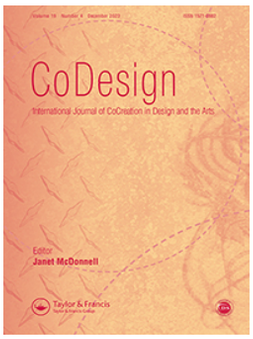

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Interdisciplinary hackathons for community-based co-design with older adults: a case study

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ABSTRACT

To facilitate the adoption of community-based practices for active ageing, it is important to design these practices together with a wide range of older adults from the community via an interdisciplinary perspective. Hackathons, originally developed by programmers, have been adapted by different disciplines and started to include a wide range of users and stakeholders. We aim to investigate how to conduct an intergenerational and interdisciplinary hackathon to support community-based co-design with older adults. In this case study, an intergenerational and interdisciplinary hackathon was organised together with a senior centre in the Netherlands. Semi-structured interviews were conducted to understand the experiences of participants and how they think the hackathon could be improved. Participants' positive experiences were categorised into five themes, and six areas for improvement were specified. The findings were discussed in relation to recent literature, and a list of future research directions was proposed to inspire future researchers interested in this topic.

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Behaviour change; interdisciplinary collaboration; intergenerational collaboration; participatory design; co-design; ecological model

1. Introduction

Global ageing has been urging researchers and practitioners to develop interventions for active ageing, which are not only about physical health but also about participation, security, and wellbeing in general (World Health Organization 2002). While most of these interventions are focused on the individual level, increasingly more interventions take the social aspect into account by connecting Older Adults (OA) with their strong ties (Sandbulte, Hua Tsai, and Carroll 2021) or with online groups (Gui et al. 2022). This is because social support has been identified as a principal element for behaviour change (Michie et al. 2014). These interventions are reported to be effective in the short term, yet their long-term effect on active ageing is unclear (De Angeli et al. 2020). This could be because online groups are only accessible to OA

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who can afford and know how to use technological interventions; hence, these groups are not truly inclusive. Moreover, since these groups are virtual, they are not integrated into the physical daily lives of OA. In addition, besides strong ties such as family members and close friends, weak ties such as neighbours and acquaintances in the living environments of OA are also vital for supporting active ageing, and the recent work of Ezio Manzini has argued that promoting liveable proximity is beneficial to all residents (Manzini 2022). Furthermore, as people age, their mobility usually gets more limited, which enlarges the role of the local community in the daily lives of OA. As well-being is a complex construct, we acknowledge that active ageing is not the only way but one approach to help some OA live independent, healthy, and happy lives.

Recent work suggests moving from designing 'for older people' to designing 'for situated communities to which they belong' to increase adoption of interventions designed for OA (Righi, Sayago, and Blat 2017). In this study, we use the same definition of community as Righi et al. and collaborate with a Senior Centre in the Netherlands to conduct community-based co-design with OA.

An important facet of active ageing is adopting a healthy lifestyle. Emerging literature has emphasised community involvement as a facilitator of behaviour change (Axon 2016; Verplanken and Roy 2016). It has been found that the engagement of residents is more lasting in community-based interventions (Axon et al. 2018). There is an accumulated body of work in the field of community-based participatory design (e.g. engaging communities in designing technological interventions), which offers methods and insights on how to design community-based interventions for active ageing (Kapuire, Winschiers-Theophilus, and Blake 2015). Besides, since the landscape of co-design was conceptualised in 2007 (Sanders and Stappers 2008), ample research has demonstrated the importance of co-designing with OA for understanding their needs early on and for creating a sense of ownership, which are essential for the intervention designed to be valuable and desirable for them to use in the long term (Botero and Hyysalo 2013; Righi et al. 2018). Many methods, tools and guidelines have been generated on how to co-design with OA on technological interventions that are used at the individual level (Frohlich, Lim, and Ahmed 2016; Ostrowski, Breazeal, and Won Park 2021; Wang et al. 2019). The question remains: how to engage OA in community-based practices fostering change towards active ageing?

