Designing Tiny Robots: Engaging Stakeholders in Collaborative AI System Design

Marigo Raftopoulos
Tampere University
marigo@strategicinnovationlab.com

Juho Hamari
Tampere University
juho.hamari@tuni.fi

ABSTRACT

This work examines the potential of creative and playful participatory methodologies to advance collaborative stakeholder design of intelligent information systems. Our work responds to widespread industry criticism of unethical practices, unintended negative consequences of 'black box' algorithmic decision-making, and organizations falling short in earning tangible business value through AI investments. We present two prototypes; interactive AI design cards and a collaborative AI design sprint process called Designing Tiny Robots targeted at alleviating the limitations of the current generation of intelligent human-machine systems. We argue that collaborative AI system design may account for a fuller range of the socio-technical interactions between stakeholders thereby improving AI technology design, effectiveness, and adoption.

CCS CONCEPTS

• **Human-centered computing**; • **Human-computer interaction (HCI)**; • **Interaction design**;

KEYWORDS

artificial intelligence, stakeholder collaborative design methods, design cards

ACM Reference Format:
Marigo Raftopoulos and Juho Hamari. 2024. Designing Tiny Robots: Engaging Stakeholders in Collaborative AI System Design. In *Proceedings of the 27th International Academic Mindtrek Conference (Mindtrek '24), October 08–11, 2024, Tampere, Finland*. ACM, New York, NY, USA, 12 pages. https://doi.org/10.1145/3681716.3681722

1 INTRODUCTION

Artificial intelligence is reshaping workplaces and is reconfiguring the design of work processes, information systems, and human-machine-algorithm interaction. However, despite the tsunami of the potential opportunities presented by artificial intelligence (AI), industry is ill-prepared, and little is known about the factors that contribute to its sustainable value creation potential [1–3]. Recent studies suggest that many organizations are falling short of creating tangible business value through AI [2] and that returns on AI investment are below expectations [3]. The failure to realize the potential of AI-enabled technologies is largely attributed to an array of technology design and implementation challenges that can be averted with more inclusive collaboration with users as stakeholders in system design [4].

The blurred boundaries between AI technology development and its use make it necessary to theorize beyond narrow approaches dominated by traditional technology adoption and digital transformation models to more accurately reflect current and future challenges that may involve a stakeholder co-creation approach [5, 6]. Value creation from AI or intelligent technologies represents unique challenges due to the complex interactions between technology, systems, tasks, and processes [52]. Furthermore, human-machine systems based on AI technologies require a more sophisticated approach to organizational design and digital transformation than have been offered by the conventional frameworks of the past [7], as well as the design of task and technology alignment in workplace and functional designs [8]. Stakeholder perceptions of AI are a key factor in influencing effective acceptance and workplace implementations of AI technologies [9, 10] however while established technology acceptance theories [11] address the utilitarian aspects of AI technology acceptance, they cannot fully explain technology threat avoidance behaviour driven by complex psychosocial factors [12] which may be contibuting to sub-optimal AI technology design and implementation. The most effective means of working with these complex AI technology challenges is in association with stakeholders, and through novel collaborative and participatory approaches [13, 14]. This is part of the research gap that we seek to address.

In this research, we use a design science approach [15] and grounded theory [16, 17] to develop and test prototype interactive design tools that support researchers, project managers, organisational leadership teams and technology developers in (a) onboarding workplaces on designing AI-enabled information systems that are human-centered and values-conscious, and (b) Offers empirically tested participatory approaches for potential stakeholder consultation and co-creation of more effective human-machines systems design. The design artifacts arising from this study offer high-level approaches for examining the underlying assumptions, expectations, and knowledge that management and technical stakeholders have about AI technology in their organisations. Consistent with design science approaches, we researched, developed and tested three sets of artefacts:

- **A set of conversational design cards** that explore AI functional design concepts, provocations on the dark side of AI, and human flourishing in the age of AI.
- **A design card game** called *Creating Tiny Robots* that engages stakeholders in creating rapid prototypes of AI systems using four challenge cards of Technology, Touchpoints, Experience, and Bugs.

Mindtrek '24, October 08–11, 2024, Tampere, Finland

ACM ISBN 979-8-4007-1823-6/24/10
https://doi.org/10.1145/3681716.3681722

- **A design sprint process and design canvases** that utilize the conversation cards and the Tiny Robots design card game in a participatory workshop environment.

Design-science research addresses *unsolved problems in unique or innovative ways* [15] and encourages researchers to take different or unique approaches to design. The design-science approach works best when requisite knowledge in a field is non-existent, there is a reliance on creativity to find the truth, and that there is an element of trial-and-error that is required in the research effort in tackling a 'wicked problem' [15]. In the remainder of this paper, we present the findings of the development and testing of these artifacts in meeting our core research question of ***How might we make AI systems design and development tangible, engaging and understandable to engage stakeholders in a process of co-creation?***

2 LITERATURE REVIEW

The development and implementation of AI-enabled technologies have seen a proliferation of a variety of approaches to ensure human-centered and ethical design principles are melded into technology development. This has largely been in response to widespread industry criticism of unethical practices, and unintended negative consequences of 'black box' algorithmic decision-making. In their research on conceptualizing AI literacy, Ng et al. (2021) emphasized the importance of integrating 'unplugged' or alternative learning tools to engage the public in learning about AI such role-playing, storytelling, and public art, which the authors consider viable approaches to establish a collaborative, robust and safe society. In industry practice, a plethora of tangible design tools and methods have been developed with a similar purpose [18]. For example, Ghajargar and Bardzell (2022) developed a set of ten concept cards to improve the AI literacy of human-computer interaction researchers and practitioners to enable creative and tangible means to explore explainable AI and gain new design perspectives [14]. Several AI design canvases have been developed [19] as practical tools to facilitate public awareness and knowledge of AI capability, and as frameworks for how stakeholders might work with these technologies to create business value and minimize harms. These works on AI design canvases have been credited the Business Model Canvas [20] originally developed and popularised by Osterwalder & Pigneur (2010).

On a more technical level, AI model cards for developers have also been developed over the last few years, spearheaded by Mitchell et al. (2019) as a method for documenting technical design guidelines and increasing the transparency of responsible machine learning and AI models [21]. This method has now been adopted by several large technology companies such as Hugging Face, Open AI, Google, and Salesforce for increased AI transparency and governance, and have been extended by other researchers. For example, Crisian et al. (2022) has extended AI model cards using a human-centered approach to model documentation for large language models for non-technical stakeholders [13]. Design methods such as ECCOLA was developed by Vakkuri et al. (2020) as a method for implementing AI ethics using a deck of 21 design cards divided into eight different AI ethics themes that are utilized in a sprint process designed to facilitate critical thinking about AI systems development [22].

The method and approach for the development of the design artifacts of this study have been placed in the field of design games [23–25] and design card methodologies [26–29]. The use of card-based methods provides tools for brainstorming exercises during design workshops that facilitate creative dialogue [24]. They also assist in creating an environment for a better understanding of the systems that are being designed and the user interactions and experiences that are being created. Physical objects such as cards also make tensions and disagreements between workshop participants more tangible and less personal. They can also speed up the design process by helping participants focus and create common ground in application design features whilst also allowing room for divergent interpretation [24]. Playfulness is deeply rooted in human culture [30] and any activity can potentially be designed with a playful approach. This is to not only provide an enjoyable experience for participants but also facilitate the creation of practical design outcomes [31, 32]. The rising popularity of using cards as design tools across many domains such as service, product, and technology design lies in the fact that they are tangible representations of abstract concepts and are simple to use and easy to manipulate when non-technical stakeholders are involved in the process [33]. This helps to make the design process more visible and less abstract [24, 32] and provides a process to reason and justify design decisions as well as facilitate a creative ideation process [25].

