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A Role of External Representations in Knowledge Transfer During Participatory Design Workshops

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Interactivity Matters – A Role of External Representations in Knowledge Transfer During Participatory Design Workshops

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Abstract

Today, our society faces many societal challenges with high uncertainty and complexity that a single person cannot solve. We have gradually recognized diverse stakeholders including non-professionals need to gather and co-create solutions collaboratively to tackle the challenges. One of the difficulties of such participatory workshops with diverse participants is its knowledge transfer. To establish a foundation for discussion, participatory workshops would require transferring appropriate evidence-based external representations of knowledge utilized both by experts and non-experts in a co-creation process. This paper investigates the impacts of three different external representations of knowledge through 12 social innovation workshops with three distinct agendas. Our experiments show that evidence-based knowledge was often appropriately transferred. However, surprisingly spontaneous, and interactive knowledge had more significant impacts than authoritative descriptive knowledge in shaping final ideas. This result indicates external representation of knowledge transferred at workshops should be designed with greater sensitivity and special attention to achieve intended outcomes.

Keywords: External representation of knowledge, Knowledge transfer, Participatory Design, Social Innovation workshop.

1. Introduction

In the society we currently live in, various societal challenges exist, and solutions are collectively being sought. In the case of global warming, international collaborative efforts based on UN SDGs can be seen as top-down actions. Regarding more immediate concerns such as declining birthrate, education gap, and working environment, actions also by local governments and companies are observed. Top-down actions by nations and companies are required to impact these social challenges. At the same time, individual commitments and actions are also indispensable as such challenges

deeply impacting ordinary people's everyday life. Thus, in responding to societal challenges, top-down approaches, and bottom-up actions to influence and permeate every corner of society are sought after.

Needless to say, it is difficult for individuals to autonomously take some actions that will lead an impact on society, even if people are encouraged to work together to solve societal issues. Therefore, various approaches and methods have been proposed to resolve societal challenges by involving individuals in more significant actions.

As one of these approaches, Participatory Design has a high affinity with actions aimed at societal challenges as a method of involving ordinary people (Schuler & Namioka, 1993; Simonsen & Robertson, 2013). Participatory Design utilizes various tools, such as field investigations through ethnography, prototypes, and participatory design workshops. Last decade, workshops have become more accessible to experts and the public, thanks to the popularity of design thinking, and are widely conducted in everyday settings.

A workshop is a meeting of two or more individuals collaborating to co-create a design to overcome an obstacle in an existing design (Thoring et al., 2020). The basic structure of workshops may be simple, but achieving effective results requires proper workshop design. Especially in the case of design workshops focusing on societal challenges, where the public without specialized knowledge participates widely, the input of relevant knowledge becomes crucial for producing high-quality outputs. The amount of knowledge possessed significantly impacts the breadth and depth of the workshop's outputs.

Therefore, in workshops where non-professionals participate, it is crucial to demonstrate, share, and communicate accurate knowledge based on evidence to support the discussions and solutions derived from them. In recent years, due to the significant impact of echo chambers and filter bubbles on society (Kratzke, 2023), the proper presentation, sharing, and transmission of relevant knowledge among workshop participants have become more critical than ever.

So, in the participatory design process aimed at achieving social innovation, how should knowledge be externalized and presented? To be more precise, how should knowledge be expressed and communicated for non-professionals to understand complex knowledge and utilize it properly as a resource for co-creating conceptual design solutions? Previously, in-depth research has been done on the forms of knowledge representation in knowledge transfer (e.g., (Boose, 1989)). However, the impact of external representation of knowledge on idea creation in workshops and an effective way of specialized knowledge transfer in workshops still need to be discovered. Therefore, this article primarily focuses on how external representation of knowledge influences knowledge transfer and its co-creation of conceptual solutions in workshops.

The article's structure is as follows: Section 2 reviews related studies, and Section 3 presents our research design for the research question. Section 4 presents the workshop results and discusses our findings in Section 5. Finally, this paper concludes with summary and future work.

2. Related research

2.1. Creativity, Co-Creation and Participatory Design for Social Innovation

Fischer (Fischer, 2000) highlighted that our society confronts the fragmentation of fields and an explosion of information. Thus, there are limits to the knowledge an individual can acquire in a lifetime today. He emphasized the necessity of co-creation for addressing our complex societal challenges posed by technological, social, cultural, and economic complexities.

