# Exploring Technology Probes in Co-Creation

Understanding Stakeholders' Familiarity with Emerging Technologies for Socio-Technical Innovation

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***Abstract*— Designers facilitating processes of co-creation to innovate socio-technical solutions often have the need to better understand stakeholders' familiarity with the technologies being addressed. This article investigates the utility of technology probes to elicit such insights from participants concerning emerging technologies, such as Augmented Reality (AR) and Virtual Reality (VR). Focusing on an early phase workshop in a multi-stage co-creation project, this study scrutinizes the utilization of a custom-built application as a technology probe. Findings from the workshop shed light on how the technology probe elicited the participants' varying levels of familiarity and perceptions regarding the technologies in question. These insights enabled the designers to customize how technologies were mobilized and used in creating the representational tools needed in facilitating for further co-creation activities.**

***Keywords-co-creation; co-design; technology probes; participatory design; mixed reality; cultural heritage; education.***

## I. Introduction

In recent years, technology probes have gained prominence as valuable tools in the pre-design stage of co-design frameworks, facilitating exploration and understanding of emerging technologies within specific contexts [1]. As described by Newaz, Karlsen, and Herstad [2] "the pARTiciPED project, jointly financed by the Norwegian Research Council and the Østfold University College, aims to undertake research on how cross-sectorial collaboration can lead to better ways of learning for future generations. The overall goal of the project is to develop concepts and principles to explain how Cross-Sectoral Collaborations (CSC) should be organized and implemented to secure transformative mutuality. Further, the goal is to explore and provide empirical evidence on how to organize and implement CSC in teacher education, to empower teacher students as confident, interested and engaged autonomous actors in these projects. This may improve and enhance the student teacher's pedagogical toolbox and strengthen the research-based foundation for educating new teachers." Throughout the project, the student teachers (from Østfold University College) collaborated with museum educators (from Moss town and industrial museum), teacher educators (from Østfold University College) and us (as designers), in order to co-create a technology-assisted teaching activity, as opposed to traditional lectures with limited scope for engagement and interactivity. The aim of the activity would be to help middle school students actively learn about their cultural heritage, more specifically the industrial history of Moss town. Within this framework of co-design, understanding the role of technology probes becomes imperative, particularly in gauging participants' familiarity and perceptions of emerging technologies. This may include technologies, such as Augmented Reality (AR) and Virtual Reality (VR), which may enable a greater engagement among students within educational settings. Reflecting on our pre-design workshop, we discuss the role of technology probes in understanding the participants' familiarity with technology, and how the process itself may contribute to building familiarity. In the following sections, we discuss existing literature with regards to co-design and technology probes (Section II), present our methodology (Section III), discuss our findings (Section IV) and finally present our conclusion and plans for future work (Section V).

## II. Related work

Theoretical underpinnings of co-design frameworks emphasize the importance of active participation and engagement of stakeholders throughout the design process [3]. Technology probes serve as lightweight interventions or artifacts that elicit responses and insights from users, thereby informing the design process [1]. In the context of the pARTiciPED project, probes were chosen as a means to understand the student teachers' attitudes towards technology in general, as well as a specific technological solution prepared specifically in the context of the project.

Hutchison et al. [1] describe technology probes to be a specific type of probe that can serve multiple goals: social - they gather information about technology use and users in real-world settings, engineering - field-test the technology, and design - inspire users and designers to envision new technological solutions. A well-designed technology probe must strike a balance between these different disciplinary influences. From a social science perspective, technology probes depart from the notion of collecting ‘unbiased’ ethnographic data. Rather, they acknowledge that the introduction of probes may alter user behavior. In the first workshop of the pARTiciPED project, which we consider as part of the pre-design stage of the co-design process [4], the focus was on the social goal, observing changes in the student teachers’ attitude towards and their understanding of the technologies presented. However, as the project progressed to its generative stage, the focus shifted towards the design goals, exploring the possible implementation of these technologies as part of a future solution.

From the perspective of design research, technology probes draw parallels to cultural probes, such as those introduced by Gaver, Dunni, and Pacenti [5], which aim to stimulate reflection through materials like disposable cameras and diaries. The term 'cultural' denotes the particular technique employed, which can be adapted to other approaches, such as empathy or technology [6]. Cultural probes, however, often are tied to a single activity conducted at a specific time and may be a representation of the relevant technologies rather than the actual technology itself. Unlike cultural probes, technology probes involve the use of actual technology in real-world contexts to observe its use and gather insights to inform future technology design [7][8].