The rise of AI technologies brings many positive benefits, however, there is also a parallel disruption that poses largely unknown systemic impacts on our social, economic, ethical, and political systems and the potential harms they may cause [34–36]. The democratization of decision-making on AI design and development is emerging in extant literature and in practice as a possible solution to these emerging problems that includes the involvement of a wide range of stakeholders using different methods of engagement that lifts public AI literacy and capability building to engage stakeholders in the co-creation of responsible and AI effective technologies [13, 18, 22]. The methods and practices in engaging stakeholders in a collaborative and co-creation process in AI systems design are limited and highly technical, and a gap where our work makes a contribution.

3 METHODOLOGY

We have taken a design science approach in the development and evaluation of artifacts [15] in our case, this is the development of design cards and a design process for the co-creation of AI systems with stakeholders. According to Hevner et al. (2004) the approach requires the creation of an innovative, purposeful artifact that contains knowledge for a problem domain, and the artifact must be evaluated to ensure its utility. For this project, three artifacts were created and tested: a set of three sets of eight conversational design cards, the *Tiny Robots* design card game, and an end-to-end design sprint process. The evaluation process we undertook was through two key steps: the feedback of an expert panel of five professional workshop facilitators, and 91 technology practitioners and researchers attending our five workshops that engaged in a

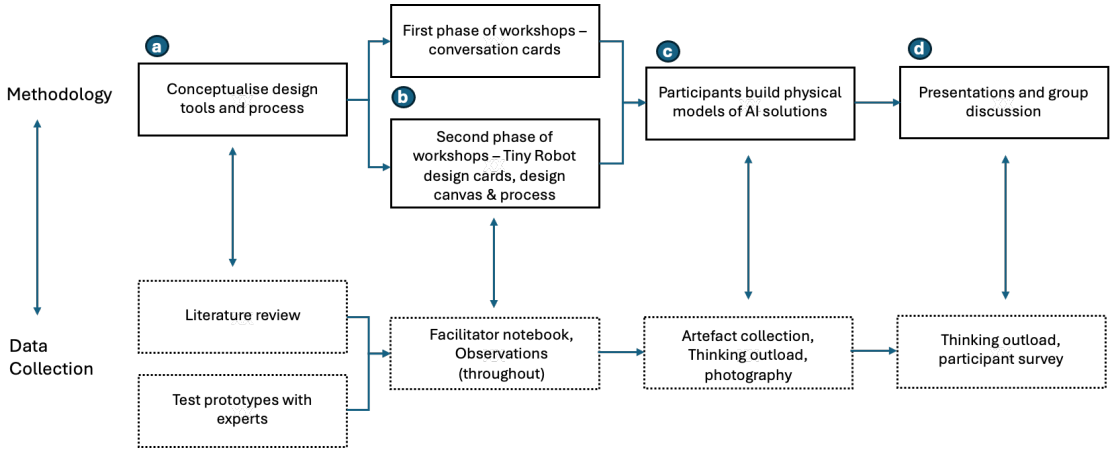

Figure 1: Methodology used in this study

Table 1: Workshop details

#	Location	Organization/Composition	Participants	Activity	Data Collection*
1	Australia	Special Interest Group	16	Conversation Cards	Exploratory
2	Australia	Management Consulting Firm	20	Conversation Cards	Exploratory
3	Germany	Agile coaches & project managers	15	90 min design sprint	Exploratory
4	Finland	Academic conference	25	5-hour design sprint	Feedback forms
5	USA	Academic conference	15	5-hour design sprint	Feedback forms
	Total Participants		91		

*Participant observation and field notes were also used for every workshop; photographs were taken of the artifacts created.

process of artifact evaluation and improvement. Designing or evaluating artifacts through workshops using co-creation approaches is considered a relevant phenomenon of inquiry in the information systems field and we have adapted the Storvang et al., (2017) and Thoring et al., (2020) standardized guidelines for conducting workshops to ensure research rigor [37, 38]. These guidelines include focus definition, role allocation, triangulation, transparency, and reflection. With this in mind, we developed a four-step methodology outlined in Figure 1. The first step (a) was conceptualizing the design tools and processes based on a detailed literature review and the testing of the initial prototypes with a panel of 5 experts in workshop facilitation for their feedback. The literature review on AI systems acceptance and implementation success was based on our prior work [4] and formed the foundation of the development of the initial prototype design cards and design process for this project.

The next step (b) shown in Figure 1, comprised of running a series of five workshops with a total of 91 participants between January 2023 to January 2024. Workshops 1 and 2 were designed to test the conversation cards as tools used to facilitate conversation and learning about artificial intelligence in business applications. Our goal for these exploratory workshops was to ensure that card designs were accessible and engaging, and that the information they contained was adequate to meet the needs of stakeholders with limited knowledge about AI technologies. The workshops included discussions on how these cards can be used in practice or be improved. Details of the workshops are provided in Table 1

The first two workshops provided the foundations for conceptualizing the development of more challenging design cards for the next phase, which was to become the *Creating Tiny Robots* design card game which was initially tested in the third workshop. This took the form of a short design sprint of 90 minutes, which was followed by workshops 4 and 5 which took the form of 5-hour design sprints held with technology and information systems scholars at two academic conferences. Data was collected formally in feedback forms in the final two workshops of 40 participants, and participant observation and field notes [40] taken by the facilitator. Informed consent was obtained from participants prior to the commencement of all the workshops. The methodology for the thematic analysis generated from the feedback forms was informed by the methods of Williams and Moser (2019) and utilized the *Atlas.ti* software. In the first round of open coding, we identified and organized the data into key initial codes and collected unique quotes from participants for each code to capture nuance and meaning. Axial coding was applied in the second level of coding to further refine, align, and categorize the themes identified in the first round of open coding. Keeping in mind that the purpose of this phase is to create distinct thematic categories [39] we ran several iterations of continuous clustering and distillation using thematic analysis and grounded theory methods to establish relationships between the themes in

Figure 2: The design sprint workshop process – the three phases based on Torbert's framework (1998)