Interestingly, in traditional creativity research, diversity has been demonstrated as a crucial source for problem-solving rather than an obstacle to creativity, as evidenced by specific cases (Page, 2007; Sawyer, 2007). Creativity and innovation have arisen from the "clashing point of two subjects, two disciplines, two cultures, which brings about creative chaos (Snow, 1993)", which are not considered special societal needs but indispensable foundational abilities. In other words, by assembling teams of experts with different knowledge backgrounds and strategically allocating them, the creativity of the entire community can be stimulated (Nisbett, 2003). From this perspective, a community with diversity can be seen not only as facing challenges in collaboration but also as a source of innovation. These recognitions underscore the importance of bringing together experts from diverse knowledge domains as a source of innovation, even though challenges in collaboration are anticipated.

The collaborative work of individuals from different fields and cultural backgrounds inevitably leads to conflicts as it presents challenges in achieving mutual understanding due to differences in vocabulary, perspectives, rules, procedures, and common knowledge (Nisbett, 2003). In order to address these intercultural challenges, boundary objects (Star, 2010; Star & Griesemer, 1989) have been recognized as a means to overcome language barriers, and intercultural collaboration support systems (Yasuoka, 2006). However, there is no simple solution to these intercultural challenges, and despite the recognized importance of intercultural collaboration, there remains to be a challenge in implementing it effectively in practice.

In response to the challenges of intercultural collaboration, Participatory Design has the potential to be helpful as a method that addresses these issues and provides valuable insights for generating creative outputs when diverse individuals co-create solutions. Participatory Design has historically started and traditionally been conducted in Scandinavian (e.g., (J. Greenbaum & Kyng, 1991; Joan Greenbaum & Ave, 2010)) and North American contexts (e.g., (Schuler & Namioka, 1993)). Although the root of the Scandinavian Participatory Design is seen in 'Democracy' and 'Equality' at work (e.g. (Ehn, 1988; Kensing & Blomberg, 1998)), modern participatory design as a method has also largely contributed to creativity and co-creation for social innovation by presenting ways for inclusion, participation, and commitment of stakeholders with diverse opinions and knowledge background.

To conduct co-creation, it is necessary to ensure that many people can participate without burdens, and Participatory Design offers tools and techniques, which help ordinary participants could commit and participate without hesitation. As Arnstein points out, participation does not merely involve being a subject of listening or engaging as token, but rather committing oneself to the creation of solutions and its design process (Arnstein, 1996).

In Participatory Design, various methods have been proposed to encourage participation and include reserved participants. Bødker (1991) advocated the use of prototypes, while Brandt (Brandt & Messeter, 2004) practiced design games. Simonsen (Simonsen & Robertson, 2013) stated that participation involves actively expressing one's opinions with a pen at hand, emphasizing the importance of commitments.

In order to promote social innovation through a bottom-up approach, individuals with diverse knowledge backgrounds must participate and engage in the design process. Participatory design research has accumulated decades of insights on achieving essential

elements such as participation, inclusion, and commitments that foster innovation and creativity while transcending cultural differences. On the other hand, while Participatory Design has been typically applied to IT system developments for decades (Simonsen & Robertson, 2013), its application to societal challenges is a relatively new and emerging applied field of study.

2.2. External Representations of Knowledge

Knowledge is vital to competitive advantage and, at the same time, difficult to work on (Nonaka & Takeuchi, 1995). Since knowledge is inherently invisible, intangible indefinite and resistant to quantification (Ahn & Chang, 2004), collecting, organizing and visualizing static and dynamic knowledge for transfer has been a more significant challenge (Nissen, 2023).

Knowledge can be broadly classified into explicit and tacit knowledge (Nonaka & Takeuchi, 1995). Explicit knowledge is knowledge that is expressed in the form of documents, diagrams, and other tangible representations. Examples include manuals, reports, databases, technical specifications, and the like. These types of knowledge are externalised so relatively easy to share and transfer. On the other hand, tacit knowledge is the knowledge that exists in a form that is difficult to articulate, such as personal experiences, skills, insights, and intuitions. Examples include expert know-how, experiential insights, and communication skills. Tacit knowledge is typically transmitted through interpersonal experience sharing and learning.

To transfer knowledge, the process of knowledge externalization is crucial. Externalization means converting an individual's tacit knowledge into an explicit form, making it easier to share and utilize. Knowledge externalization and transfer are essential for promoting knowledge sharing and utilizing within organizations and fostering innovation (Opland et al., 2023).

Previously, external representation of knowledge has been approached primarily through tangible externalisation such as documentation (manuals, procedures, reports, technical specifications), databases and knowledge bases (database of best practices, experiences, etc.), utilization of collaboration tools, and training and education programs (workshops, seminars, training) (Kirsh, 2010). Due to technological constraints, writing has been the primary focus of external representation of knowledge for many years. However, in recent years, various forms and approaches to external representation have been proposed in the context of knowledge transfer.