In this light, we formed an interdisciplinary team guided by the COM-B model (Michie, Atkins, and West 2014). This model has been widely applied to active ageing, which posits that for one to change behaviours (B), one's capabilities (C) and motivations (M), as well as the opportunities (O) offered in one's physical and social environments all play a vital role (Michie, Atkins, and West 2014). Recent research also identified the impact of technology in supporting the physical environments (e.g. active environment design) and social environments (e.g. community building) for behaviour change, for example, in children's outdoor play behaviour (Khalilollahi et al. 2022). Therefore, to facilitate the adoption of community-based practices for active ageing, it is crucial to design these practices together with OA in the community with an interdisciplinary perspective. Hence, in this project, we formed an interdisciplinary team from Built Environment, Industrial Design, Public Health, and Information Technology to address active ageing comprehensively by covering all the elements in the COM-B model.

Hackathon offers one approach to integrate an interdisciplinary perspective in the design of community-based practices with OA. Originally designed for programmers, hackathons are now being appropriated by stakeholders across diverse disciplines. During a hackathon, participants are divided into teams, given a clearly defined challenge, and are supported during the creative process to devise solutions for the defined challenge given limited resources and time. The support comes in the form of toolkits, mentors, and presentations, to name but a few. It has become a popular tool for bringing people together to imagine new possibilities for the application of technology (Falk, Kannabiran, and Hansen 2021). Given this shift away from the production of programming codes, they might instead be seen as an increasingly popular participatory design activity (Hope et al. 2019). End-users have been increasingly involved in these events due to a growing body of literature on making hackathons more inclusive and accessible for marginalised voices and sensitive topics (Birbeck et al. 2017).

Building upon existing research, we organised an interdisciplinary hackathon that involved students from the four disciplines (Built Environment, Industrial Design, Information Technology and Public Health) and a community of OA. In this paper, we report the participants' experiences in the hackathon, what they think could be improved, and provide a list of future research directions on exploring community-based co-design with OA.

2. Materials and methods

Guided by the research question, we adopted a constructivist approach with a case study design. This allows for an in-depth exploration of complex phenomena within their real-life context. Intergenerational hackathons, which bring together participants of various ages and backgrounds, present such a rich context for generating situated knowledge on interactions, processes, and experiences of participants in co-designing community-based active ageing. The hackathon organisation team includes the CEO and a secretary of the Senior Centre Ontmoet&Groet (O&G), and a representative from each aforementioned discipline from three universities in the Netherlands. The study protocol was approved by the Human Research Ethics Committee of Eindhoven University of Technology. All participants filled in an informed consent form before the hackathon. The key steps of the study and the main activities within each step will be explained in the following subsections. In the subsections, we will also describe the challenges that occurred, which will be reflected in the discussion section.

2.1. Hackathon planning and recruitment

The hackathon plan was informed by literature and refined by a series of meetings with the organisation team. A toolkit was developed to support participants during the hackathon; its effect has been reported elsewhere (Wang et al. 2022). Students were recruited from the four disciplines via convenience sampling. The plan was to recruit students at similar education levels; however, since the students have different schedules in different disciplines and universities, we widened the selection criteria on their education levels, i.e. from undergraduates to PhDs. Group gardening was selected to be

the design case, and the challenge of the hackathon was to produce concepts promoting group gardening in the OA community.

We also consulted the available guidelines on involving OA in hackathons (Kopeć, Nielek, and Wierzbicki 2018; Kopeć et al. 2018), the only two studies explicitly involved OA in hackathons and reflected on how to involve OA better. According to (Kopeć et al. 2018), hackathons with OA should be one-day events and focus on the design process to facilitate their participation; a common group size is 4–6 participants. Since we planned to include a student from each of the four disciplines in a team, one or two OA were recruited for each team. We used leaflets to advertise and recruit students and OA. Moreover, the secretaries in O&G recruited OA via face-to-face contact. Specifically, they assessed which OA would be interested in this event, used the leaflet to help explain the event, and gave the leaflet to OA if OA decided to participate. The leaflet for the students contained background information on the context of O&G, the challenge, and the evaluation criteria. The leaflet for OA was simpler, explaining there is a co-design activity on group gardening with students from several universities. We provided all participants with the contact details of the principal investigator in case they had any questions before, during or after the hackathon. A series of presentations were planned for the hackathon by several speakers, which include the CEO of O&G and a few authors in this paper (CV, AK, GW) to cover a range of topics for supporting participants during the hackathon. The details of the presentations are reported in the next section. Four coaches, each from one of the disciplines, were recruited to facilitate the design process and give advice to the participants throughout the hackathon.

