future scenarios. This activity is part of a three-year programme where students and teachers are co-creating more authentic and dialogic ways of learning about technology, and in particular, computational thinking. The food-based activity *Crackers* presented here has been valuable to bring this community together to articulate their experiences with an advanced level of reasoning about computation prioritising ethical, creative, critical, reflective, and community dimensions.

Remote learning has become more relevant with the Covid-19 pandemic. Activities like *Crackers* are based on materiality and sharing a space. In recent months we all have learned to adapt and creatively rethink how to replicate or, better yet, translate these activities into formats that can be experienced remotely. We have not been in the position to run *Crackers* remotely yet, this falls into the category of future work. One option is to organize a 'Zoom party' (synchronous group video call) where people get the ingredients beforehand, and the videos of cooking robots are shown during the session while ideas are documented in a shared document or online whiteboard.

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