Boose (Boose, 1989) showed cognitive maps, decision tables, rules, scripts, etc., as a method of presenting expertise. Yasuoka (Yasuoka, 2021)

compared external representations of knowledge for abstract knowledge, such as living lab practice, and argued that the recipient's maturity level in the respective field plays a significant role in representation rather than there being a single ultimate solution for external representation. For beginners, Q&A-type representation was found to be more readily accepted by beginners. At the same time, pattern language was shown to be more suitable for individuals with a certain level of knowledge in the field. On the other hand, in traditional crafts, which have recently gained attention as a context for knowledge transfer, it has been recognized that the initial learning step involves interactions of the master-apprenticeship style knowledge transfer. However, the situation changes beyond the beginner's stage. Even for tacit actions that are difficult to express in words, the analyses have suggested that visual expressions such as movies can facilitate knowledge transfer of tacit knowledge that satisfies experts, even without face-to-face interaction (Yasuoka, 2021).

In this way, the form of external representation of knowledge in knowledge transfer has undergone significant leaps beyond the constraints of writing. With the advancement of technology, diversity can be observed in external representations of knowledge encompassing not only documents but also sensory aspects such as audio, visual, and tactile elements. However, research on how specific forms of knowledge externalization can influence idea creation through knowledge transfer is underrepresented to the best of the author's knowledge.

3. Research Design

In conducting design workshops for social innovation, what forms of external representation of knowledge are desirable when knowledge is provided within the constraint space such as a workshop? When participants with diverse backgrounds in a group engage in co-creation activities at workshops, how can knowledge that supports innovation be best expressed to facilitate effective communication, sharing, utilization, and co-creating output leading to solutions?

The authors conducted a series of social innovation workshops using multiple forms of external representation of knowledge to investigate how different forms of knowledge representation may impact the goal of effective idea creation through knowledge transfer. The base structure of the workshops was organized at Future Living Lab.

Future Living Lab is a two-year's research collaboration among a telecom company, a Name of Danish university (Denmark) and a Name of Japanese university (Japan). The lab aims at staging a future way

of living in 2030 through a collective design process with citizens. Starting in January 2022, the lab has provided collaborative design stages for co-creation through collective conceptualization, discussion, reflection, and makings towards wicked societal challenges (Buchanan, 1992; Rittel & Webber, 1973). In the first project year, 2022, the lab conducted three social innovation projects, and each project had a focused theme, such as 1) the Future of Food, 2) Community-based Childcare, and 3) the Future of Work. The project themes were chosen based on three criteria; closely related to everyday life, geographically rooted, and recognized as a societal challenge.

The following section will introduce workshop design, the selected forms of knowledge representation, and the applied evaluation criteria.

3.1. Social Innovation Workshop

The Social Innovation Workshops were conducted as design workshops, with four sessions for the three themes mentioned above. Participants of the workshops would collectively shape concepts and ideas for solutions to societal challenges. All workshops utilized the back-casting approach, envisioning 2030 as a near-future scenario.

The workshops were conducted between March 2022 and February 2023 (Table 1). Each session lasted approx. three hours, with several breaks interspersed throughout the workshops. The authors invited participants to join through the public recruitment process, targeting individuals interested in the specific societal challenges addressed.

Table 1. Workshop Schedule.

	1 st	2 nd	3 rd	4 th
The future of Food	March 23	May 24	June 21	Aug 2
Community-based Child care	Sep 17	Nov 7	Nov 29	Dec 13
The future of Work	Oct 31	Dec 7	Jan 11	Feb 24

Regarding the discussion theme, three topics were selected as mentioned above. "The Future of Food" is a topic that is relevant to everyone's daily lives. It is not only associated with relatively familiar social issues, such as food loss and diabetes, but also connected to larger-scale societal challenges, such as its impact on carbon dioxide emissions.

"Community-based Childcare" is a topic that aims to address childcare within the local community. In our society, interaction with neighbours has decreased, the isolation of parents raising children has become a significant societal challenge. This issue might be seen to target parents with small children at first sight. However, this challenge is not only limited to the

parenting generation but also to community in general. It is essential to consider individual families and entire community for envisioning a future childcare.

The "The Future of Work" is familiar topic to all, encompassing a substantial part of individuals' lives. We have witnessed significant transformations in the working landscape, notably driven by the emergence of novel work arrangements, such as remote work, influenced by the unprecedented impact of the COVID-19 pandemic. Moreover, concerns have arisen regarding the potential displacement of human labour by artificial intelligence (AI), propelled by advancements in AI research and its increased adoption in various societal domains. Additionally, a future decline in the working-age population is projected. Given the uncertain and uncontrollable nature of the future work environment and the necessity to consider diverse perspectives beyond one's own, the future of work is an apt subject for participatory dialogue.

Every topic has been related to all genders and all generations in a broad context. It can potentially transition from personal interest to social concern and scale its scope easily in terms of time and space.