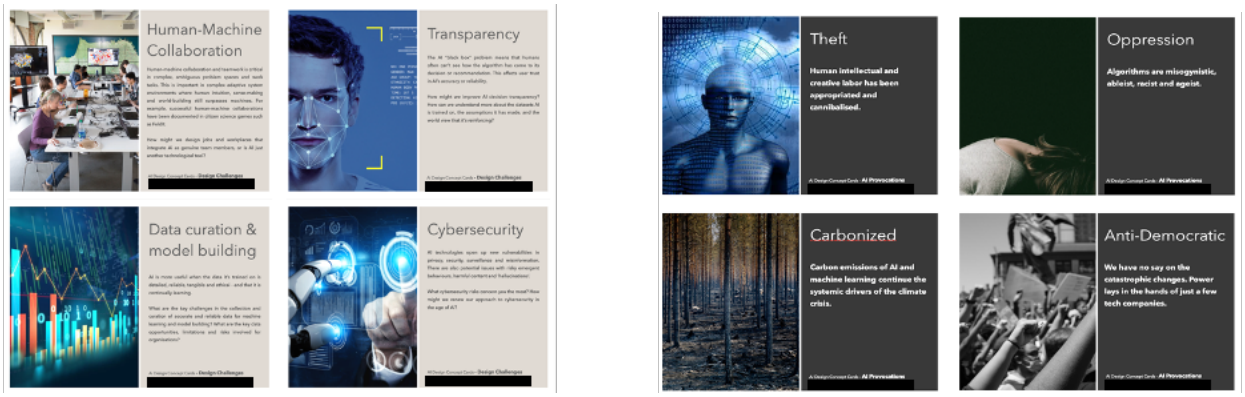

Figure 3: Example of Conversation cards - Design cards and Provocation cards (Flourishing not shown)

the data [41]. Participation and mutual learning were key to underpinning the epistemology of this research [43]. The methodology used to collect data was based on Torbert's (1998) 'first, second, and third person' research framework which incorporates opportunities for individual participant reflection, participation, and collective insight generation [42]. According to Torbert (1998), the 'First person' phase relates to building an "enquiring approach" so participants may proceed with enhanced awareness. This was built into the first initiation phase of our workshop process illustrated in Figure 2.
In Torbet's (1998) 'Second person' analysis comes through dialogue and the development of "communities of inquiry and learning organizations". We built this into our second phase of *Teambuilding*. Torbet's (1998) 'third person' is more impersonal and "aims to create a wider community of inquiry" which we built into our third *Solution Building* phase. The next sections of this paper detail the final results of our work which includes details of the final sets of the AI conversation cards (section 3), the Tiny Robot design card game (section 4), and the design sprint workshop process (section 5). We finish this paper with a discussion (section 6) and limitations and opportunities for further research (section 7).

4 RESULTS OF AI DESIGN CARDS

In this section we present the results of generating the creation of the design cards (AI concepts, AI provocations and human flourishing) using a design science approach outlined in sections 4.1 to 4.3. The results of the thematic analysis on the feedback on the use of the cards by workshop participants are detailed in section 4.4.

4.1 Creation of the AI concept cards

Ten AI concept cards were developed based on the key elements of AI systems design that arose in our literature review. Ten were chosen to not have an unwieldly number of cards that need to be managed by workshop facilitators and workshop participants, similar to others in the domain [14]. The concept cards were intended as conversation starters or open a field of inquiry amongst stakeholders at the early stages of exploring AI and were not intended to be fully comprehensive on the topic. The ten key concepts included items such as human-machine collaboration, transparency, cybersecurity, data curation, and model building. A description of each concept was provided on the card. An example of AI concept cards is shown in Figure 3.

4.2 Creation of the AI Provocation Cards

Following the approach used in the development of the AI concept cards in section 4.1 above, ten AI provocation cards were developed based on the key barriers or negative consequences of AI technologies prevalent in extant literature [34–36]. These include, for example, items such as theft, oppression, carbonized, and anti-democratic. For these cards only a statement was made as an act of provocation for stakeholders to explore the adverse effects of AI technologies. An example of AI concept cards is shown in Figure 3.

Table 2: Participant Feedback and Thematic Codes and clusters on the use of AI design cards

Design Cards: 4 clusters and 13 themes (codes)	F	Design Cards: 4 clusters and 13 themes (codes)	f
A. Kickstart the process	60	C. Facilitate interactions and experiences	78
•Get started or warm-up	38	•Rich human conversations	18
•Icebreaker	22	•Enjoyment using the cards	35
		•Facilitated learning or awareness	16
B. Facilitate knowledge generation & sharing		•Challenges design participation	9
•Topic introduction	30		
•Useful reference points	15	D. Improvements needed	23
•Helpful as new topics	14	•Topic justification	11
•Useful ideas on technologies	11	•Unclear definitions or more information	8
		•Spend more/less time on activities	4

(f=Frequency of occurrence; each bullet point is a thematic code that emerged in the data and is based on the number of times it was mentioned in the open-ended responses)

4.3 Creation of the Human Flourishing Cards

Ten human flourishing cards were developed based on our literature review and leveraged the increasing concerns of human flourishing in the digital era popularized by the seminal work by VanderWeele (2017) and included items such as curiosity, mindfulness, purpose, and empathy [44]. Each card posed three questions for the teams to discuss. These were (1) In the age of AI how do I build my (card name)? (2) what needs to change for this to happen? (3) Who advances and who is left behind? The use of the AI conversation cards worked very well as a stand-alone exercise for introducing the implications of AI technologies to different stakeholder groups.

4.4 Results of the thematic analysis on the design cards

As detailed in our methodology, a thematic analysis was conducted on the feedback given by participants in the final two long-form workshops of the series (workshops 4 and 5). Participants were asked open-ended questions to reflect on their use of the three sets of conversational design cards. There were four key clusters and 13 different themes (thematic codes) that emerged in the data, as depicted in Table 2. Ten themes focused on the positive feedback that centered around the three clusters of *(a) kickstarting the process.* This cluster included themes of providing a positive start to the workshop process and providing an effective warm-up or icebreaker on the topic. In the next cluster: *(b) facilitating knowledge generation and sharing* included themes on how the cards provided useful introductions to AI, informational reference points to anchor the workshop, and an effective introduction to AI topics and technology ideas. In cluster *(c) facilitating interaction and experiences,* themes included how the cards assisted in facilitating rich human conversations, facilitating learning and awareness of the AI topics and issues, and challenging participants in the design process. Several mentions were made on the fundamental enjoyment of the physical and tangible nature of the cards in the design process. The final cluster: *(d) improvements needed,* provided critical feedback for improvement that included themes of a deeper understanding of why the cards were limited to the provided themes, and that definitions were unclear or too general for some participants. This feedback will be essential in the continual revision of the cards and the workshop process.

Examples of participant feedback regarding the AI design cards illustrate the themes of facilitating knowledge generation and sharing: "These concepts were new for me, hence very helpful", "I really enjoyed the rich conversations with the people on my team who came from diverse backgrounds", "Gives you an idea for the technological base, which is really useful for the user side (business-push vs tech-pull)."

Examples of participant feedback for the AI provocation cards illustrate how the cards fulfilled their purpose of provoking deeper thought on the negative consequences of AI issues: "These were great conversation starters, a lot of discussion can and should be had around these issues", "As the name suggests, it provoked us to look at the problems as well as the solutions", "Made me realize that it's important to address user concerns and AI design needs to or address these issues." Similarly, with the human flourishing cards, their purpose was fulfilled in stimulating thought and conversation on topics uncommon in AI design practices: "It was challenging thinking about the consequences of AI on flourishing. Made me realize AI will change us", "This was a hopeful lens, we talked about how AI can transform the way we think about knowledge and education e.g. it's about asking the right questions."

