Making Technology Matter for Processes of Co-Creation and Innovation in Cross-Sectorial Collaborations

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***Abstract*—This article discusses the use of different representations of technology to expose, inform and engage participants taking part in co-creation activities. In our project, the participants co-create an activity to support the learning of cultural heritage. We build our research on the "design choices framework", which provides a convenient structure for co-creation projects, but does not address the role of technology in such projects. We discuss the benefits of adding a technology choice addressing how to enhance co-creation processes and improve the utility of the framework. By representing technology through, e.g., images, demos, and prototypes, appropriately in different stages of our co-creation project, we see a clear, positive impact.**

Keywords-co-creation; design; design choices; innovation; cross-sectorial collaboration; technology.

I. INTRODUCTION

To address increasingly complex societal challenges, it is imperative to collaborate across organizations and different sectors and conceptualize innovative approaches to tackle them. Involving multiple stakeholders working toward a shared goal, however, creates difficulty in balancing their interests [1]. Taking inspiration from the field of Participatory Design (PD), we look to create a shared understanding through representational tools focusing on ICT solutions, and by this, facilitate for co-creation. Many projects implement co-creation as a process, agenda or tool [2]–[4] to support design and innovation. Lee et al. [4], attempt to provide some structure to the co-creation process through their 'design choices' framework. While this framework is mostly based on technology design projects, there is little focus on the representation of technology and its impact on the co-creation process, which is becoming increasingly relevant [5]. Bjögvinnson et al. [6] discuss the importance of representations to introduce new technologies and make it more accessible for a broader range of stakeholders. In our project, we focus on finding ways to represent technology in co-creation processes and seek to strengthen Lee et al.'s [4] ´design choices´ framework. The technology aspect was fundamental for our design process, having a strong impact on the co-creation experience, and in turn, the project results.

The research has implications for organizations looking to incorporate technology into their co-creation process, and for designers seeking to facilitate stakeholder engagement and drive innovation. The guiding question that is addressed in this paper is: in what ways can the representation of a diverse range of technology be used and be of value in co-creation processes?

We attempt to answer this question from our work in the pARTiciPED project. The overarching goal of the project is to explore a way for teachers in Norwegian schools (current and upcoming), to collaborate with external partners from various cultural institutions, and co-create innovative ways of teaching, resulting in a more engaging, enjoyable, and integrated (in terms of the overall school curriculum) learning experience for secondary school students. The external partners could be artists, musicians, actors, or in our case, museum educators. We, the designers, have facilitated the co-creation process through a series of workshops following the principles of PD, such as 'having a say' and 'mutual learning' [7], and incorporated the representation of technology through various tools, such as interactive prototypes, design cards, images and demonstrations.

In the following, we present the Design Choices Framework developed by Lee et al. [4]. Then we describe our project in relation to the framework, focusing on the impact of the technology choices we made, followed by a discussion on how the framework could benefit from an additional design choice related to how technology should be represented. In conclusion, we present the potential societal impacts of the improved co-creation processes.

II. DESIGN CHOICES FRAMEWORK FOR CO-CREATION

Lee et al. [4] present their design choices framework to build an understanding of what kinds of dimensions a co-creation project consists of, and which attributes and alternatives are relevant when planning and conducting such a project. The framework consists of ten design choices: *1) Openness of the brief*, describing the mode of inquiry with which the project approaches the goals of co-creation, *2) Purpose of Change*, elaborating on what and why certain changes are necessary to be achieved through the co-creation project, *3) Scope of Design* which is often closely related to the purpose of change, but rather than focusing the long term impact of the project, looks at what specifically will be designed during the co-creation process, *4) Diversity in Knowledge*, bringing together stakeholders from different fields of expertise with comprehensive knowledge of the product, service, or process they are developing, *5) Differences in Interests*, requires careful planning to incorporate stakeholders' interests, manage the complexity of