3.2. External Representation for Workshops

The external representation of knowledge prepared for the workshops consisted of three forms: statistical data, videos, and the Human Library.

For statistical data, multiple sources were utilized, then knowledge were presented in the form of written texts, graphs, and other visual formats. The statistical data incorporated publicly available information from national entities and private companies obtained through online sources. The aim was to provide knowledge that deepened the understanding of the themes from various perspectives and helped participants recognize the relationship between the themes and their own experiences. The preparation of statistical data prioritized clarity and comprehensibility. Rather than simply listing numbers, efforts were made to visualize the data through charts and tables, accompanied by concise explanations. At workshops, these outputs were distributed to the groups in the form of printed materials, such as papers or cards, accompanied by oral explanations.

Regarding the theme of "the Future of Food", the statistical data included knowledge that could be readily associated with everyday life and information highlighting significant societal challenges on a larger scale. The external representation entailed presenting both knowledges that resonated with participants' daily experiences and showcasing cutting-edge developments, such as global trends in plant-based food.

For "Community-based Childcare", the statistical data incorporated perspectives beyond the direct participants in childcare. As the goal was to engage the entire community as stakeholders, the external representation reflected the viewpoints of individuals not directly involved in childcare. This approach aimed to comprehensively understand the topic and foster collaboration among diverse community members.

Regarding the "the Future of Work" theme, the statistical data aimed to broaden perspectives beyond the current working environments. It included information about the diversification of working styles, work environments, and value systems. Moreover, it highlighted emerging trends, such as changes in the perception of work time. The intention was to encourage participants to think beyond conventional notions and explore the expanding work possibilities. Below is a partial selection of the presented statistical data and an example of its representation (Figure 1).

Table 2. Selected Statistical Data.

Theme	Example of Extracted Statistics
The Future of Food	Veg. consumption trends per capita. Annual food loss generation. The impact of climate change on everyday food. Global sources of methane emissions. The proportion of land used for food production.
Community-based Childcare	Population and age distribution. A list of community support for parents with children. Experiences for parents with children. Relations between citizens without children and the local community.
The Future of work	Trends in the working-age population. Employment rate among older adults. International comparisons of well-being related to work. The relationship between telework and work motivation. The prevalence of side/multiple jobs.



Figure 1. Selected knowledge representations.

Movies were created by conducting exclusive interviews with extreme experts who are highly aware and have activities related to each theme. The interviewees were selected with consideration for diversity, including individuals ranging from teenagers to those in their 60s and both genders. The recorded interviews were edited to approximately one minute in duration. Six videos were prepared for The Future of Food, three for Community-based Childcare, and four for the Future of Work. Table 3 summarises selected statements and an example of representation (Figure 2) from a portion of the videos prepared for each theme.

Table 3. Selected Utterance from Expert Interviews.

Theme	Example of Extracted Knowledge
The Future of Food	I reduced meat consumption while the urgent need for climate change mitigation necessitates the utilization of autonomous vehicles. Various dietary styles, such as insect-based diets and veganism, have emerged. The quantity of food consumed is decreasing, with individuals willing to spend money on nutritionally beneficial food for their bodies.
Community-based Childcare	In parenting, important factors include a supportive community, collective responsibility in childcare, and the recognition that parents are imperfect individuals. When there is economic and psychological stability, concerns about others' judgments are less prominent, and people in the surrounding environment are more tolerant of children's noise and disruptions.
The Future of work	I work from 8:00 a.m. to 4:00 p.m. and am satisfied with their current arrangement, intending to maintain the same working pattern in the future. I prioritize reducing work hours to allocate more time for caring for grandchildren and engaging in leisure activities. The ability to work flexibly is highly valued in this regard.



Figure 2. Selected knowledge representations.

The Human Library serves as an interactive external representation of knowledge. We adopted the original concept of the human library, which is defined as "an event that gets strangers talking openly and directly with each other about prejudice (Simon, 2010)". In our workshop, an individual with deep expertise in the topics participated as a "human book," allowing workshop participants to engage in interactive dialogues with them. The expert actively interacted with the groups during the workshop, answering questions and facilitating discussions.

3.3. Evaluation Method

The authors collected two types of data during the workshop to understand the impact of each external representation of knowledge on the design process for social innovation. One is the social innovation ideas generated by each team as their solution to the challenges; the other is semi-structured interviews conducted with the workshop participants.

The two authors, researchers A and B, both with ten years of experience in Information Systems and Design Research, evaluated the social innovation ideas. The evaluation considered two dimensions; one is the maturity level of the final ideas presented, and the other is the influence of the three knowledge representations. Regarding the impact of the form of external representation of knowledge, we analyzed how their proposed concepts were influenced by the form of representation and to what extent. For example, two analysts examined whether there was an influence of "statistical data," "movies," or "Human Library" on the final concepts and then compared the results.