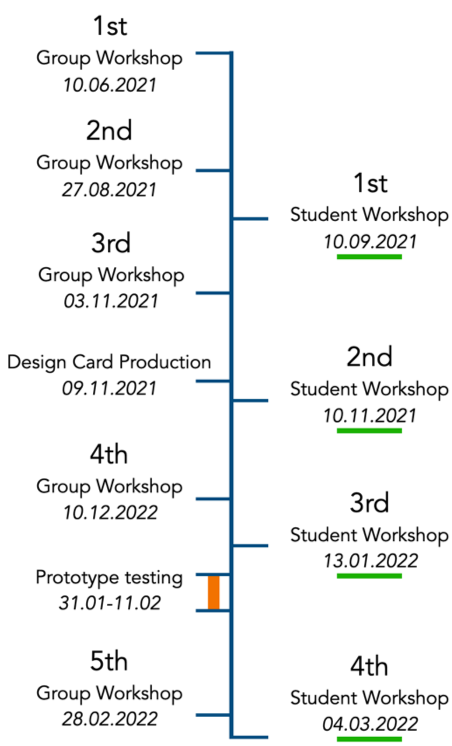


Figure 1. Project Timeline

A successful technology probe is characterized by simplicity and flexibility, serving as a tool to identify promising avenues for future technology design rather than a fully-fledged prototype. Moreover, it is open-ended and co-adaptive, allowing users to both adapt to the technology and creatively shape its use for their own purposes [1][9]. Previous research has highlighted the effectiveness of technology probes in stimulating creativity, imagination, and collaboration among participants in various domains, including education [10][11]. This was also the case in our project, where we observed creativity both in the content that was created during the use of the probe, and in the suggestions of how different technologies could be used to enhance cultural heritage teaching.

## III. Methodology

The research methodology employed in the pARTiciPED project draws upon Participatory Design (PD) principles, emphasizing active involvement and collaboration among stakeholders. Figure 1. Project Timeline presents the timeline of major activities of the project. Over the course of nine months, a series of 9 workshops were conducted (Figure 1), guided by PD principles, such as 'having a say' and 'mutual learning' [12]. In this article, we discuss the first student workshop. This workshop was held on June 10, 2021, serving as a foundational exploration of various emerging technologies, such as AR, VR and geolocation in the context of educational innovation.

### *A. Pre-Design Workshop*

The main participants for this workshop were 51 pre-service students (university students studying to become teachers) who were currently in the 4th year of their teaching studies. The workshop commenced with an introduction to the industrial history of Moss, Norway, facilitated by a museum educator from Østfold Museums (Figure 2). They were then given time to discuss the different themes that emerged in the presentation and visualize their ideas in the form of mind maps. This contextualization provided participants with insights into the historical significance of the town, setting the stage for the exploration of AR and VR technologies.

Figure 2. Museum educator presenting historical context

Following the history lesson, the participants were asked to fill out an online survey so we, the designers, could gain an understanding of their familiarity with technology. As presented in the first image in Figure 3. From left to right, Screen shot of 1st survey, 2nd survey, and geolocated content creation app the survey included questions regarding the participants’ previous experiences with technology. We subsequently introduced the participants to several technologies, such as AR, VR, 360 imagery, and projection mapping. The presentation included images and videos of how these technologies are, and could be, used to share knowledge, especially in the context of cultural heritage and museums.

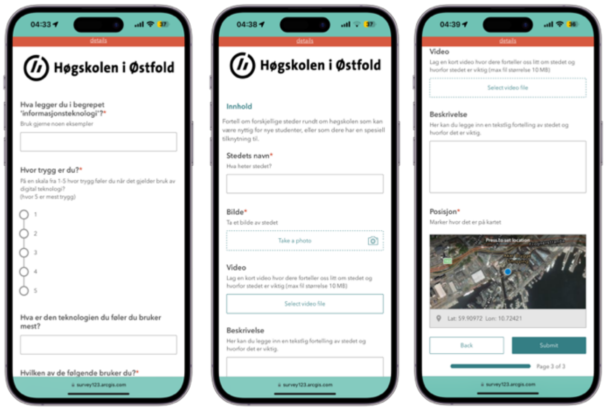


Figure 3. From left to right, Screen shot of 1st survey, 2nd survey, and geolocated content creation app