2.2. Hackathon setup

The hackathon was hosted on 4 May 2022 from 9:00 to 18:00, the physical setup of which is shown in Figure 1. The hackathon was planned to be hosted in O&G, however, due to clashing activities on the same date, we had to choose either to change the location of the activity or change the date. Since changing the date implies students from one discipline cannot join the hackathon, we changed the venue for the hackathon to be inside

Figure 1. Hackathon environment (image blurred for anonymisation).

a nursing home that is a 5-min-walk away from O&G. The CEO of O&G organised the venue and catering as well as presented throughout the hackathon.

The hackathon consists of 25 participants (16 students and 9 OA). Sixteen students registered for the hackathon, with thirteen native Dutch speakers and three non-natives. Each international student was allocated to one team; this is because the co-design sessions were conducted in Dutch to help OA feel comfortable, and the plan was that the international student could receive regular updates and contribute to the team by having one or more teammates translate. The students recruited from Public Health are medical students with experience interacting with OA. The original plan was to have four interdisciplinary teams of four students, with one representative of each discipline present in each team. Yet, one student from Built Environment could not attend due to illness, while an extra student from Industrial Design joined the event.

Nine OA participated in the co-design sessions with four from 10:30 to 12:00 and five from 14:00 to 15:30. The OA in the morning were visitors to O&G, while the OA in the afternoon were volunteers in O&G. At O&G, the visitors only participate activities, while these activities are organised by volunteers and secretaries. The visitors' role at the morning co-design workshop is to ideate with the students from scratch, while the volunteers' role at the afternoon co-design workshop is to evaluate the initial concepts developed in the morning and then ideate with the students to improve them. Hence, the final design concepts took in both the visitors' and volunteers' perspectives. OA were matched to each team by the CEO of O&G based on his knowledge about the OA and his observations of the students, with the aim of creating the most productive group dynamics. The team composition is shown in Table 1.

The hackathon agenda is categorised into 5 stages, which are 'Discover', 'Design', 'Develop', 'Evaluate', and 'Deliver'. This categorisation was inspired by the Double Diamond Design Process Model, a widely recognised and effective approach to problem-solving and innovation in the field of design. It provides a framework for structured thinking and emphasises the importance of divergent and convergent thinking at different stages of the design process (Kochanowska et al. 2022). An overview of the hackathon agenda is shown in Figure 2. The key activities in each stage will be explained in detail below, while speakers of each presentation are mentioned within the brackets, and the content of their presentations is bolded in the text.

In the *Discover* stage, guided by the name cards, students sat with their team members as soon as they arrived. After being welcomed by the organisers with a presentation about the **purpose of the hackathon** (AK), **the context of O&G** (CEO of O&G), and **advice and tips on co-design** (GW), an ice-breaking activity was carried out to let students

Table 1. Team composition in the hackathon.

	Team one	Team two	Team three	Team four
Industrial Design	1BS	2BS	1BS	1BS
Information Technology	1MS	1PhD	1MS	1MS
Public Health	1MS	1MS	1MS	1MS
Built Environment	1PhD*	0	1PhD*	1PhD*
Older adults	1M+1A	1M+2A	1M+1A	1M+1A

The Arabic numbers indicate number of participants; BS: Bachelor's students; MS: Master's students; M: morning; A: afternoon; *: non-native speaker.

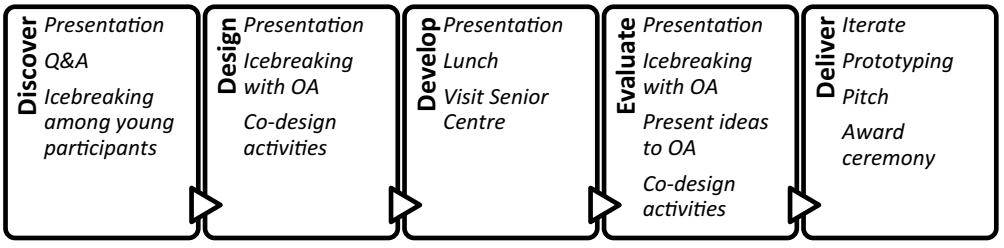

Figure 2. Hackathon agenda overview.

express their assumptions about the disciplines in which their teammates are, and their interpretations of the key concepts of this hackathon (e.g. 'co-design', 'behaviour change'). Then, students from each team discussed what knowledge and skills they could bring to the team and listed them in a table.