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their relationships, and potential conflicts, *6) Distribution of Power*, as power dynamics may be influenced by the stakeholders' knowledge, interests, roles and backgrounds but also between designers leading the co-creation activities and those participating; designers need to be aware of their role as facilitators, and decide how active or neutral they will be in the process, *7) Types of Co-creation Activities*, refers to the different events throughout the project, or stages within a single co-creation event that may include techniques such as future workshops, or generative tools to share, disseminate and create knowledge *8) Setting for Co-creation*, making sure that the location and materials used can greatly impact the success of a co-creation, *9) Outputs of the Project* can refer to what is created by participants during the co-creation activities, but can also be in the form of consolidated reports and proposals by researchers or designers, both of which can range from ideas for concrete changes and their visualizations (e.g., improvement ideas, touch points, customer journey maps) to new service concepts (e.g., scenarios, videos, service blueprints, and process models) to future strategies (e.g., a set of experience goals and future roadmaps), *10) Outcomes of the Project* refer to changes achieved on a larger scale, such as changes in mindset, processes, and culture, which have a direct impact on the target population. These design choices are further grouped into four categories where they can be related to the following: *Project Preconditions* (design choices 1-3), *Participants* (design choices 4-6), *Co-creation Events* (design choices 7-8), and *Project Results* (design choices 9-10).

III. METHODS

The design process for the project was iterative, as presented in the timeline in Figure 1. We used both participatory prototyping, design cards and probes in our workshops [8]. Brandt et al. [9] present 'the making of things as a means of design participation', which is what we did. A variety of methods, such as observation and interviews, were used to gather data during the co-creation activities. Observation as a research method enables the study of a phenomenon in 'naturally occurring settings' [10][11]. In other words, for our research, we gain knowledge about how different participants experience the collaborative design process by directly observing their interactions in real-life situations and retrospectively through audio recordings, notes, and photographs. Interviews enable the capture of people's point of view, with reflections and rationalizations. In this study, we undertook semi-structured interviews with some of the participants [12]. By analysing the data gathered, with a plan, act, reflect approach [13], we were able to unpack several aspects of the co-creation process, relevant to strengthening the design choices framework.

Throughout the duration of the project, we conducted a total of nine workshops. Four of these workshops were with 4th-year pre-service teachers, which we call student workshops. Five smaller workshops were conducted with the project group, including museum educators and teachers. We call these group workshops. All of these workshops took place over a period of nine months, starting from when we held our first workshop on the 10th of June 2021, until our final workshop on the 4th of March 2022. This timeline is presented in Figure 1. The group workshops consisted of 8 participants, 3 females and 5 males. These participants represented the Østfold Museums (1), the department of education at the Østfold University College (1), secondary school teachers (2) in Viken county, pre-service teachers (1), and designers (3). The main participants for the student workshops were 51 pre-service teachers who were currently in their 4th year of the teaching studies. All participants of the project provided written consent to participate in the project and all its relevant activities. The participants were informed about how the data would be collected, analysed, and stored, as well as who would have access to the data. The data collection was reported to the Norwegian Agency for Shared Services in Education and Research, a public administrative body under the Ministry of Education and Research.

We will now use the design choices framework to present and give a rich description of the project, before moving further to our findings related to how representational tools made technology matter in our workshops.

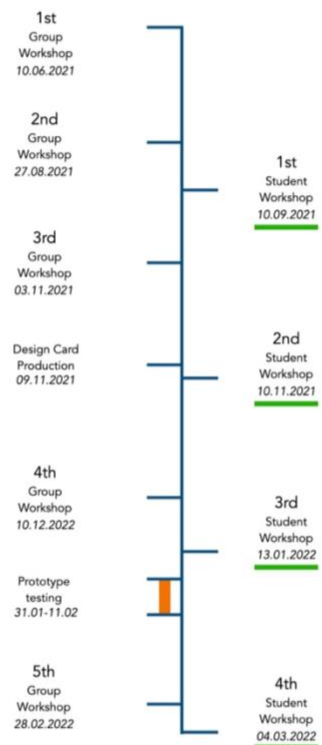

Figure 1. Project Timeline

A. *Design Choices Related to Project Preconditions*

1) *Openness of the Brief*

The goal of the pARTiciPED project is to improve cross sectorial collaborations in schools and more specifically how the school sector and cultural sector collaborate in The Cultural Schoolbag' (TCS), a program set up to provide cultural experiences to Norwegian school children. As the