5 RESULTS – TINY ROBOT DESIGN CARD GAME

The second phase of the workshops, as illustrated in Figure 1, focused on the Creating Tiny Robots design card game. Consistent with Torbert's (1998) 'first person' phase we commenced this design workshop with a participatory methodology to build an 'enquiring approach' so participants may proceed with 'enhanced awareness'. This entailed commencing with a self-reflection exercise on building one's own AI designer avatar with *Lego Serious Play* blocks, nominating a personal design 'superpower' that they bring to the workshop, and then a group exercise to share their stories.

Table 3: Participant feedback: thematic codes on the teambuilding phase

Building your own avatar exercise	F	Sharing team member avatar stories exercise	f
Enabled personal creativity	22	Get to know each other	31
Feelings of empowerment	16	Enabled to build empathy	18
Enabled self-expression	10	Enabled work effectively together	18
Invited personal involvement	11	Created an interesting and fun environment	12
(f=Frequency of occurrence; each thematic code is based on the number of times mentioned in participant reflection and feedback)			

5.1 The team building phase - create your AI designer avatar.

We form smaller groups of approximately five people (depending on overall numbers) to undertake an AI design challenge. First, we use a *Lego Serious Play* exercise [45] to build your own avatar or persona of an *AI Designer.* The request we ask of participants is to also choose a *personal superpower* as a systems designer that you are bringing to the co-design challenge. Once all the avatars are created after 15 minutes, each team member presents their avatars and superpower stories to the group and creates a team gallery of figurines for display. Participants were able to keep these on completion of the workshop. The reasons for this phase are twofold. The first deals with potentially bringing innate designer bias out in the open, and that it facilitates peoples' need to feel like they belong to a group. This aims to establish openness, understanding, and empathy to create teamwork and workshop cohesion. Feedback for this session is outlined in Table 3 below:

Participant feedback on building their designer avatar and sharing their story centered around the personal enablement of four key themes: creativity, empowerment, self-expression, and personal involvement in the design project. An example of the emotion this generated can be seen in a few indicative quotes such as: "This ignited my creativity", "Such a good moment, it felt empowering", "It felt good to explain my avatar", and "Excellent way to encourage self-expression".

Participant feedback on team member stories centered around building team dynamics themes: getting to know each other, building empathy, working effectively, and creating interest and fun. An example of the emotion this generated can be seen in a few indicative quotes such as: "This allowed us to get to know our teammates", "The method helped us relate to one another emotionally", "This helped me build empathy towards them and this, in turn, helped us work more effectively".

5.2 The solution building phase – Creating Tiny Robots card game.

As shown in Figure 1, we named the solution building phase 'Creating Tiny Robots' to introduce a fun and playful element into the process to better engage participants in learning about the key elements of AI systems design from a user's perspective. There are three elements in the solution building phase – the Tiny Robot design cards, design canvases and the building of physical prototypes which are outlined in detail below.

5.2.1 Tiny Robot Design Card Game. The Tiny Robot Design Cards were designed to provide a gameful experience to engage stakeholders in a motivating environment to learn and experiment with different AI design ideas. We conceptualized our Tiny Robots game as a design game that helps to structure stakeholders' design dialogues as scaffolding, drawing inspiration from design games being used in the earliest phases of service co-design projects [46]. Figure 4 depicts the flow of workshop activities on AI solution building.

The flow of the Creating Tiny Robots card game is as follows:

1. At the beginning of the session, the group is divided into teams and a **problem is presented** for all teams to work on. Consistent with Design Thinking and Design Sprints. It is emphasized that this was a demonstration exercise and that we were just testing the tools and process. We are careful to explain that in the real world, the problem presentation requires more time and research for all stakeholders over a longer period of time.
2. There are four sets of cards (see Figure 5), and each team randomly selects one of each: The first is a **Task card** which is defined as the task that the AI solution (or Tiny Robot) is to perform. There are eight cards in this set which include recognize, personalize, predict, and optimize. Given the emergent nature of AI technologies, a brief description was provided on these cards to ensure participants understood the nature of the technology.
3. The next set of cards is **Touchpoints** which is defined as the technology or interface the target user will be interacting with and the means by which the AI solution will collect or provide data. The touchpoints included are social media, artificial assistant, beacon or sensor, virtual or augmented reality.
4. The third set of cards is **Experiences** which is defined as the design of interactions or experiences to engage with the target user. Experiences included crowdsourcing, game or simulation, community forum, quiz or puzzles.
5. As a stand-alone group exercise, the **Tiny Robots exercise** entails the team placing the cards face down on a table and picking up one card from each set of **Task, Experience, and Touchpoint**. It should be noted that the design of the cards focused on human-machine interaction rather than machine-machine interaction. Due to the challenging nature of the exercise, we also tried having the names of the cards face-up so participants had time to consider which cards they chose. This was important for groups who may have limited knowledge of the composition of technology systems.

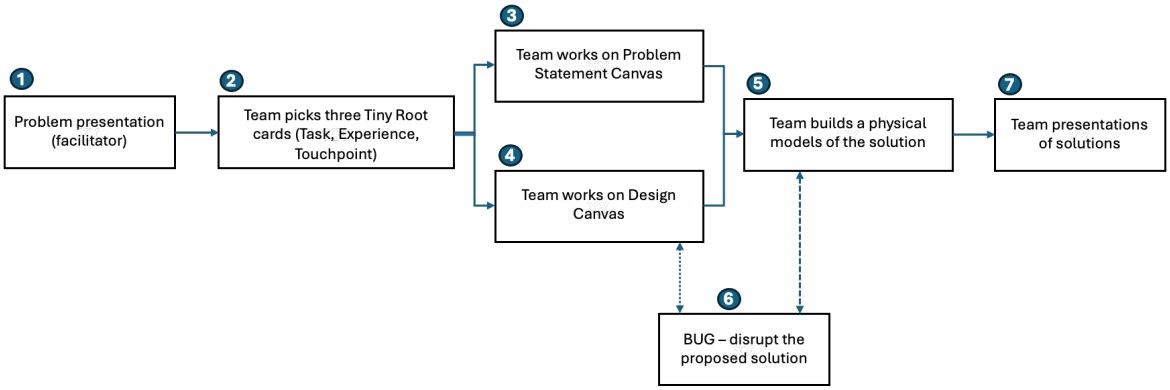

Figure 4: Flow of activities for the 'Tiny Robots' AI solution building phase (workshops 3-5)

Figure 5: Tiny Robot Design Cards: Tasks, Experience, and Touchpoints (Bugs cards not shown)

6. The last set of cards are **Bugs** which are defined as problems associated with technological, design, or implementation limitations and challenges. Bugs included are bias, hostile actors, uncanny valley, and breach.
7. Team presentation of solutions. This is an important sharing and reflections sharing of the different approaches to the same problem, consistent with Torbet's (1998) 'third person' stage that creates a wider community of inquiry.

The theoretical foundation behind the Tiny Robot 'game' is to (a) encourage participants to work within design constraints in building solutions, (b) provides an engaging environment for participants to deeply question and understand the sample of cards that they drew, and (c) gain an appreciation of how a simple system is designed and integrated with one simple touchpoint, user experience, and technology. A sample of cards is provided in Figure 5.