In the *Design* stage, the co-design session started with a presentation in Dutch (CV) when all the OA arrived. The presentation helped OA to **recap the goal of the session, facilitated ice-breaking and introduced a fictional character Anne**, an OA who likes gardening but is experiencing physical challenges and living alone. In the morning session, the first activity was created to let OA tell students if they would like to add more information about Anne. This activity was followed by a series of questions to provoke team discussion. The questions were printed on A3 papers, and participants were encouraged to draw and write on Post-its and stick them on the papers. The questions were distributed to the teams in the sequence below: 'What should we take into account?', 'Possibilities, concepts, and ideas?', 'What are your favourite ideas?', 'What can motivate users to stay engaged?'. This is the stage where their preliminary idea originated.

In the *Develop* stage, after OA left, the students were introduced to **the toolkit for supporting their design process** via a presentation (GW) and visited the O&G under the guidance of the CEO of O&G during the lunch break.

In the *Evaluate* stage, a new group of OA joined, and the same presentation and icebreaking were carried out as in the morning (by CV in Dutch). After ice-breaking, students presented the idea selected in the morning (*Design* stage) to OA. A template was created for the students to pitch their ideas to OA in a structured way. Then some questions printed on A3 papers were distributed to the teams to provoke discussion in the co-design activities (e.g. 'What do you like about this idea?', 'What do you think could be done better?').

In the *Deliver* stage, when the OA left, the students had 1.5 hours to iterate and prototype their ideas. At the end of the hackathon, each team pitched their concept for five minutes, and eight judges were invited to ask questions and rate the concepts against the assessment rubric. Seven of the judges work in local organisations on promoting active ageing and one judge had researched how to design for promoting active ageing during her PhD. The team that received the highest score (from all the judges combined) was awarded the best team.

During the hackathon, to motivate OA and address their concerns about lacking technical knowledge, we explained that technical skills were less important than their

willingness to share their insights and experience. For both co-design sessions, there was a **wrap-up presentation** (CV) to let OA know they had achieved the goal of the workshop, and each of them received a pot of flowers as a thank-you gift. We also reiterated that participants could resign at any time and that we would provide them with transportation and any help they may require, as stated in the informed consent forms.

2.3. Data collection

In this paper, we report the methods used for data collection and analysis relevant to this paper's research question. As it is vital to understand the experiences of participants to reflect on the co-design process, we conducted interviews with the participants similar as in previous studies (Bossen et al. 2010). OA received group interviews ($n = 9$) after the co-design sessions during the hackathon. Two field researchers conducted the interviews in Dutch. The open-ended questions focused on their experience in working with students, whether they plan to be more active or not, and any improvement advice for the next hackathon. The interviews were scheduled immediately after the co-design sessions to ensure all OA have a fresh recollection of the co-design sessions. The interviews were also located in a different room and OA were affirmed that the discussion is confidential among them and the researchers. A group format was adopted because the CEO of O&G suggested that OA enjoyed each other's company. This is also confirmed by the researchers' observations in O&G that OA would only like to participate in an activity when other OA members join. A weakness of group interviews is that participants tend to provide socially desirable answers. In line with the principles of community-based participatory research and recognising the reciprocal nature of the study, the enjoyment of the OA during the data collection process was given priority, hence a group format was followed. The researchers explicitly communicated to the OA that there are no right or wrong answers, emphasising an inclusive and non-judgemental environment during the interview. Most students ($n = 14$) participated in a follow-up individual interview after the hackathon. The time span ranged from 1 day to 2 weeks after the hackathon. Four field researchers conducted these interviews with each researcher in charge of interviewing students from one discipline and ensured that there was no previous contact between the researchers and the students before the hackathon to minimise social desirability bias. The open-ended questions focused on their experience in working with OA and students from other disciplines and any improvement advice for the next hackathon. Each student was assured that the conversation is confidential, and all data will be anonymised immediately afterwards. All interviews were audio-recorded and transcribed.