Semi-structured interviews with participants of the innovation workshop were conducted within one week after the workshop, with an average duration of 32 minutes. The interview questions were divided into three categories, as shown in Table 4, and for each category, follow-up questions were asked based on the responses. For example, regarding the created innovative solution, we asked, "How much do you think of your output as an innovative solution?" The interviews were recorded using Zoom or a voice recorder and transcribed afterwards.

Table 4. Three interview question topics.

1	Created innovative solution. Ex. How much do you think of your output as innovative solution?
2	Mindset and opinion change towards the topic Ex. Did you learn any or change your view on the topic by participating the workshop?

3	Influence of the three knowledge representations Ex. Do three presented knowledge representations influence your output?
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4. Results

4.1. Participants

An overview of the participants in the social innovation workshop is shown in Table 5. The participants consisted of experts and non-experts, including students. In each session, approximately one-third of the participants were experts or individuals with in-depth knowledge of the topic. The number of participants varied depending on the theme, ranging from 13 to 24 individuals.

The participants were primarily those interested in the specific topics solicited through general recruitment, while some students from the author's research laboratory also responded to the invitation and participated.

Figure 5. Attributes and Nr. of Participants in Each Theme

	1 st	2 nd	3 rd	4 th
Three Future of Food	21 (8, 13)	18 (7, 11)	22 (9, 13)	24 (8, 16)
Community-based childcare	14 (11, 3)	13 (4, 9)	20 (11,9)	15(11, 4)
The Future of Work	24 (12, 12)	24 (12, 12)	24 (12, 12)	24 (12, 12)

*(A,B) A=Professional, B=Non-professional

4.2. Workshop outputs

In a total of 12 workshops across the three topics, all groups submitted innovation ideas in the end. A summary of the analysis results regarding the influences of the three knowledge representations is presented in Table 6. Out of the 11 teams, five teams reflected the knowledge presented in the statistical data into their final concepts. Additionally, six teams incorporated perspectives and comments mentioned in the movies, while ten teams reflected at least some of the knowledge mentioned in the Human Library into their concepts. These results were also confirmed through interviews and supported by participants' comments.

Team	Future of Food				Childcare				F. of Work		
	1	2	3	4	1	2	3	4	1	2	3
Statistics											
Movie											
Human Library											

Table 6. Influence of Knowledge Representation.

4.3. Interview outputs

Among the 243 participants, 98 individuals participated in the interviews, accounting for 40.3% of the total participants. The interviews ranged from 17 to 63 minutes, with an average duration of 32 minutes.

Table 7. An Overview of Interviewee Participation

	1 st	2 nd	3 rd	4 th
Thre Future of Food	17/21	10/18	12/22	17/24
Community-based childcare	14/14	13/13	20/20	15/15
The Future of Work	21/24	10/24	4/24	7/24

5. Discussion

This research investigated the influences of three knowledge representation forms introduced to the three social innovation workshops to understand the impact of the form of external representation of knowledge in knowledge transfer at workshops.

The evaluation showed that presenting an external representation of expert knowledge is beneficial in social innovation workshops without doubt as a fundamental notion of knowledge transfer in the form of a workshop. Regardless of its form, knowledge sharing is a first step to making the design move (Ehn & Kyng, 1991), and in the context of innovation workshops, where non-experts gathers are particularly effective.

Experienced individuals can confidently express their opinions without supporting evidence, while beginners need more confidence. By having statistical facts, beginners can gain confidence to express their opinions. (Future of Food, Subject P)

One participant expresses the above comment on statistical data, which can be applied to all forms of representation. Particularly in such social innovation workshops where non-experts participate together with experts, having an authorized knowledge foundation makes it easier for individuals to express their opinions.

In the co-creation process, when all participants viewed the external representations and engaged in discussions based on that knowledge, the shared knowledge functioned as boundary objects (Star & Griesemer, 1989), fostering a common understanding and leading to co-created concepts among participants with different knowledge background. In situations where individuals with different knowledge come together for co-creation, providing knowledge representation accessible to all would serve as a concrete platform for discussion in such intercultural collaboration process (Yasuoka, 2015).

While there are common effects across the three external representations, each retains unique characteristics. We will discuss three distinct findings regarding the forms of external representations for knowledge transfer: information overload, the importance of physical presence, and the significance of interactivity.

5.1. Information overload

Statistical data appears to have been effective in knowledge transfer, as it influenced the proposed concepts by being explicitly referenced or touched upon in some statistical data. The influence of statistical data can be observed in five out of 11 teams in the solutions proposed. This broad usage of statistical forms of external presentation of knowledge indicates that statistical data is a compelling representation form for knowledge transfer in workshops, and the transferred knowledge is received, digested, and utilized by diverse team members during the co-creation process.