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scope was open-ended (focusing on cross sectorial collaborations), the process was also exploratory, enabling us, the design researchers, to create and experiment different types of co-creation methods. There was an additional component to the brief, which was to explore how to create a mixed reality learning experience fitting TCS. Thus, to focus on XR technology throughout the co-creation process, was central.

2) Purpose of Change

In accordance with the open-ended brief, the project team focused on supporting the collaboration between museums and schools, fostering innovation and new ways of thinking through access and exposure to technology. Being exposed to and having participated in co-creation activities, we expected the project members to have a more positive attitude toward collaboration with each other and a better understanding of each other's expertise, needs and priorities. This would in turn serve our purpose of improving the current TCS program.

3) Purpose Scope of Design

As the main purpose of change was to enhance collaboration between multiple organizations, leading to a better TCS program, the scope of design would be on two different levels. One would be to develop co-creation tools and techniques to support cross-sectorial collaboration. The other would be to design digital concepts with complementary teaching curriculum that provided high school students with a more interactive and engaging experience of cultural heritage as part of a TCS activity.

B. Design Choices Related to Participants

1) Diversity in Knowledge

The group participating in the activities represented a high diversity of knowledge: the museum staff had extensive knowledge of cultural heritage including history and artefacts, and the how to disseminate that knowledge; the teachers could bring in their experiences in the field related to the school and teaching processes; the pre-service teachers would also bring in a certain amount of knowledge about teaching, based on their education and previous practical experiences; lastly, the design researchers brought their expertise in design—on the co-creation process and tools applied.

2) Differences in Interests

The design researchers needed to design the process in a way that would support the different interests of the participating stakeholders. The teachers wanted to contribute their expertise in making the experience being designed relevant to the students, the schools and for achieving the learning objectives set out by the government. The teacher-educator's main interest was to provide a relevant learning experience for her students, the pre-service teachers. The pre-service teachers had the primary objective of completing their course in the best way possible. The museum educators were keen to attract the students and make the interested in cultural heritage. The design researchers wanted to develop and experiment new types of co-creation methods.

To accommodate for the negotiation of these interests, we employed various kinds of visual objects and facilitation techniques, for example, mind maps, simulation, scenarios, and idea generation with design cards.

3) Distribution of Power

As the design researchers were the ones at the helm of the project, there was an inherent imbalance of power biased toward the designers, especially since we were choosing the methods to be used. Additionally, the young pre-service teachers who were participating in our workshops, looked up to the more senior teachers, and the museum staff, as authoritative figures. While some authority was needed to conduct the project and its activities, the designers carefully maintained their role as facilitators.

Through participatory design techniques [9], we enabled the project members, and the pre-service teachers participating in our workshops, to contribute with knowledge, ideas, and opinions in different forms. We paid special attention to the power imbalance when designing co-creation activities to engage the participants, regardless of knowledge backgrounds. For example, we introduced various technologies and let the participants try them out to create a common understanding of the possibilities the technologies could provide.

We focused on creating possibilities for teachers and museum staff to share their knowledge and present their ideas. Rather than making creative inputs ourselves, we helped the pre-service teachers perform the co-creation tasks, for instance with the design card game. In the co-creation workshops, the pre-service teachers were asked to reflect on the theme and current challenges from the viewpoint of teachers, to then work on a relatively new concept for a future curriculum, based on the content that was discussed, and the technology that was presented.