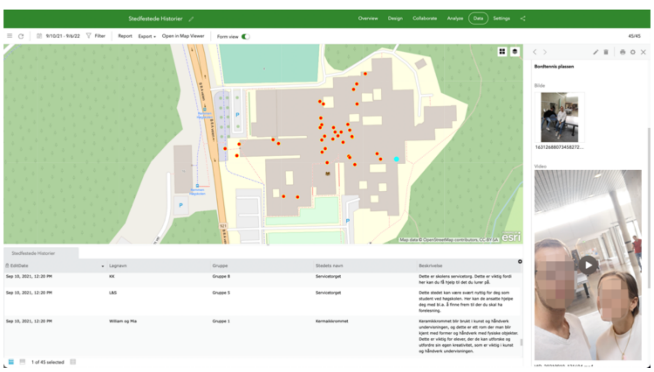

Figure 4. Screenshot of results of all the submitted geolocated content that was presented in front of all the participants

After a lunch break, we conducted a 45-minute session that focused on our technology probe which also introduced the students to geolocation technology. The students were given a custom-made mobile application, to create a 'virtual museum' of the university campus. They did this by taking pictures, recording videos, and adding text descriptions about different parts of the campus, while positioning the media on a map (this could be done automatically using their device's GPS, or by selecting the location manually). The 3rd image in Figure 3 shows the interface of the mobile application that was used by the participants. All the content created by the participant groups were automatically accumulated into one 'virtual museum'.

The content was visible as markers on a map, and upon clicking the markers, it was possible to see the images and videos, and read the text. The interface where all the submitted content was aggregated and could be accessed, is presented in Figure 4. The map is the most prominent feature, with text content below it. Images and videos are visible on the right side of the interface.

We spent another 30 minutes together with all participants, looking through some of the content that was created, and ended the session with another survey (second image in Figure 3) about the activity they had just completed. The survey consisted of questions about their experience with the mobile application, any challenges they faced, as well as possible applications of such technology in the context of this project.

The final session of the workshop lasted for 30 minutes. During this session, the participants were asked to identify 3 important takeaways from the day's activities, reflecting on the history of Moss town, the impact the industry had on its society, the technological possibilities, as well as the educational component of engaging middle school students to learn about these topics. We ended the day with a 15-minute session to wrap up and discuss what we would be doing going forward. The data from this workshop formed the basis for the subsequent workshops in the pARTiciPED, and also informed the tools and techniques that would be used going forward.

### *B. Scientific Method*

As briefly described by Newaz, Karlsen, and Herstad [2], a combination of observation, and surveys was employed to gather comprehensive data during the workshop. Each method was selected to provide a nuanced understanding of the collaborative process and the participants' interaction with the technology probe, their surroundings, and each other. We also wanted to learn about the participants' familiarity with various technologies, as well as their creativity during the workshop.

Observation, as a research method, offers insights into phenomena within "naturally occurring settings" [13][14]. By immersing ourselves in the participants' environment, we gained invaluable insights into their interactions, experiences, and reactions. Through direct observation and retrospective examination via notes, photographs, and audio recordings, we uncovered unspoken cues and authentically observed how participants engaged in the activities.

Survey responses from all participants formed another crucial aspect of our data collection strategy. Participants were given 2 surveys to complete. One at the beginning of the technology session, and a second survey after they had completed the activities related to the technology probe. The surveys were designed to capture both tangible and nuanced aspects of the participants' engagement throughout the workshop. The first survey was aimed at learning about the participants' familiarity with technology and consisted of questions related to the use of technology in their daily lives, as well as questions related to their knowledge of emerging technologies. The second survey was more reflective about the workshop. The questions focused on the different technologies that were presented, the technology probe that was used, and relevant future applications of the technologies presented in an educational context. Combining survey data with qualitative observations fostered a holistic understanding of the role of the technology probe.

Given the exploratory nature of our study, we opted for an inductive approach to data analysis, building codes from the ground up [15]. Initially, each question was assigned a distinct code category for analysis. We conducted an initial round of in vivo coding, meticulously examining responses to the selected questions. Subsequently, a second round of coding was performed through thematic analysis, grouping responses into cohesive themes [16]. Our analysis encompassed a detailed examination of the responses from both surveys provided by the 43 student teachers that participated in this workshop.