The interview results further support these findings. Statistical data is regarded as highly reliable and serves as material that strengthens each perspective. It provides a foundation for discussions, leading directly to generating ideas for potential solutions. Multiple interviewees commented on the contributing role of statistical data in their discussion process.

Regarding it [statistical data] as reliable data, the participants' initial vague ideas gradually evolved into more concrete solutions (Future of Food, Subject K)

On the other hand, there are doubts to which extent, the rich information provided by the statistical data was utilized. In the proposed solutions and interviews, there was almost no evidence of detailed data usage, such as graphs and specific numbers presented in the statistical data. It suggests that the utilization of statistical data did not involve in-depth analysis or a deep understanding of the fact backed-up by data, remaining relatively superficial. For instance, Subject F at the Future of Food Workshop expressed as following, and a similar response was mentioned by Subject H at the same workshop:

Due to time constraints, I could not delve deeply into the materials, but the data clearly served as a starting point for our discussions. In a way, the things we already knew were shown as data. (Future of Food, Subject F).

The knowledge shown in the statistics was already well known to us, but to be fair, we had only been aware of the facts. We had yet to consider the

implications or what it meant for the future (Future of Food, Subject H).

In this study, it can be argued that the external representation of statistical data resulted in limited understanding. Despite its excellent knowledge visualization using figures and tables in the statistical data, participants of the social innovation workshops presented challenges in deeply comprehending the underlying knowledge of the representation of the statistical data.

The primary reason for this limitation is believed to be the time allocated for participants to engage with the statistical data, which was approximately 20 minutes for each workshop. Simply put, the time constraint was insufficient for participants to digest and absorb the rich knowledge. Additionally, in social innovation workshops like the one conducted in this study, which involved diverse non-expert participants, there may have been variations in the maturity level required to interpret and comprehend the statistics as shown in another research (Yasuoka, 2021), potentially leading to information overload among participants. Therefore, while the potential for utilizing statistical data in the workshop cannot be denied, its effectiveness may depend on the composition of participants and their ability to process the rich knowledge.

5.2. Physical presence matters

This study observed that the impact of knowledge becomes more robust when the individuals behind that knowledge are transparently visible. Notably, there were multiple cases where surprising facts directly attributed to each participant's knowledge acceptance. Participants remembered and reflected on these impactful fragments and utilized them in the solution. This phenomenon was particularly evident in the knowledge conveyed through videos and the Human Library.

For instance, knowledge of veganism was mentioned in both statistical data, videos, and the Human Library, resulting in the proposed concepts such as "vegetable-based diet" and "avoiding meat". The interviews supported this tendency, with many individuals citing "being surprised" as their reason for retaining that knowledge. In other words, it remained in their memory not simply because knowledge was properly transferred but because they were surprised by the individuals who transferred it. For example, in one video from the "Future of Food", an elementary school girl presented reasons for importance of becoming vegan and avoiding meat. Many participants got the knowledge and reacted, probably not because it was novel or important knowledge but because a young girl

mentioned it. For instance, Subject F from "the Future of Food" workshop stated:

In the video, I learned something that was not present in the statistical data and that I myself did not know. I was shocked by what the little girl said about not eating meat. The authentic voice made me feel the human touch more than the statistical data did. (Future of Food, Subject F)

In some cases, the presented knowledge was interpreted differently by the participants from the original intention of the authors. The interviews exposed the participants interpreted and contextualized fragments of knowledge that had surprised them rather than simply understanding the facts described in the representations of knowledge. In the video, for example, the underlying message about adopting an environmentally friendly diet was overshadowed by superficial examples. Specific surprising topics such as "eating insects" and "not eating meat" mentioned in the video have been transferred as trustful knowledge rather than the perspective of adopting an environmentally friendly diet.

5.3. Interactivity matters

An interactive and dynamic external representation of knowledge was found to impact knowledge transfer significantly. The influence was observed to be greater with representations that interactive dialogue, such as Human Library, followed by the embodied real individuals, such as videos, surpassing the impact of statistical data. In the interviews, many subjects referred to the Human Library and mentioned knowledge they directly heard in real-time.

Participation [in the Human Library] allowed me to engage in the flow of discussion, which was beneficial in understanding presented knowledge. (Future of Food, Subject A)

I realized that there is a wide variety of work styles worldwide, and I became aware of my limited perspective. (Future of Work, Subject M)

These comments could be interpreted as follows. The possibility to deepen understanding on the spot when questions or doubts arise upon receiving knowledge is believed to contribute to facilitating understanding of knowledge and enabling smoother knowledge transfer. The importance of interactivity is well known in external representation (Kirsh, 2010) and also in learning behavior that acquiring new knowledge requires some actions (Kolb, 1984) and interactivity (Latilla et al., 2019).