C. Design Choices Related to Co-creation Events

1) Types of Co-creation Activities

Our choice of co-creation activities for the project were selected based on the purpose of change and the scope of design. We also considered the knowledge, interest, and power distributions among the participants. The project included a series of workshops leading up to the trial and testing of a prototype learning experience in the field. We conducted two large scale workshops in addition to several smaller workshops within the project team. In the following section, we will focus on the two large workshops.

The first large workshop involved the project members and a class of 51 pre-service teachers, designed to create a shared understanding between the stakeholders. The museum representative set the scene by introducing the theme of Moss town's industrial history. The teacher educators then introduced the current curriculum and teaching goals set for Norwegian secondary schools. In this workshop, we led 3 activities. We first presented current and emerging technologies that are, or could be, used by museums to provide cultural heritage education. Then, we conducted an online 'digital literacy' survey. Lastly, we created a technology probe in the form of a webapp that allows the user to create video, image, or text content and geolocate it on a map. The students used this to create content presenting different parts of the university campus. Through these activities, we were able to learn about how comfortable the pre-service teacher participants were with different forms of technology. At the same time, the participants were exposed to new technology and were given the opportunity to become aware of their possibilities. This was crucial to us, to plan the way forward and reflect on which technologies the pre-service teachers were comfortable with using.

The second large workshop was focused on ideating concepts for a TCS learning experience, and for this, we created a design game using a bespoke deck of design cards. The concepts developed in the workshop were later used to inform the development of a working prototype and tested in the field with secondary school students in the county. All pre-service teachers were allocated practical training / internships for 4 weeks, at various schools. During this period, they would dedicate two classes to run the TCS activity. They had some time beforehand to use the tool themselves and implement it as part of the lessons. We observed six classes across four schools, from the 31st of January to the 11th of February 2022. In some cases, we were able to follow up with interviewing the pre-service teachers conducting the activities, immediately after the class.

2) Setting for Co-creation

To encourage the participants to be motivated and productive, we paid careful attention to the physical setting, materials, and atmosphere of the workshops. The pre-service teachers commonly sit in rows, listening to lectures from their professors, so for the indoor part of our workshops, we arranged the tables into groups, where four to six participants could sit around each table. By this, the participants were able to interact with each other much more easily and be active in the creative process. This proved to be particularly useful when doing the design game, as the physical setting not only allowed for better interaction within the group, but also made it easier to arrange the cards on the table, and to draw/sketch their proposals. One activity required the participants to spend time around the campus, to build a virtual museum with one of the technologies that was presented to them. Not only did this provide very valuable results as to how the technology was perceived, but it also created a much more enjoyable experience for the participants, which was apparent from the creative content they created during the activity, and from feedback in the surveys given at the end of the workshop.

D. *Design* Choices Related to Project Results

1) Outputs of the Project

Over the course of the workshops, there were several artefacts that were created, and data was collected in various formats including audio recordings, observation notes, and photographs. After the first workshop, we had questionnaire responses regarding technology literacy, and mind maps that the participants had created of the cultural heritage themes related to the selected case for our project (industrial history of the city of Moss). The participants also created a virtual museum/digital campus guide containing content created by the participants, using a purpose-built web-application enabling the creation and publishing of geo-tagged media content. The results and data from this first workshop were analysed, and subsequently informed the design of the second workshop, for which we, the designers also produced a customized deck of design cards. The design cards were also based on a combination of the results from the workshop, and a follow-up workshop conducted within the project team. The design cards themselves, can also be considered as an output of the project.

At the end of the second workshop, each group produced complete concepts for a TCS activity. These were documented and visualized on an A3 sheet of paper and presented to the entire group. Based on these concepts created by the groups, a member of the design team built a web-based tool, that would enable the pre-service teachers to carry out their planned teaching activities. The third workshop, which we had to do digitally, resulted in concrete teaching plans created by the participants, which could then be implemented in the secondary schools that were participating in the project.