Two examples are given to participants of how these three elements work together – one positive and one negative. For example, the following simple negative scenario is presented: For a problem statement of *how can a political party swing unsure voters?* and based on the drawing of the cards of (Task: Personalize + Experience: Quiz + Touchpoint: Social Media), an example solution is presented as *the building of a fun and seemingly innocent quiz on 'What personality type are you? that is distributed on social media, specifically Facebook, to collect data to profile the use in order to send targeted, personalized advertisements.* A second positive and wholesome example was also given. The more examples given to the participants the more likely they are to understand the flow of the game-like activity.

5.2.2 Tiny Robot Design Canvas. The design canvases (depicted in Figure 6) were designed to provide scaffolding to aid participant thinking and creativity. They consisted of three canvases. The first is a definition of the problem statement: like all design sprint demonstration exercises, a short, prearranged case study is presented to the group. The more successful approach was to email participants before the workshop to nominate their case for the group to work on – the facilitator selected the most appropriate

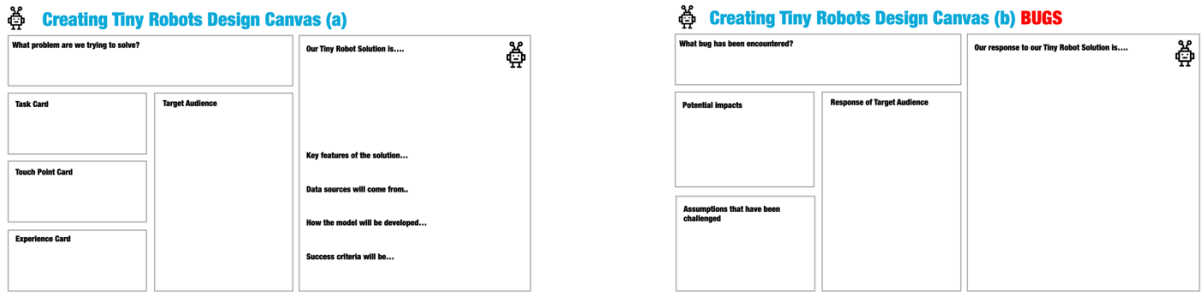

Figure 6: Tiny Robot Design canvases example

case and appointed the project owner as the group 'expert' on the nominated design challenge. The second is the design canvas which on which the potential solutions are recorded in writing, and the final canvas is on the introduction of system bugs and how the design team would make the necessary adjustments to their designs.

From the observations made during the workshop documented in the facilitator's field notes [40] participants appeared comfortable with the format of the canvases due to their popularity based the original work by Osterwalder & Pigneur (2010) and by design thinking, agile methodologies, and design sprint canvases. It was noted that participants tended to find this aspect a challenge as it entailed verbal and written conceptualization of their idea generation and only took brief bullet points in most cases. Participants were more enthusiastic in the hands-on building of their solutions and found that rapid iteration of their ideas took place during the process of building or making – the teams then retrospectively made notes on their canvases after they were happy with their creations (presented in the next section).

From the facilitator's observations and fieldnotes, the canvases appeared slow down the teams particularly if one team member took 'ownership' of writing up the ideas, other participants tended to retreat. However, when the building phase commenced, it was more of a democratized process as everyone started to build something (empowered by their own personal build with their avatar in the previous session) and then combined the ideas into a solution. When the facilitator asked questions of the designs – particularly about the anthropomorphic elements or the connections between mechanical and biological forms, the process of the participants 'think-aloud' [47] gave insight into the thought processes ranging from design elements, participant mood, emotion, and engagement experienced during the process. Particularly interesting was what could not be articulated with anthropomorphic forms with "We didn't even think about it, it just happened that way."

5.2.3 Tiny Robot Solution Design – The hands-on build. External representations such as the building of physical protoypes and models are ubiquitous in design and all creative endeavors [48] as a means to provide a link between tacit and explicit knowledge, and between conscious and unconscious representation of thought and ideation. The ideation process has been claimed to be prenoetic [49] therefore the building of physical prototypes is an embodiment of what the rational mind cannot yet articulate. Using a sketch or prototype in a design process represents a single design possibility, however, they also represent the beginning of the development of a whole set of other possibilities for the eventual product [48]. Sennet (2008) describes this process as a conversation with materials by taking a mental idea and giving it a physical form and that triggers different physical, social, and cognitive processes with those participating in the design process [50]. These thoretical foundations have been the basis for popular design methodologies that include Design Thinking, Design Sprints, and *Lego Serious Play* which formed a key part of this study. An example of how the materials were presented to participants as soon as they walked into the Tiny Robots workshop room can be seen on Figure 7. The intention here is to create a liminal space to heighten participant anticipation of an engaging, hands-on experience.

Participant feedback in the form of a reflection on the activities processed from the formal surveys indicated that participants were positive and often enthusiastic about the fun and engaging experience and processes. This can be seen in the participant feedback outlined in Table 4, where in all three phases of the Tiny Robots exercise the common themes that emerged were the enjoyment of being challenged by design activities that provide a range of intuitive, informative, and fun tools in a supportive, team-based environment.

For the **Tiny Robt Design Cards,** a percentage of participants in the long workshops (30% in Workshop 4 and 20% in Workshop 5) stated that they were challenged by working within design constraints or were confused by the process and needed more guidance or information. While these aspects were progressively improved at each iteration of the workshop from the beginning, our observations noted that the reduction of human-AI interactions to the three elements of *Task, Touchpoint, and Experience* was not intuitive to the group that felt challenged by the exercises and hence required more explanation to think about human-machine interaction in this way. It was also observed however that many of these participants had limited knowledge about the different AI technologies and how they are used in current business systems outside of generative AI.

There was a good level of information sharing between participants about their knowledge of AI technologies and this was one of the objectives of this project to have stakeholders sharing knowledge and ideas, consistent with Torbet's (1998) 'third person' stage that creates a wider community of inquiry. Participants were enthusiastic with the **Building of Solutions phase** and the **Sharing of Solutions phase**. A small number of participants believed that they were "not creative" and felt some level of discomfort with the

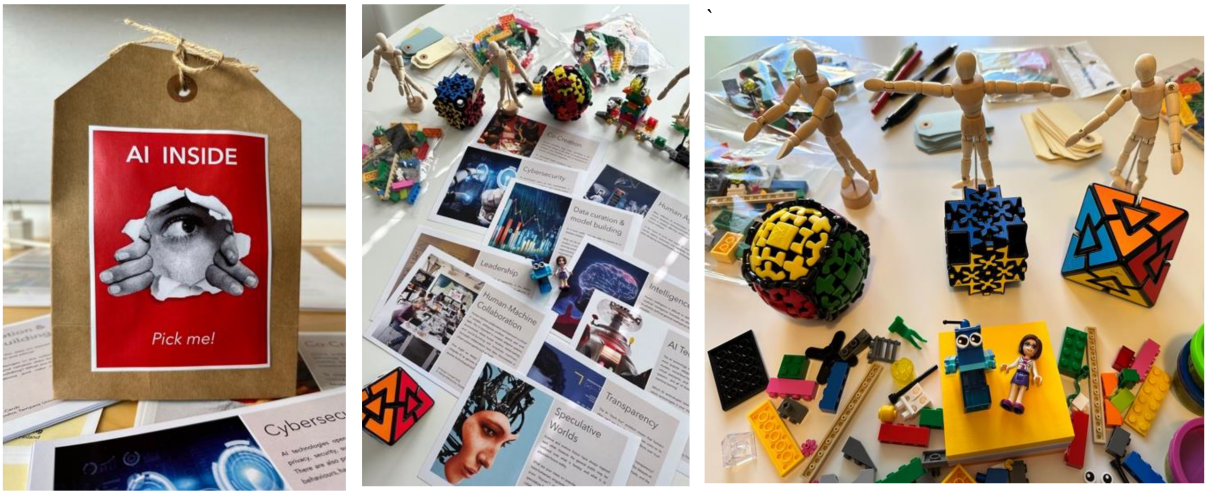

Figure 7: Presentation of workshop materials to participants in a liminal space

Table 4: Participant feedback and thematic codes summary from Tiny Robots Exercise