However, the significance of interactivity in knowledge transfer extends beyond the Human Library in our cases. To our surprise, within the context of real-time interactive knowledge transfer, some group members' opinions in the workshop were unexpectedly given considerable authority. Even if these opinions were not evidence-based or merely represented a single individual's views, they occasionally significantly influenced the final innovation concepts. This impact of interactivity was comparable to the influence of authoritative knowledge presented in the form of statistical data, movies, and the Human Library. In some cases, it had an even more significant impact. Only a few but some of the final innovation ideas from certain groups showed little to no influence from the expertise provided by the experts. They were solely composed of the group participants' naïve opinions.

In the interviews, a few subjects referred to personal anecdotes from group members as trustworthy knowledge. Although there were instances where clearly inaccurate knowledge was expressed by team members, such comments occasionally gained authority as trustworthy knowledge from individuals with deep understandings on the subject matter and were not questioned. For example, in "the Future of Food", Subject K stated the following:

As H mentioned, cows do not impact environmental degradation. We must not underestimate the efforts made by our predecessors. (Future of Work, Subject K)

Even if there is a significant amount of knowledge provided based on statistics or academically validated evidence, it does not necessarily guarantee that they will be utilized in co-creation for social innovation. At times, we observed insights such as personal opinions that are not evidence-based could quickly gain authority within a group, highlighting the persuasiveness of face-to-face interactions.

6. Conclusion

In this study, we conducted a preliminary examination of effective knowledge transfer when conducting participatory design-based social innovation workshops. Currently, a wide range of possible forms for external representation of knowledge have become technically feasible with technological developments and have been proposed. We aimed to consider what forms of external representations of knowledge are suitable for knowledge transfer without being limited to traditional documents or knowledge visualization models.

Our social innovation workshops conducted in this study brought together diverse participants with different knowledge backgrounds, attempting to design innovative solutions to societal challenges based on authorized knowledge in workshops. In participatory design for social innovation, experts and non-experts are involved in innovation and participated in the design process. In such situations, the perspective of accurately transferring high-quality knowledge and leveraging it in the design process for innovation becomes increasingly important, especially given the current concern, such as echo chambers (Kratzke, 2023).

Our experiments revealed several insights regarding knowledge transfer within workshops, focusing on the form of external representation of knowledge, and the challenges associated with effectively utilizing knowledge. Statistical data was found to have high quality but was limited by the constraints of time for browsing and digestion, making it difficult to effectively use in workshops. It was also observed that individuals tend to remember knowledge with their interpretation, together with subjective impressions of the owner of the utterance. When they encounter surprising information, they tend to stick to the knowledge in innovation activities. Furthermore, interactive representations of knowledge, such as videos, or face-to-face interactions, were found to have a more substantial impact on their acceptance of knowledge.

This study employed qualitative analysis based on the collected data from four sessions of three social innovation workshops. Thus, generalizing the findings should be approached with caution. The results can be attributed to face-to-face interactions and contextual factors within the workshop setting, given that knowledge transfer was the focused agenda.

Moreover, this study highlights the importance of sensitively understanding the relations of the context, effective communicative facilitation, and the desired forms of external representation of knowledge, particularly in addressing social issues. Our presented work is the first step to appropriate a form of external representation of knowledge in the knowledge transfer at social innovation workshops. Without doubts, there are limitations in this work. For future research, conducting a quantitative analysis of the data collected in this study would be beneficial.

References

- Ahn, J., & Chang, S. (2004). Assessing the contribution of knowledge to business performance: The KP3 methodology. *Decision Support Systems*, 36(4), 403–416.
- Arnstein, S. (1996). "A Ladder of Citizen Participation." *Journal of the American Planning Association*, 35(r.),