Following this third workshop, the design team built a new and improved web-based application with which the pre-service teachers implemented their planned teaching activities. The design team was also able to collect data by visiting the schools, observing the activities, taking notes, and through follow-up interviews with the pre-service teachers.

TABLE I. OVERVIEW OF TECHNOLOGY REPRESENTATION AND CO-CREATION ACTIVITIES

Tools	*Event*	*Goals*	*Participants*
Oral presentation	Group workshop 2	Scoping, Introduction	Pre-service teachers Museum staff
	Student workshop 1	Introduction	
Surveys	Student workshop 1	Understanding participants' familiarity with technology	Pre-service teachers
Images	Group workshop 2	Scoping, Introduction	Pre-service teachers Museum staff
	Student workshop 1	Introduction	
Design Cards	Student workshop 2	Idea generation Concept development	Pre-service teachers
Demonstration	Student workshop 1	Increasing familiarity	Pre-service teachers Museum staff
	Student workshop 3	Increasing familiarity Concept Development	
Interactive prototype	Student workshop 1	Increasing familiarity	Pre-service teachers
	Student workshop 3	Hands-on experience Idea generation	
	Field testing	Identifying pros and cons	

2) Outcomes of the Project

In addition to the tangible outputs of the project, there were additional outcomes from each activity as their goals were achieved. This is shown in 0These could also be a basis for change in the way the museums, the teachers, and those in charge of the TCS program collaborate and design future teaching experiences. Regarding technology, there was increased awareness of, and familiarity towards, technology among all participants and an increased willingness to incorporate technology to improve and reform existing processes.

IV. RESULTS

It was clear that the different technology representations had a positive impact on the activities, and consequently on the results. In our first three workshops (two group

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workshops, one student workshop), we were working to build a shared understanding of each other's expertise, and interests.

A. Group workshop 1

Already from the first workshop, we highlighted the technological possibilities. Except for the designers, the members of the workshop initially had little to no concern for the technological aspects of designing a XR learning experience. It was only towards the end of this first introductory workshop that we briefly introduced the possibilities of using Augmented Reality (AR), Virtual Reality (VR) and projection mapping technology to create a learning experience. We proposed the use of these interactive technologies to digitally co-create historical artefacts and sites. Subsequently, the other group members reacted positively, and hinted at the fact that "this could be an interesting way to present cultural heritage to the students". They provided no further input or elaboration, however, which leads us to believe that they had not really thought about how technology could be used to increase engagement and curiosity among the target secondary school students before now.

B. Group workshop 2

In the second workshop, which took place at the Moss Town and Industry Museum (Moss, Norway), we again briefly discussed the technological possibilities verbally. Here the goal was to learn about Moss and its history, as well as plan how we would conduct the first workshop with the pre-service teachers. We would also have to decide how to present the technology for the participants at the upcoming workshop, and thus we, the designers would again present several technologies that could be relevant. Interestingly, building on the discussions from the previous workshop, both the museum representative, and one of the teachers discussed how certain technologies could be relevant. The museum representative suggested to create a 'digital assembly line' which would, through VR, allow the students to experience what it was like to work on the assembly line of a factory. A second suggestion from the teacher educator was to use AR technology, so the students could walk around their own towns and place 3D models of historical buildings and artefacts there.

C. Student workshop 1

In the third workshop, now involving pre-service teachers, technology was represented in many forms: oral presentation, images, interactive prototype and surveys. Through the different representations of technology, we tried to make the participants familiar with some relevant technologies while at the same time get a better understanding of how familiar the participants already were. In this workshop, we led three technology related activities. We first presented current and emerging technologies could be used by museums to teach about cultural heritage. This was done through an oral presentation, supplemented by images and video of relevant examples. We then conducted an online 'digital literacy' survey. The survey included general questions about the participants' use and familiarity with technology, and specific questions regarding technologies such as VR and AR. Responses from the survey showed a varied level of familiarity with the presented technologies.