2.4. Data analysis

Thematic analysis was conducted via Atlas.ti v9 guided by established guidelines (Braun and Clarke 2019). Three researchers (GW, CV, and AK) independently coded all the interviews with OA and one-third of the interviews with students and then discussed the coding until reaching a consensus. GW thereafter coded the rest of the transcripts. All the organisation materials for the hackathon and the data collected during the hackathon are available upon request.

3. Results

3.1. Perspective of the students

Four themes were identified regarding the experience in the hackathon, and four areas of improvement for the hackathon were found. We also discovered that students have mixed opinions regarding the large variety among OA. The students are quoted within the quotations in the text.

The most-mentioned theme for positive experiences is **working with the new**, by twelve students ($n = 12$). 'The new' means new people or new topics. Most students commented that it is 'nice to work with other disciplines' and 'different disciplines bring in different perspectives' or 'ideas'. While some students also mentioned simply working with 'new people', 'people from different cities' bring fresh perspectives. Some students from Information Technology and Built Environment also reflected that this hackathon format is new to them, and it is interesting to work on something vastly different from their daily tasks.

The second most-mentioned theme for positive experiences is **working with OA**, by eleven students ($n = 11$). The sub-themes are 'OA are engaged and cheerful', 'OA have great ideas', 'OA are open-minded and constructive', 'OA are easy to communicate and understand the ideas'. Yet, not all students had positive experiences when working with each OA. Some students found it hard to communicate with some of the OA. Interestingly, some students in the same team have different opinions about working with the same OA. Yet, the number of positive quotes far outweighs the number of negative quotes. In general, the experience of working with OA is positive.

The third most-mentioned theme for positive experiences is **nice teamwork**, by eight students ($n = 8$). Some students found it 'nice' to make 'all disciplines contribute to one goal'. Despite the language and culture barrier, international students think they contributed to their teams by asking critical questions, proposing ideas, drawing, and prototyping. The observation reveals that the students contribute to the teamwork in different ways, for example, some actively engage the OA, some write notes, and some draw ideas at the same time.

The fourth most-mentioned theme for positive experiences is **well-structured activities**, by seven students ($n = 7$). Many students liked the ice-breaking activity between the disciplines, from which they got to know more about other disciplines and explain their own disciplines to others. However, one student in Team 1 found this activity 'somewhat awkward', since he had to lead the other team members to do the activity. The other activities that some students liked were the co-design presentation and the visit to the senior centre. A student from Industrial Design commented the hackathon is well-structured so that they can 'go through a few iterations' for their concept.

The most-mentioned theme for future improvement is **language barrier**, by fourteen students ($n = 14$). This is raised by not only international students but also native students and OA. International students mentioned that although their teammates translated the conversation into English when co-designing with OA, they 'received the information with delay, missed details of the conversation, and could not form a dialogue directly with OA'. Native students found it 'takes time and effort' to do the translation, and some OA expressed that they do not know any English. Despite the language barrier,

all international students contributed to their teams. Yet they indicated that they might contribute more if there were fewer language barriers.

The second most-mentioned theme for future improvement is **missing elements of classic hackathon**, by five students ($n = 5$). All students from Information Technology and one from Built Environment have participated in hackathons where programming is a key element. Since this hackathon was focused on the design stage, programming was not essential. In the end, no student did any coding. Some students found that they did not contribute from their disciplines, and one student specifically mentioned that he felt the 'social pressure' not to use his laptop since his teammates were not using it. Eventually, he did not use his laptop and reflected that he 'missed using it'. When asked about the contribution of students from Information Technology in the hackathon, some students from this discipline commented that even though they did not code, they contributed to the team by 'knowing what are technically feasible' for the design, which was echoed by their teammates.

The third most-mentioned theme for future improvement is **missing relevant materials**, by four students ($n = 4$). For example, some students mentioned that interacting with two OA was insufficient to know OA as a user group. They expected 'more information about OA as a user group'. Students from Built Environment commented that the information about the neighbourhood was limited. A medical student said that because the OA in her group arrived earlier than the presentation on co-design, she 'did not know what to discuss with the OA'. A student from Industrial Design would like to know more about the 'research background' of the hackathon. Even though we have covered the general needs of OA and research background in the introduction presentation as well as provided information about the neighbourhood in the toolkit, the information we provided seems not to be enough to build the confidence of some students in understanding the challenge. Students liked the idea of visiting O&G during lunchtime, yet a medical student commented it would be better to visit the centre earlier to know the context first.