- 216–224. <https://doi.org/10.4324/9781315748504-47>
- Boose, J. H. (1989). A survey of knowledge acquisition techniques and tools. *Knowledge Acquisition*. [https://doi.org/10.1016/S1042-8143\(89\)80003-2](https://doi.org/10.1016/S1042-8143(89)80003-2)
- Brandt, E., & Messeter, J. (2004). Facilitating collaboration through design games. *Proceedings of the Eighth Conference on Participatory Design Artful Integration: Interweaving Media, Materials and Practices - PDC 04, 1*, 121. <https://doi.org/10.1145/1011870.1011885>
- Buchanan, R. (1992). Wicked Problems in Design Thinking. *Design Issues*, 8(2), 5–21.
- Ehn, P. (1988). *Work-Oriented Design of Computer Artifacts*. Lawrence Erlbaum Assoc.
- Ehn, P., & Kyng, M. (1991). Cardboard computers: Mocking-it-up or hands-on the future. In *Design at Work: Cooperative Design of Computer Systems* (pp. 169–195). <https://doi.org/10.1017/CBO9781107415324.004>
- Fischer, G. (2000). Symmetry of ignorance, social creativity, and meta-design. *Knowledge-Based Systems*. [https://doi.org/10.1016/S0950-7051\(00\)00065-4](https://doi.org/10.1016/S0950-7051(00)00065-4)
- Greenbaum, J., & Kyng, M. (1991). *Design at Work: Cooperative Design of Computer Systems*. Lawrence Erlbaum Associates.
- Greenbaum, Joan, & Ave, F. (2010). Situations and Interactions : Digital café squatting and participatory design. *PDC '10: Proceedings of the 11th Biennial Participatory Design Conference*, 243–246. <https://doi.org/10.1145/1900441.1900492>
- Kensing, F., & Blomberg, J. (1998). Participatory Design : Issues and Concerns. *Computer Supported Cooperative Work*, 7(3–4), 167–185.
- Kirsh, D. (2010). Thinking with external representations. *AI and Society*, 25, 441–454. <https://doi.org/10.1007/s00146-010-0272-8>
- Kolb, D. A. (1984). *Experiential Learning: Experience as The Source of Learning and Development*. Prentice Hall, Inc. <https://doi.org/10.1016/B978-0-7506-7223-8.50017-4>
- Kratzke, N. (2023). How to Find Orchestrated Trolls? A Case Study on Identifying Polarized Twitter Echo Chambers. *Computers*, 12(3), 57. <https://doi.org/10.3390/computers12030057>
- Latilla, V. M., Frattini, F., Petruzzelli, A. M., & Berner, M. (2019). Knowledge management and knowledge transfer in arts and crafts organizations: evidence from an exploratory multiple case-study analysis. *Journal of Knowledge Management*, 23(7), 1335–1354. <https://doi.org/10.1108/JKM-11-2018-0699>
- Nisbett, R. (2003). *The Geography of Thought: How Asians and Westerners Think Differently...and Why*. Free Press.
- Nissen, M. E. (2023). A Method for Assessing Knowledge Flow Efficiency, Cost and Performance. *Proceedings of the 56th Hawaii International Conference on System Sciences*, 4871–4880.
- Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-creating Company*. Oxford University Press.
- Opland, L. E., Bley, K., & Pappas Illias O. (2023). Is Motivation always the Key ? – Antecedents of Employee-Driven Digital Innovation. *Proceedings of the 56th Hawaii International Conference on System Sciences*, 4818–4827.
- Page, S. (2007). *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies*. Princeton University Press.
- Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4(2), 155–169. <https://doi.org/10.1007/BF01405730>
- Sawyer, K. (2007). *Group Genius : The Creative Power of Collaboration*. Basic Books.
- Schuler, D., & Namioka, A. (1993). *Participatory Design: Principles and practices* (p. 334). Routledge.
- Simonsen, J., & Robertson, T. (2013). *Routledge International Handbook of Participatory Design*.
- Snow, C. P. (1993). *The Two Cultures*. Cambridge University Press.
- Star, S. L. (2010). This is not a boundary object: Reflections on the origin of a concept. *Science Technology and Human Values*, 35(5), 601–617. <https://doi.org/10.1177/0162243910377624>
- Star, S. L., & Griesemer, J. R. (1989). Amateurs and Professionals in Berkeley ' s Museum of Vertebrate Zoology , 1907-39. *Social Studies of Science*, 19(3), 387–420. http://www.lchc.ucsd.edu/MCA/Mail/xmcamail.2012_08.dir/pdfMrGHgzULhA.pdf
- Thoring, K., Mueller, R. M., & Badke-Schaub, P. (2020). Workshops as a research method: Guidelines for designing and evaluating artifacts through workshops. *Proceedings of the Annual Hawaii International Conference on System Sciences, 2020-Janua*, 5036–5045. <https://doi.org/10.24251/hicss.2020.620>
- Yasuoka, M. (2015). Collaboration Across Professional Boundaries – The Emergence of Interpretation Drift and the Collective Creation of Project Jargon. *Computer Supported Cooperative Work: CSCW: An International Journal*, 24(4), 253–276. <https://doi.org/10.1007/s10606-015-9229-2>
- Yasuoka, M. (2021). How to transfer tacit knowledge for living lab practice - Consideration on tacit knowledge representations. *Proceedings of the Annual Hawaii International Conference on System Sciences, 2020-Janua*, 5131–5140. <https://doi.org/10.24251/hicss.2021.625>
- Yasuoka, M. (2006). Collaboration Support in the Initial Intercultural Collaboration Phase. *Participatory Design Conference, Vol.2.*, 129–132.