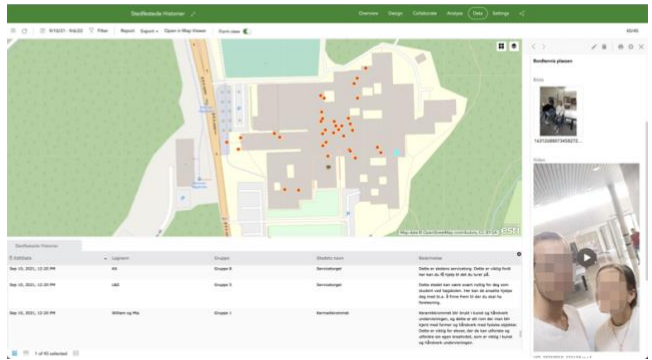

Figure 2. Virtual museum application

We also developed an interactive prototype in the form of a web-based application, that allowed them to create video, image, or text content and automatically incorporate its geographic location from the participants' device. The students essentially created a 'virtual museum', presenting different parts of the university campus, and describing its significance (see Figure 2.

There was a clear positive transformation in the participants' attitudes from when the technologies were presented orally, to when they themselves got to try out the technology. They were much more engaged and seemed to care much more about the entire process. This was apparent when several students exclaimed that initially they "did not quite see how the presented technologies could be relevant in the context of teaching cultural heritage to secondary school students". On the other hand, after the 'virtual museum' activity, most students expressed that "this could be very relevant in the given context". There were many more participants engaging in discussions after the activity, and this was also evident in the subsequent survey responses. They were also excited to share the content they had created in the application and so, due to popular demand, we presented many of their videos in front of the entire group, which also turned out to be quite entertaining.

This understanding was crucial for us designers, to plan the way forward. How could we further incorporate technological aspects in our future co-design activities, while considering the participants' familiarity with those technologies?

D. Student workshop 2

In this workshop, building on our previous activities, we needed a way to represent technology that would facilitate brainstorming and creativity. We chose to organize a design game using a bespoke set of design cards. Technology was one of the key categories in the deck. We were able to identify four relevant categories that needed to be addressed when creating a TCS activity. These were the following: things, requirements, actions, and technology. We identified nine 'things' that were relevant to Moss town's industrial history, thirteen 'requirements' from a pedagogical point of view, ten 'technologies' that could be used and twelve 'actions' that

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could be encouraged. Each card had a title, colour code indicating the category, and a relevant image in the background that provided a visual cue to the title.

Figure 3. Student Workshop 2 – Design Cards

We facilitated the design game to let participants design their ideal concepts (see Figure 3. Using the different categories of cards, the pre-service teachers were able to sketch three concepts. In a second round, participants were asked to identify and select the good parts from all three concepts and design a final concept that would be presented to the class. Technology became the cornerstone of all the concepts that were presented. 9 of the 11 groups in the workshop included some form of technology as a central part of their proposals, with most incorporating several technologies as evident in Figure 4. The example to the left proposed using AR to recreate important historical figures. The example to the right proposes the use of maps and simulation games to get acquainted with the cultural heritage and history, and then create content about some historic event that can be projected Figure 4.

Figure 4. Workshop 2 concept examples, incorporating AR, projection mapping, maps, and simlation games as technological components

E. Student Workshop 3

This workshop was conducted online due to COVID-19 restrictions. We created a demo toolkit in the form of an AR app. This was both a demonstration of the technology, but also allowed the participants to try it out. The goal of this workshop was to conceptualise and plan a larger activity for secondary school students based on the available technology. Participants were to incorporate this demo app into a concreate TCS activity. The app was created using Facebook's Spark AR. The pre-service teachers created a lesson plan including how they would introduce the information about Moss town's industrial history, how they would introduce the toolkit, and how they would incorporate the activities using the toolkit into the learning activity. Again, the app was central to the teaching plans they all made.