The fourth most-mentioned theme for future improvement is **lack of time and intense schedule**, by three students ($n = 3$). Some students reflected that they would like more time to 'refine their ideas and use the toolkit', and some mentioned that their 'energy levels decreased in the afternoon'. Several students remarked that the hackathon is 'intense' and would like 'more breaks and movements in between'. Two students found that there are too many presentations, especially the presentations to OA are regarded as 'repetitive' because the format is the same in the morning and afternoon sessions. In addition, three students felt that they had used skills and knowledge from life experience rather than from their disciplines. A student from Built Environment suggested that if there is extra time, the teams can think deeper and divide tasks based on disciplines.

Almost all students noticed the **large variety among OA** regarding their physical abilities, cognitive abilities, preferences, and personalities. Some OA are interested in gardening, while some are not. Students have mixed opinions about the effect of this wide variety of OA on their design outcome. Six students ($n = 6$) find it challenging to work with OA who do not like gardening or digital technology, have physical limitations (e.g. 'hearing issues') or have cognitive limitations (e.g. 'do not understand questions'). One student mentioned that one OA they worked with was 'fixated' on her garden, and it was hard to get her feedback on a shared garden. On the contrary, eight students ($n = 8$)

reflected that, despite the difficulty, they got 'relevant insights' from co-designing with OA. In Teams 3 and 4, the medical students were credited by others as team members who knew how to interact with OA. A student in Team 3 also appreciated that having OA who do not like gardening makes their design more inclusive: 'for people who are not interested in gardening, they can sit on the bench, enjoy the view, and talk to others who are gardening'. This feature is well-liked by the judges.

3.2. Perspective of OA

One main theme was identified regarding the hackathon experience, and two areas of improvement for the hackathon were found. Quotes were presented within the quotations (translated from Dutch to English).

Regarding the hackathon experience, all OA ($n = 9$) appreciated that the **students were collaborative, attentive and respectful** during the co-design. Some OA found students listened carefully and asked interesting questions; some OA were impressed that the students collaborated very well despite being from different disciplines. One OA also reported that she 'learned a lot from the students'. This theme links to some tips students shared on how to interact with OA among themselves, such as 'do not interrupt', 'eye contact', and 'ask about past life stories'.

Concerning areas for improvement, six OA mentioned that they **missed practical information about the hackathon** ($n = 6$). Since the hackathon was not hosted at O&G, some OA found it hard to find the location. Besides, some OA did not expect to have international students working with them, and one OA mentioned that she did not know 'what would happen during the hackathon'. Even though the goal of the hackathon was communicated to all participants through the leaflet during the recruitment stage, it's possible that the event itself is very new to some OA, and hence communicating the event via the leaflet is not sufficient for them.

Moreover, five OA were curious about **how their inputs would be applied after the hackathon** ($n = 5$). One OA also mentioned that since the concepts from the hackathon are very new, she 'was not sure if they could be applied in O&G'.

In general, the feedback from OA is immensely positive. The CEO of O&G sent us an email the following day expressing that many OA came to him and thanked the team for the great organisation.

4. Discussion

This case study provided a detailed account of conducting an intergenerational hackathon promoting active ageing and generated in-depth and situated insights on the experiences of participants and what areas of improvements they wanted to see. In this section, we will discuss our findings in relation to recent literature and propose a list of future research directions for researchers interested in this topic. To facilitate navigation, themes delineated in the results are highlighted in bold for quick reference.