By analyzing the gathered data, we were able to reflect upon the influence of the technology probe on the participants' familiarity with the technologies.

## IV. Findings and Discussion

### A. Technology probe

During the probing activity, as the students were going around the university campus in their groups, we observed a high level of engagement, and energy. The participants were actively creating photo and video content and uploading it to the 'virtual museum' application. It was apparent that they were enjoying the activity, as many of the participants were laughing as they were creating content and reviewing it before submitting it to the system.

Several of the participants approached us during the activity as they were not able to upload their videos. We realized that the system would not be able to accept files larger than 10 megabytes. This was one of the major challenges that many of the participants faced. We categorized this as a technical challenge. Interestingly, most of the participants were able to troubleshoot the problem themselves. They understood the file size limit, and subsequently created and uploaded shorter videos. However, some of the participants were not able to identify the reason for the upload error by themselves (despite the error message as shown in Figure 5), and therefore were not able to troubleshoot the error either. They of course received help from us to circumvent the error.

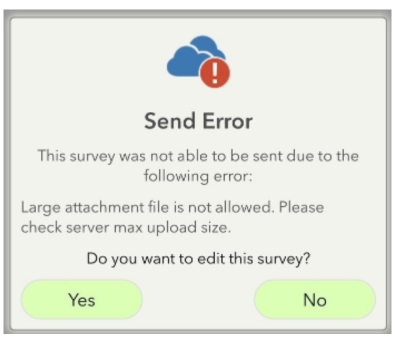


Figure 5. Error notification about file size that popped up for many of the participants

More than half of the participants did not feel this technical issue was a major challenge (Figure 6). Rather they expressed frustration with the following: the fact that it was hard to be creative when choosing the location and creating relevant content for that location; practical things, such as background noise and people moving in the background when filming. 25% of the participants did not feel they faced any significant challenges during the activity.

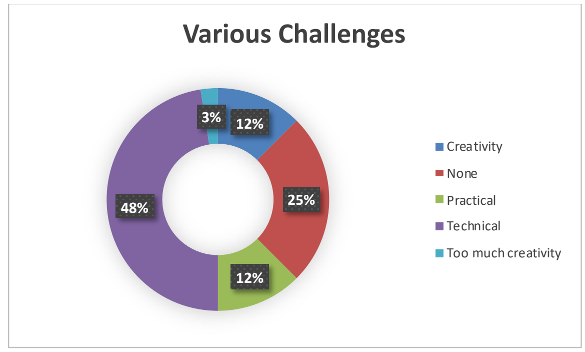


Figure 6. Various challenges reported by the participants

In terms of interest and aptitude, the participants displayed a strong inclination for the technology in use. The hands-on experience provided valuable insights into their comprehension of the available technologies and its potential benefits within an educational environment. The participants recognized the ability of this technology to improve student engagement and learning experiences. This was evident when all agreed on the relevance of geolocated content-creation application for teaching middle school students about their cultural heritage, with many highlighting its pedagogical value. Some recommended the use of VR and AR to enhance the students' experience, while others suggested using tools that the middle school students are already familiar with. One student said, "most of our students these days use TikTok, so we could use something like that, to let the students share their knowledge with others".

### B. Familiarity

The idea of using tools that are familiar, is also relevant in the context of our workshop. Analysis of participants' interactions with the technology probe, coupled with survey responses before and after the activity, provided valuable insights into their familiarity and comfort levels with the technologies we presented, such as Augmented Reality (AR) and Virtual Reality (VR) and geolocation. Initially, less than 14% of participants were acquainted with AR, while over 90% demonstrated awareness of VR technology. Those familiar with AR cited examples, such as 'snapchat filters' and 'Pokémon Go', showcasing their understanding of the concept in relation to systems they were familiar with. Interestingly, all participants were familiar with GPS technology, although only 23% could fully articulate its definition.

Drawing from Herstad and Holone's [17] insights on familiarity as a subjective phenomenon, we understand that familiarity encompasses individuals' understanding of themselves, their surroundings, and the activities they engage in. It manifests through signs, such as easiness, confidence, success, and performance [18]. In the context of our project, familiarity with the presented technologies is crucial for participants' readiness to incorporate these tools into their teaching practices. Heidegger's [19] concepts of involvement, understanding, and the unity of self and world further explain the nuanced relationship between individuals and technology. Participants' interactions with the technology probe during the workshop provided tangible evidence of their engagement with the tools and their ability to adapt to new technological environments.