F. Field testing

The goal of this activity was to evaluate the outcomes of the previous workshops in the real world, and so, we needed to provide a working technological artefact that could be given to the secondary school students to use. Based on the results of workshop 3, we built a more complete version of the AR tool in the form of a web-based application. The application allowed the students to take pictures of themselves, use filters to apply historical clothing (e.g., uniforms) to the pictures, and place that composite image onto a historical background. The complete image was then used as the basis for more discussions in the class. The secondary school students enjoyed using the application, uploading pictures, putting on filters, and writing stories about what they had made (Figure 5.

Figure 5. Testing web app in secondary schools

As the students were introduced to the web-application, there was increased discussion and dialog between the students and the teachers, as well as among the students. Some students used their mobile phones while some used tablet devices provided by the school. Some groups were also allowed to go out of the classroom to create their content. They were being physically active, running around, posing for the pictures, and applying a variety of filters and background images. Subsequently they discussed what backstory they had conceived to create their final images. One group, for example, placed their own images in front of a group of factory workers, and used that as a basis to discuss the poor working conditions at the time, how the workers would look after each other, and how they later formed unions. Some groups incorporated our application into a larger workflow consisting of other tools they had on their computers. For example, after having generated an image using our tool, some groups further placed that image into a PowerPoint presentation, added more text, recorded audio to narrate their story, and finally combined all of this to present to the class. How the students were able to make this tool their own, and use it creatively in combination with other tools, was a clear signal of how introducing new technology, can lead to solutions and concepts that might not have been conceived otherwise.

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G. Student Workshop 4

Following the field testing, we had a final workshop with the pre-service teachers. The goal of this workshop was to reflect on the entire co-creation process, the outputs, and the final application in schools. We did not introduce any new technology, nor did we have any specific part of the workshop dedicated to technology. By now, technology had been applied to the problem, informed the concepts that were developed, and constrained the activities that were carried out in the field. However, the participants were given a final chance to design a teaching activity based on their experiences from the field. Surprisingly, almost all groups had very similar concepts, which resembled the activities they had just conducted in the field and proposed minor improvements to how the technology should be used.

H. Summary

From the first to the final workshop, we used several forms of representation to present and involve technology. Initially, when the brief was relatively open, we presented different technologies in a more general way through simple representations such as images, through surveys and orally. This allowed us to gain an understanding of the participants' familiarity with different technologies (and technology in general), spark curiosity among the workshop participants, and allowed them to imagine new possibilities involving the use of technologies. We also presented a simple working prototype (virtual museum application), which allowed the participants to become more familiar with AR, and thus become more comfortable the application. Participants started to discuss how the technology could be relevant to the larger problem we were trying to address.

To facilitate idea and concept generation, we incorporated technology in the form of design cards. This allowed the participants to be part of a creative process combining their budding teaching expertise with their newfound knowledge of different technologies, resulting in innovative and realizable concepts. As the concepts became more certain, and context-specific, we could then create high-fidelity technology probes to be used in the real world, and incorporated into larger, more complete teaching/learning activities. As these activities were conducted in secondary schools all over the region, we could also reflect on the pros and cons of those activities, and how they could be improved.

In the final student workshop, following a period of field testing, we also noticed that after having used the high-fidelity probes, it was difficult for the participants to think creatively, as their thinking was very constrained by familiarity with the application they had used. It thus became clear that how the technology is represented matters greatly for what outcomes are achieved in the co-creation process. Low-fidelity, general representations of technology provided the opportunity for creativity and innovation, while high-fidelity representations were more useful for critique and improvements. This leads us to discussing why technology and its representation is also an important design choice.

V. Discussion

What was apparent from all the activities in the different stages of the project was that including an appropriate representation of technology in the right stage of the co-creation process, directly impacted the results of each activity as well as the entire process. We observed three major effects of including a technological aspect throughout our co-design activities.