Building on previous work (Kopeć, Nielek, and Wierzbicki 2018; Kopeć et al. 2018), we explored that providing guided and structured activities is helpful in fostering intergenerational collaborations during hackathons. Specifically, Kopeć et. al. took a crucial step to invite OA to hackathons, yet they reported that some

OA were left alone by the younger participants; sometimes, both sides did not know how to start a discussion and some younger participants mentioned that they decided not to spend too much time interacting with OA because they are worried their opinions will be biased by the one or two OA they are interacting with. Based on these insights, we structured the hackathon with pre-defined teams so that no OA would feel left behind. We also created guided activities with worksheets that served as discussion topics among participants during co-design. We reflect that the positive experience of all OA could be partly because of the structure we provided and partly because we adopted an interdisciplinary approach. Kopeć et. al. involved younger participants from Technology and Design backgrounds, while we involved students from two additional disciplines – Public Health and Built Environment. Some medical students have rich experience in interacting with OA, and their teammates reported that this was extremely helpful during the hackathon. In line with the findings from Kopeć et. al., we found that the team having the closest collaboration with OA received the highest score from the judges, which indicates that interacting with only 1 or 2 OA is still valuable for creating desirable design solutions. However, we also acknowledge that the experiences and motivations of the students could be one confounding factor here. Students who have more experience and are more motivated in the hackathon could devote their skills and energy to both form close collaboration with OA and produce desirable concepts.

4.1. Future research directions

4.1.1. What to prioritise when the intergenerational hackathon has to be conducted with limited resources?

Since the literature on hackathons involving OA is limited, working closely with O&G during the development of the hackathon helped us to deliver a hackathon that is well-liked by OA. Previous studies also reflected on the importance of involving the community in their advisory board during hackathon development (Hope et al. 2019). While we did not co-develop the event with students, who are also participants of the hackathon. This might have led to the experiences of **lack of time and intense schedule**, **missing relevant materials**, **missing elements of classic hackathon**. One might argue a two-day event could address the lack of time and intense schedule experienced by the students. On the first day, the students can visit the senior centre first and then co-design with OA. On the second day, the students can focus on refining their ideas, using the toolkit, and prototyping, where they can divide tasks and go deeper into their own disciplines. This could help them to apply knowledge and skills from their own disciplines (e.g. programming), which addresses the concerns of some participants who missed elements of classic hackathons. In an ideal situation, when there is plenty of time, we can co-develop the event with students and conduct a two-day hackathon. However, in real-life scenarios, resources are limited both on the sides of researchers and participants. Especially in the community context, which usually do not possess significant resources (Botero and Hyysalo 2013). Moreover, as intergenerational hackathons involve many stakeholders who have different schedules, it is challenging to find a time that suits all and ensure the venue is available at this time. Recent research has explored how to conduct participatory design in resource-limited settings by strategically involve participants along the design

process (Mejía et al. 2023). In the same vein, we encourage future researchers to explore what should be prioritised in an intergenerational hackathon under limited resources.

4.1.2. How deeply should OA be involved?

In our study, OA were only involved in two co-design sessions rather than the whole hackathon, and this was decided in consultation with O&G on what is comfortable for OA. We also did a team bonding activity among the students before the co-design sessions so that students could focus on bonding with OA later on. When compared with the study where OA were involved in the whole hackathon (Kopeć et al. 2018), we see the pros and cons of this approach. The pros are that none of OA feels left out, and all of them had pleasant experiences with students. The cons are that OA did not identify themselves as part of the hackathon team and had less ownership of the ideas developed: while we emphasised to OA that they could stay as long as they wanted after the co-design session, no OA stayed. One could argue that we did not fully involve OA as team members in the hackathon, while we prioritised that the environment is creative while physically and emotionally comfortable for OA. The guidelines developed for better participation of OA in software development also emphasised that it is not necessary for OA to present throughout the hackathon so long as they are involved in the design and evaluation phases (Kopeć et al. 2018). We encourage future researchers to explore ways of involving OA in interdisciplinary hackathons further.

4.1.3. How to balance scaffolding, open ideation and power?

Our hackathon has more scaffolding in comparison to previous hackathons (Kopeć et al. 2018); Specifically, the researchers decided on what activities to do, how the teams are formed, and what tools to be used. The benefits of this structured approach have been discussed earlier, while this approach also hinders open ideation and reduces the power of participants. For instance, if we provide more freedom about the design process, could each team use a design process that best suits them and be more creative? However, if we reduce our power as researchers and let participants decide on when to do what, could this place more power on the design students in each team and cause a power imbalance? Some researchers argue that designers are in a special position in the design process where they know the best about this field (Sanders and Stappers 2008). On the other hand, when researchers execute their power over the participants, which, according to some, is not a true participatory process (Kelly 2019). Build on previous research (Sakaguchi-tang et al. 2021), we ask, what are the necessary structures and skills researchers should provide to engage participants in decision-making during co-design at different levels?