Design Cards phase	f	Model Building phase	f	Sharing Solutions phase	f
Enjoyed the design constraints	35	Self-doubt and limitations	11	Interest in different approaches	28
Inspires alternate thinking	33	Iterative building of ideas	22	Platform to collaborate	32
Fun and intuitive experience	30	Fun and interesting	30	Enjoyable and playful	25
Useful prompts to mix and match	21	Productive to visualize	22	Stimulates creativity	22
		Challenging exercise	11	Generates compassion	16

(f=Frequency of occurrence; each thematic code is based on the number of times mentioned in participant reflection and feedback)

physical act of making models, and this can be seen in the self-doubt and limitations thematic category in Table 4. However, the process of engaging in teamwork in the Tiny Robots exercise helped these participants overcome or work through their self-doubt. The positive feedback from participants indicates the importance of the addition of a variety of interactive and creative exercises in modern digital systems design as a means to externalize ideas on human-AI interaction, a notion supported by Dix & Gongora (2011).

Participant feedback on the Tiny Robots design cards exercise centred around facilitating pathways through technology design challenges: "It was difficult to think about design constraints, but it made total sense by the end." "These were helpful prompts and I like that you could mix and match them to create multiple iterations." "Inspired thinking about the tiny robot design. Very intuitive and fun." Similar themes emerged in the feedback on the building of physical models exercises that used tactile materials and interactivity: "I'm not good at this but I enjoyed working with the team." "Loved it! This was easy to adopt and helps understand the technology design cycle", "Helped in better visualizing the problem and solution." "A very useful and productive exercise that helped us to formulate 'out-of-the-box' ideas and crystalize solutions so rapidly!" This culminated in explanations given by participants on how the process led to constructive outcomes in the sharing of solutions exercises: "It was interesting to listen to different ways each team had in approaching the same problem. This was the best part." "A nice platform to share your ideas. I enjoyed giving a playful 'pitch' which helped imagine the possible applications and commercial aspect of our ideas." "I was very impressed by the creativity and compassion of the proposed solutions. Forces you to think about communication and the presentation early in the design phase."

6 DISCUSSION

To address our research question of How might we make AI systems design and development tangible, engaging and understandable to engage stakeholders in a process of co-creation? we developed and tested a variety of artifacts in the forms of AI design tools that can be used in the collaboration and co-creation of AI-enabled systems. The objective of this research is to investigate how we can improve AI systems to be more human-centered, transparent and trustworthy that may contribute to more optimal AI acceptance and implementation of business applications. Our approach and methodology are in line with what Dix and Gongora (2011) describe as focusing on external representations of design so that we are able to make sense of tools and for reflection and creativity which will ultimately lead to improved design [48].

Figure 8: Gallery of AI system design artefacts created by workshop participants.

The different artifacts presented in this paper can be used in sequence or independently of each other. For example, the three sets of concept cards worked very well on executive teams who didn't want to delve into the detail of a system design; the key benefits they saw from the concept cards were tools to facilitate conversation amongst consulting teams (particularly between the technology and management teams in their firm) and with their clients to demystify AI technologies in an engaging, informative and non-threatening environment. Critically, however, we found that a certain percentage of participants from each of the three design sprint workshops (around 20-30%) still found it challenging to grasp AI concepts or to conceptualize human-machine interaction down to task/touchpoint/experience. Despite the domain being an emergent and highly complex, endeavors still need to be made to democratization of this knowledge to attain true collaboration and co-creation with a wide range of stakeholders affected by AI implementations.

For other participants such as researchers and project managers, the making part of the methodology using the Tiny Robot design cards and methodology was particularly rewarding as they were engaging with this part of the process as a problem solving, solution-orientated approach. An example of artifacts created are provided below in Figure 8. In our analysis of the AI models developed by the participants, we noticed a concentration of anthropomorphic designs and considered whether the materials provided for the build phase could be considered suggestive or potentially leading participants towards anthropomorphic designs. Given that Ramduny-Ellis et al. (2010) maintain that the nature of materials and tools provided to participants in a design space has a profound impact on the kinds of externalizations produced, we would like to highlight a need to experiment without the provision of anthropomorphic forms in the building materials to compare the outcomes in the solutions that are developed [51].

As can be seen in the gallery above, artefacts showed distinctly andromorphic forms of AI solutions. From the notes taken during the 'think-aloud' [47] sharing sessions, participants were clear on the importance of human-machine connectedness and collaboration. This can be seen in the exhibits in the form of mechanical or non-biological materials attached or connected in some way to the human forms. The subconscious mind makes connections that cannot always be verbalized which raises the need for a deeper understanding of both conscious and subconscious factors in collaborative designs using engaging methods in this emergent and complex domain of AI technologies.

The positive feedback on the building and sharing physical representations of solutions indicates the importance of the value of these elements in modern system design. However, we need to be cognizant that software development is a complex process that may not in its current form be able to accommodate more involved and time-consuming creative co-creation practices. Current AI technology development is modular, fragmented, and difficult for developers to trace responsibility and accountability. For example, Widder & Nafus (2023) identified "dislocated accountabilities" which has been created by the modularity of roles and responsibilities and division of labor across different actors in the AI technology supply chain [57]. Similarly, Schmidt et al. (2023) found considerable role ambiguity among developers of AI-based systems which blurs the boundaries of system accountability [53]. This has led to calls by researchers to develop software development models that consider human-centered priorities early in the development cycle using novel computational tools [54]. Technical solutions to building business systems seldom consider the complexity of socio-technical interactions between stakeholders, and that these interactions have considerable impacts on organizations and society [55]. While researchers believe that the current system of AI software development is unlikely to change any time soon [57] human-centered design and collaborative elements like the artifacts developed in this study help to challenge the current system with opportunities to raise the bar for better practices.

We reflect on our work and consider Ng et al., (2021) in their review of AI literacy as having three levels; knowing and understanding AI, using and applying AI, and evaluating and creating AI, that can be viewed as a hierarchy in the level off understanding, where one

level needs to be mastered before moving onto the next [18]. This is not too dissimilar to Brennan & Resnick's (2012) key dimensions of computational thinking framework: *computational concepts* (the concepts designers engage with as they program), *computational practices* (the practices designers develop as they engage with the concepts) and *computational perspectives* (the perspectives designers form about the world around them and about themselves) [56]. The implications of the work presented in this paper are that our three artifacts reflect this pattern, however it is only a microcosm of what is required and necessary to incorporate into AI development workflows. The raising of AI literacy for all system stakeholders is a longer-term endeavor that can only be glimpsed in the brief sessions over a 5-hour workshop period. We offer our work as a contribution towards this collective endeavor.