First and foremost, there was a clear increase in engagement when the workshop participants were introduced to novel technologies and their capabilities. The discussions became more active, more questions were asked, and more suggestions were offered.

Secondly, by being able to interact with, and try out the technology themselves, initially on a smaller scale, the participants gained a level of mastery they could use as a resource later in the process.

Finally, having gotten a good understanding of the technological possibilities, the participants were able to suggest realistic and innovative concepts that incorporated the technology in relevant and beneficial ways.

Judging from the positive impact of technology in the co-creation process, we believe 'representation of technology' should be an additional design choice that needs to be considered when planning co-creation projects. We see that identifying technological possibilities can help with several aspects of Lee et al's [4] design choices framework.

- To help define the *scope of design* as the choice of technology will both limit, and guide it;
- balance the *distribution of power* by familiarizing all participants with the technology;
- enhance *activities* and *settings for co-creation* by providing supportive tools for co-creating with technology;
- help generate *outputs of the project,* as technology is both the means and goals in many co-creation projects; and finally,
- contribute to a new mindset among the participants that is more aware and positive to technology, a first step towards becoming lasting *outcomes of the project* activities.

It must be noted, however, that the choice of technology and its representation must be appropriate to the stage of co-creation, and in accordance to how familiar the project participants are with the technology. One of the challenges in any co-creation or indeed in all co-anything processes is mutual learning [13] and mutual understanding. A shared or common understanding of possibilities, limitations and challenges is the goal with any co-anything processes. At the same time there must be room for respect and wonder about what unique understanding and engagement there is from the different stakeholders.

One approach to make representations of diverse range of technologies is to invoke the concept of familiarity. We are familiar with the tools, technologies, and environment we live in. By focusing on familiarity, we build on people's and user's pre-existing involvement, understanding and relationship of the "everyday" world, such as naive physics (up, down), our

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own bodies and the surrounding place, or things we use in everyday life. The familiarity concept is introduced by Turner [13] to HCI and inspired by other concepts such as the use of metaphors, analogies, similarities and resemblances. The familiar is often what we are comfortable and safe with. What we are unfamiliar with, are often things that we do not engage with, have no skill or understanding of and are foreign to. To move from something that is unfamiliar and making it familiar is what we often do when learning something "new", and hence the concept is used in pedagogies [14].

One way to operationalize the concept of familiarity in the context of representing technologies and tools is to investigate the three underlying human phenomena of: Understanding of, engagement with and relationship in. In what way do you understand this tool in use? In what way are you engaged or involved with it? And what kind of relationship do you have with this technology or tool in your everyday life? This may be strong indicators of degrees of familiarity with tools and technologies. And learning about the familiarity of tools and technologies among the various stakeholders might then be applied and used when representing technologies and tools in co-design processes that make sense and that engage the participants.

Through such engaging co-design processes, the relevant stakeholders can become active participants contributing to a variety of different design goals, such as: design for experiencing, design for emotion, design for interacting, design for sustainability, design for serving, or design for transforming [3]. Familiarity with technology can first and foremost be a resource, which can be a building block for effective co-creation, as we have discussed in reference to the design choices framework [4]. Through its understanding, designers can suggest the right representations of technology, at the right stages of the co-creation process, with the right participants. Additionally, as the co-creation process progresses, exposure, interaction, and engagement with different representations of technology can help build this familiarity even further, leading to even more insightful participation, better design choices and more innovative and relevant outcomes of co-creation.

VI. Conclusion

Technology matters, as does the practice of co-creation, especially when addressing the increasingly complex challenges of today's society. We have found that using different representations of technology can significantly enhance co-creation processes and improve the utility of existing frameworks, such as the design choices framework. By representing technology through images, demos, and prototypes, we have seen a clear and positive impact on participant engagement and collaboration. We believe that further exploration and experimentation in the use of technology in co-creation projects can help to create more inclusive and equitable design processes.

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