4.1.4. What are the effective ways of expectation management?

Some experiences of the participants connect with insufficient expectation management, i.e. **missed practical information, missed how inputs would be applied, missed elements of classic hackathon, language barriers**. One would argue that, in addition to the current content, the leaflet for both students and OA should inform them about the language to be used in the hackathon: if there are more than one language to be used, how the language barrier will be addressed (e.g. translation service, auto-translation software). The leaflet for the students should also provide more research background and explain

the rationale for focusing on co-design in this hackathon, where programming is not essential. This will address the concerns of participants who missed elements of classic hackathons in advance. Together with the informed consent form, a reminder leaflet distributed one or two days before the event could help participants to recall what will happen in the hackathon and other key details such as location, timeline, and contact information of the researchers. If the event has to be hosted outside the community, the venue's location will also be illustrated on a map to help OA with wayfinding. The leaflet will also encourage them to contact the researchers if they feel not fully prepared after receiving all the information. This will address the need of OA participants for detailed information about the hackathon. This leaflet will also inform OA about what will happen after the hackathon and that an update will be given on how their inputs are implemented. This addresses the need of OA on seeing the impact of their input. However, bombarding participants with information leaflets could cause fatigue as well. We question what are the effective ways of expectation management for intergenerational hackathons, for instance, would it be more effective to combine leaflets with communication via key persons and/or existing communication channels in the community?

4.1.5. Pros and cons of intergenerational hackathons in comparison to traditional co-design workshops with OA

A few studies have explored hackathons as a unique participatory design setting where varied communities come together around a shared objective in a 'pressure cooker' for ideas (Hope et al. 2019; Porter et al. 2017; Taylor and Clarke 2018). Traditionally, participatory design with OA on active ageing were usually conducted by researchers with a series of co-design workshops (Botero and Hyysalo 2013). An intergenerational hackathon is similar as conducting several co-design workshops in parallel with researchers as coaches rather than direct facilitators. It would be interesting to compare the pros and cons of intergenerational hackathons in comparison to traditional co-design workshops with OA. In terms of the desirability and feasibility of the designed outcome, the cost-effectiveness of organisation, the experiences of participants in the design process, which approach is more suitable for which context? Given the intricate and contextual nature of co-design activities, a quantitative, positivist comparison might not be the most effective approach. Instead, we advocate for a reflective exploration of these dimensions within both intergenerational hackathons and traditional workshops. Researchers should document the context of their studies in detail, providing a rich foundation for future investigations to build upon and learn from.

4.2. Limitations

This study has a few limitations. The first limitation concerns selection bias. Since OA were self-selected to attend the hackathon, even though some were not interested in gardening, they all enjoyed social interactions and were relatively mobile. OA who are less sociable or mobile might not be represented by the participants of our study. Moreover, the secretaries were more likely to approach OA who are socially active in O&G during recruitment. Hence, the voice of the hard-to-reach was not heard. Moreover, all models have limitations, and so does the COM-B model. This model did not include the time perspective during

behaviour change. Furthermore, we also encountered difficulties with organising an interdisciplinary hackathon. Since each faculty (Built Environment, Industrial Design, Public Health, Information Technology) has its own agenda and resources, in the end, we recruited students with various academic levels and cultural backgrounds, while the non-native speakers were all from one discipline. On the other hand, it is more common in real life to collaborate with people from various academic levels and cultural backgrounds. Hence, the hackathon resembles more of a real-life challenge than an experimental controlled setting, hence a higher ecological validity.

For future work, we plan to develop a functional prototype based on the four design concepts generated in this hackathon and deploy it in O&G to evaluate its effect in supporting OA with group gardening. This will serve as a case study for designing community-based active ageing. We hope the readers could draw inspiration from our findings to push forward the wave of community-based active ageing via an interdisciplinary approach. Our case study here serves as a point of departure for future debate and refinement of applying interdisciplinary hackathon as an approach for community-based co-design with OA.

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