7 LIMITATIONS AND OPPORTUNITIES FOR FURTHER RESEARCH

There are seven key limitations with this work that we would like to acknowledge and offer suggestions for opportunities for further research. (1) Only one/same facilitator was used in this study, but different assistants were used to help at each workshop. Optimal methods suggest two facilitators, or even the separation of roles between the researcher, the facilitation of the workshops and the data collection [38] however resourcing limitations prevented us from doing this. (2) The project artifacts of the different design cards and the workshop process were designed for stakeholders in the early stages of exploring AI-enabled information systems. An opportunity for further research is to develop more advanced tools for more advanced practitioners and stakeholders, as their expertise and expectations would differ. (3) The final three workshops were tested on professionals and academics in a prototyping environment, however the next stage of the development of these artefacts requires that they be tested in the wild during the actual development of AI technologies in practice. A good next step in this regard is to develop a focused case study in a single organization looking to introduce an AI enabled technology to solve a specific business problem, with a diversity of stakeholders invested in the outcome, to thoroughly test the approaches in this paper.

Limitation (4) Participants self-selected to attend the workshops on the promise of a fun and creative process using novel AI design cards and a design-sprint methodology. We also acknowledge that the positive response to the workshops could be attributed to this in terms of 'preaching to the converted'. This raises the need to perhaps test on an uninitiated audience to these methods or seek the input of participants who do not identify as liking creative, hands-on experimental processes. The opportunity discussed in item number 3 above where a diversity of employees will be participating is relevant here as well. (5) We believe the methods outlined in this paper have the potential to supplement the development of AI Model Cards building on the works of Mitchell et al. (2019) and Crisian et al. (2022). However, this has not yet been tested and is an opportunity for further research. (6) The presentation of the three sets of eight conversation cards at the beginning of the session (on AI concepts, dark provocations and on human flourishing), while providing a high-level view of the key issues, can in effect bias the views and perceptions of the participants. Particularly in terms the provocations of the dark side of AI and in terms of the importance of human flourishing which can be considered a subliminal nudge to incorporate these ideas. While we did not note any direct objections or claims in this regard amongst participants, it needs to be documented as a possible limitation.

Continuing this theme, (7) Practitioner bias in the creation of the design tools and research methods is always present in such studies. As the researchers and creators of these tools, we are conscious that our worldview is from a human-centered design perspective and our concerns about the limitations and potential harms of AI have influenced the design of these tools and the facilitation of the methods. However, we posit that this may also provide an important counterbalance to the lack of conscientiousness of the world views that are creating the current generation of AI technologies and their unfolding unintended negative consequences [34–36].

8 CONCLUSIONS

Despite the potential of AI technologies to improve business performance, it has been widely reported as delivering limited returns on investment. This has been largely attributed to organizational enablement issues as well as technology adoption issues among system users. One way to manage these limitations is to engage a wide range of stakeholders in the AI technology co-creation process that may account for a fuller range of the socio-technical interactions between stakeholders and thereby alleviate issues in relation to technology design, effectiveness, and adoption. In this study we propose a set of AI design cards and an AI design sprint process that can be used by researchers, organisational leaders, and project managers to better collaborate with stakeholders in developing more robust human-centered AI technology designs and enablement strategies. The greater challenge however remains that the current complexity of the AI software development value-chain, and the high complexity in AI concepts is still challenging collaborative approaches to AI system design with a wide range of stakeholders.

ACKNOWLEDGMENTS

The authors wish to thank Audrey Thompson for her contribution to the creation of the workshop tools and processes. This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 101023024 for Augmented-Humans.

REFERENCES

[1] Pumplun, L., Tauchert, C., & Heidt, M. 2019. A New Organizational Chassis for Artificial Intelligence - Exploring Organizational Readiness Factors. *European Conference on Information Systems*.
[2] Shollo, A., Hopf, K., Thiess, T., & Müller, O. 2022. Shifting ML value creation mechanisms: A process model of ML value creation. *The Journal of Strategic Information Systems*, *31*(3), 101734.
[3] Mikalef, P., & Gupta, M. 2021. Artificial intelligence capability: Conceptualization, measurement calibration, and empirical study on its impact on organizational creativity and firm performance. *Information & Management*, *58*(3).
[4] Raftopoulos, M., and Hamari, J. 2023. Human-AI Collaboration in Organizations: A Literature Review on Enabling Value Creation. *The European Conference on Information Systems (ECIS) 2023 Research Papers. Kristiansand, Norway.*
[5] Waardenburg, L., Huysman, M., & Sergeeva, A. V. 2022. In the land of the blind, the one-eyed man is king: Knowledge brokerage in the age of learning algorithms. *Organization science*, *33*(1), 59-82.

[6] Wagner, D. N. 2020. The nature of the Artificially Intelligent Firm-An economic investigation into changes that AI brings to the firm. *Telecommunications Policy*, *44*(6), 101954.

[7] Hanelt, A., Bohnsack, R., Marz, D., and Antunes Marante, C. 2021. A systematic review of the literature on digital transformation: Insights and implications for strategy and organizational change. *Journal of Management Studies*, *58*(5), 1159-1197

[8] Goodhue, D. L., and Thompson, R. L. 1995. Task-technology fit and individual performance. *MIS quarterly*.

[9] Cao, G., Duan, Y., Edwards, J. S., and Dwivedi, Y. K. 2021. Understanding managers' attitudes and behavioral intentions towards using artificial intelligence for organizational decision-making. *Technovation*, *106*, 102312.

[10] Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., Eirug, A., Galanos, V., Ilavarasan, P. V., Janssen, M., Jones, P., Kar, A. K., Kizgin, H., Kronemann, B., . . . Williams, M. D. 2021. Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, *57*.

[11] Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D. 2003. User acceptance of information technology: Toward a unified view. *MIS quarterly*, 425-478.

[12] Liang, H., & Xue, Y. 2009. Avoidance of information technology threats: A theoretical perspective. *MIS quarterly*, 71-90

[13] Crisan, A., Drouhard, M., Vig, J., & Rajani, N. 2022. Interactive model cards: A human-centered approach to model documentation. In *Proceedings of the 2022 ACM Conference on Fairness, Accountability, and Transparency* (pp. 427-439)

[14] Ghajargar, M., & Bardzell, J. 2022. Making AI understandable by making it tangible: exploring the design space with ten concept cards. In *Proceedings of the 34th Australian Conference on Human-Computer Interaction* (pp. 74-80).

[15] Hevner, A., S.T. March, J. Park, and S. Ram. 2004. "Design science in information systems research", *MIS Quarterly 28*(1), pp. 75–105.

[16] Corbin, J., & Strauss, A. L. 2008. *Basics of qualitative research 3e*. Thousand Oaks, CA, USA: Sage.

[17] Muller, M. 2014. Curiosity, Creativity, and Surprise as Analytic Tools: Grounded Theory Method. In: Olson, J., Kellogg, W. (eds) Ways of Knowing in HCI. Springer, New York, NY.

[18] Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. 2021. Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*, *2*, 100041.

[19] Kerzel, U. 2021. Enterprise AI Canvas Integrating artificial intelligence into business. *Applied Artificial Intelligence*, *35*(1), 1-12.