Despite encountering technical challenges during the activity, such as file size limitations, participants demonstrated problem-solving skills and adaptability, reflecting their familiarity with the technology and their willingness to overcome obstacles. This proactive approach to troubleshooting aligns with Heidegger's [19] notion of readiness to respond and act appropriately in each situation.

On the other hand, the challenge of being creative, though only raised by a smaller number of could also be attributed to familiarity. Perhaps, those students were not familiar with the process of creating digital content? Our data shows otherwise, as only 2 of the 43 students had never edited a video before. Perhaps they were not creating content online? Or perhaps, despite regularly creating content to share with friends and family, these participants were not comfortable doing the same when the content would be available publicly, or at least to a group that extended beyond a certain threshold. While we did not collect any data in this regard, it could be valuable to explore these questions from the perspective of familiarity.

The workshop not only provided insights into participants' familiarity with various technologies but helped us create scaffolds that contributed to their increased understanding and enthusiasm for utilizing these tools in educational contexts. Sanders [20] suggests that that designers should understand the aspirations of ordinary individuals and create scaffolds to help them realize these aspirations. These scaffolds, according to Sanders and Stappers [3], are frameworks for experiential engagement that can facilitate collaborative innovation and creative expression among stakeholders. In our project, we see parallels with Sanders' notion of scaffolds. In our case, we employed technology probes as tools to elicit insights, foster collaboration, and inspire creative expression among participants. Sanders [21] further elaborates on the concept of scaffolds, defining them as tools that foster everyday creativity and collective creativity. This conceptualization aligns closely with our approach to Technology Probes, where we aim to provide participants with tangible experiences and opportunities to explore emerging technologies, such as Augmented Reality (AR) and Virtual Reality (VR) in the context of education.

### *C. Outcomes*

Based on the final feedback session of the workshop, the top 3 insights we could extract from the workshop include: 1) as a result of all the activities throughout the day, the participants were able to establish some common goals for the project at large, 2) the participants were able to achieve collaborative creativity while working with each other, not only in the context of the thematic discussions, but also in the context of creating content for the ‘virtual museum’ application, and suggesting future developments, and finally 3) the participants gained a heightened awareness of technological possibilities.

The participants displayed varied levels of understanding and familiarity regarding the technology introduced. Initially hesitant about the unfamiliar technology, their understanding improved as the workshop proceeded, eventually transforming skepticism into inspiration. Their recognition of the pedagogical value of technology, particularly in teaching middle school students about cultural heritage, underscores the potential of technology probes in fostering co-creation and collaborative innovation in education. When asked whether they could see this kind of technology could be relevant to teach cultural heritage to middle schoolers, an overwhelming majority responded positively, as evident from the following selection of responses:

> *“Yes, it can. Then you don't have to travel to places to visit them - which can be nice in a pandemic.”*
> *“Yes; absolutely, you can go around and explore different places and at the same time document it for others”*
> *“Yes absolutely! One can use it to make informative videos about cultural history”*
> *“Yes, you can use technology to convey so that you can see what you want and see at any time. Not just when there is a lecture.”*

The hands-on experience with the technology probe also helped create a scaffold and enabled participants to imagine its potential applications. This served as a springboard for structuring subsequent generative workshops. As the participants became more familiar with the technology and its applications, they also gained a deeper understanding of history from the museum educator. To further the design process, we realized we needed to devise tools and techniques that could build on this newly gained familiarity and understanding of both the historical theme and the technology's potential. The ultimate goal was to allow the student teachers to conceive of an engaging teaching activity using the technology, effectively familiarizing middle school children with their cultural heritage in a fun and easy way. Consequently, we decided to create design cards, and use them in the next co-design workshop to represent the historical themes, technological landscape, and educational requirements for such a teaching activity.

## V. Conclusion and Future Work

The utilization of technology probes in the pre-design stage of the co-design process proved instrumental in eliciting responses and insights from participants. The hands-on workshop allowed us to gauge the participants' familiarity with emerging technologies like AR and VR and laid the groundwork for a collaborative design process that can facilitate collaborative innovation among the stakeholders, thereby informing the design and implementation of certain tools and techniques in the subsequent stages of the co-creation process. Moving forward, further research in this area holds the potential to enrich our understanding of the role of technology probes in educational innovation and participatory design processes, ultimately contributing to the enhancement of learning experiences for students.

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