[20] Osterwalder, A., & Pigneur, Y. 2010. *Business model generation: a handbook for visionaries, game changers, and challengers* (Vol. 1). John Wiley & Sons.

[21] Mitchell, M., Wu, S., Zaldivar, A., Barnes, P., Vasserman, L., Hutchinson, B., ... & Gebru, T. 2019. Model cards for model reporting. In *Proceedings of the conference on fairness, accountability, and transparency* (pp. 220-229).

[22] Vakkuri, V., Kemell, K. K., Jantunen, M., Halme, E., & Abrahamsson, P. (2021). ECCOLA—A method for implementing ethically aligned AI systems. *Journal of Systems and Software*, *182*, 111067.

[23] Brandt, E., and Messeter, J. 2004. *Facilitating collaboration through design games*. In proceedings of the eighth conference on Participatory design: Artful integration: Interweaving media, materials and practices, pp.121-131.

[24] Hornecker, E. 2010. Creative Idea Exploration within the Structure of a Guiding Framework: The Card Brainstorming Game. In proceedings of TEI 2010.

[25] Mueller, F., Gibbs, M.R., Vetere, F., and Edge, D. 2014. Supporting the Creative Game Design Process with Exertion Cards. *CHI 2014,* Toronto, Canada.

[26] Flanagan, M., and Nissenbaum, H. 2007. A game design methodology to incorporate social activist themes. *CHI*, San Jose, California, USA.

[27] Friedman, B., and Hendry, D. G. 2012. The envisioning cards: A toolkit for catalyzing humanistic and technical imaginations. *CHI*, Austin, Texas, USA.

[28] IDEO. 2003. *IDEO Method Cards: 51 Ways to Inspire Design*. Palo Alto: IDEO.

[29] Schell, J. 2008. *The Art of Game Design: A Deck of Lenses*. USA: Schell Games.

[30] Huizinga J. 1955. *Homo Ludens: A Study of the Play-Element in Culture*. Beacon Press.

[31] Arrasvuori, J., Boberg, M., Holopainen, J., Korhonen, H., Lucero, A. and Montola, M. 2011. *Applying the PLEX Framework in Designing for Playfulness*. In proceedings of 2011 International Conference on Designing Pleasurable Products and Interfaces (DPPI '11), ACM, pp.179-186, New York, USA.

[32] Lucero, A., and Arrasvuori. J. 2010. *PLEX Cards: A source of inspiration when designing for playfulness*. In proceedings of the 3rd International Conference on Fun and Games pp.28-37, ACM, New York, USA.

[33] Wölfel, C., Merritt, T. 2013. Method Card Design Dimensions: A Survey of Card-Based Design Tools. In P. Kotz, *et al.* (Eds.), *INTERACT* 2013, part I, LNCS 8117, pp.479–486. IFIP International Federation for Information Processing.

[34] Marcus, G. 2022. Artificial General Intelligence Is Not as Imminent as You Might Think, *Scientific American, June 6,* 2022

[35] Birhane, A., Kalluri, P., Card, D., Agnew, W., Dotan, R., & Bao, M. 2021. *The Values Encoded in Machine Learning Research*. http://arxiv.org/abs/2106.15590

[36] Bender, E. M., Gebru, T., McMillan-Major, A., & Shmitchell, S. 2021. On the Dangers of Stochastic Parrots: Can Language Models Be Too Big?. In *Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency* (pp. 610-623).

[37] Storvang, P., B. Mortensen, and A.H. Clarke. 2017. "Using workshops in business research: A framework to diagnose, plan, facilitate and analyze workshops", In *Collaborative Research Design: Working with Business for Meaningful Findings*. 155–174.

[38] Thoring, K., Mueller, R., & Badke-Schaub, P. 2020. Workshops as a research method: Guidelines for designing and evaluating artifacts through workshops. Proceedings of the 53rd Hawaii International Conference on System Sciences (HICSS).

[39] Williams, M., & Moser, T. (2019). The art of coding and thematic exploration in qualitative research. *International management review*, *15*(1), 45-55.

[40] Emerson, R. M., Fretz, R. I., & Shaw, L. L. 2001. Participant observation and fieldnotes. *Handbook of ethnography*, 352-368.

[41] Strauss, A., & Corbin, J. (1998). Basics of qualitative research techniques.

[42] Torbert WR. 1998. Developing wisdom and courage in organizing and sciencing. In: Srivastva S, Cooperrider D (eds) Organizational wisdom and executive courage. New Lexington Press, San Francisco, pp 222–253.

[43] Farrow, E. 2021. Mindset matters: how mindset affects the ability of staff to anticipate and adapt to Artificial Intelligence (AI) future scenarios in organisational settings. *AI & society*, *36*(3), 895-909

[44] VanderWeele, T. J. (2017). On the promotion of human flourishing. Proceedings of the National Academy ofSciences, U.S.A., 31,8148-8156. https://doi.org/10.1073/pnas.1702996114

[45] Kristiansen, P., & Rasmussen, R. (2014). *Building a better business using the Lego serious play method*. John Wiley & Sons.

[46] Hannula, O., & Irrmann, O. 2016. Played into collaborating: Design games as scaffolding for service co-design project planning. *Simulation & Gaming*, *47*(5), 599-627.

[47] Yang, S. C. 2003. Reconceptualizing think-aloud methodology: Refining the encoding and categorizing techniques via contextualized perspectives. *Computers in Human Behavior*, *19*(1), 95-115.

[48] Dix, A., & Gongora, L. 2011. Externalization and design. In *Proceedings of the second conference on creativity and innovation in design* (pp. 31-42).

[49] Gallagher, S. *How the Body Shapes the Mind*, 2005. Oxford University Press.

[50] Sennett, R. *The Craftsman*. Allen Lane, London 2008

[51] Ramduny-Ellis, D., Hare, J., Dix, A., Evans, M. and Gill, S. 2010. Physicality in Design: an exploration. *The Design Journal*, 13(1).

[52] Spies, R., Grobbelaar, S., and Botha, A. 2020. A scoping review of the application of the task-technology fit theory. In *Responsible Design, Implementation and Use of Information and Communication Technology: 19th IFIP WG 6.11 Conference on e-Business, e-Services, and e-Society, I3E 2020, Skukuza, South Africa, April 6–8, 2020, Proceedings, Part I 19* (pp. 397-408).

[53] Schmidt, J. H., Bartsch, S. C., Adam, M., & Benlian, A. (2023). ACCOUNTABILITY INCONGRUENCE AND ITS EFFECTS ON AI DEVELOPERS'JOB SATISFACTION.

[54] Hartikainen, M., Väänänen, K., & Olsson, T. (2023, April). Towards a Human-Centred Artificial Intelligence Maturity Model. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems* (pp. 1-7).

[55] Raisch, S., & Krakowski, S. (2021). Artificial intelligence and management: The automation–augmentation paradox. *Academy of management review*, *46*(1), 192-210.

[56] Brennan, K., & Resnick, M. 2012. New frameworks for studying and assessing the development of computational thinking. In *Proceedings of the 2012 annual meeting of the American educational research association, Vancouver, Canada* (Vol. 1, p. 25).

[57] Widder, D. G., & Nafus, D. (2023). Dislocated accountabilities in the "AI supply chain": Modularity and developers' notions of responsibility. *Big Data & Society*, *10*(1), 20539517231177620.