

How participatory design works

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How Participatory Design Works: Mechanisms and Effects

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ABSTRACT

We argue that the distinguishing features of Participatory Design are not the participatory activities as such but the mechanisms used, the effects produced and the way in which these are sustained. We use program theory to illuminate how participatory design works and how it may be understood as more than a collection of methods or a matter of configuring user participation. Program theory operates by formulating the causal relations between the planned inputs, the process and the effects in terms of output, outcome and impact. While participatory design might appear similar to co-design or user-centered design on the level of design activities, PD differs in terms of the mechanisms employed and how effects and their sustainment are conceived. Looking at participatory design through the lens of program theory highlights how particular mechanisms work towards not only the designed product but also towards generating gains and lasting effects for participants.

CCS CONCEPTS

• **Human-centered computing** → **Participatory design**;

KEYWORDS

Participatory design, program theory, mechanism, effect

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1 INTRODUCTION

In this paper we start from the observation that Participatory Design (PD) is ultimately concerned with establishing and maintaining processes that empower the people involved, and that the distinguishing features of PD, are not the participatory activities as such, but the processes of which they are part, the nature of the outcomes pursued and the way in which effects are sustained. However, these distinguishing features of how PD attempts to accomplish its aims can often seem murky for new researchers entering into the field, whether they are new graduate students or seasoned veterans from other fields. We argue that Program Theory (PT) [4] holds a strong potential for illuminating the relationship between PD means and intended outcomes, one that will allow both an explication of this relationship for researchers wanting to engage with PD, but also a strong theoretical foundation for existing PD researchers to reflect critically on how, whether and why their activities leads to empowering effects.

Using Program Theory to examine PD is a novel idea and the main contribution of the paper. In our view, PT is well-suited to bring forward the point that what distinguishes PD is the quality of the processes of design, since PT is concerned specifically with processes, mechanisms and causal relations [15]. The notions of ‘causal’ and ‘mechanism’ may be uncommon in contemporary PD language, but should not be conceived of in a strict natural science sense, but in a broad social science sense as something promoting or leading towards a desired result. As such, the aims of Participatory

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Design, empowerment and emancipation through design processes, align very well with what Program Theory tries to describe: how PD strives towards developing activities that support mechanisms such as mutual learning, empowerment, and collaborative reflection.

The backdrop for this argument is a significant increase of interest in PD within Human-Computer Interaction (HCI) research. In a recent study, Malinverni et al. [61] found a 580% increase over a ten-year period in the number of PD papers in the ACM digital library (2003-2013), and DiSalvo [26] found that 68% of the CHI papers using the phrase ‘participatory design’ have been published in the last decade. While HCI contributions focusing on PD generally provide excellent resources, they tend to mainly characterise PD through the phenomenon of ‘participation’ or as a collection of methods - most often some kind of ‘user workshop’. While not entirely wrong, such depictions overlook central characteristics of PD that distinguish it from mere ‘user involvement’ and ‘co-design’. Throughout the years, a series of contributions have offered to consolidate PD principles and practices in introductory books (e.g. [34, 75, 76]) as well as in overview papers [65, 67, 68, 73]. The most comprehensive effort to present the methods and practices of PD to the HCI community is found in the work of Michael J. Muller, who has developed and refined taxonomies of PD methods since 1993 [66]. Recently, Vines et al. [83] discussed the trend towards ‘user design’ in HCI and argued that the main issue, for HCI, might be considered in terms of the acts of ‘configuring participation’.

We extend the concern for understanding the role and nature of participation in HCI research by characterising PD as a design practice that, while similar to other participatory practices in terms of activities, differs fundamentally in its aims, approaches and outcomes. In order to do so, we use of program theory as a way to illustrate how PD works and how it may be understood as more than a collection of methods or a matter of configuring user participation. While PD might appear similar to other participatory practices, such as co-design, on the level of design activities, PD differs in terms of the interactional processes, or in the wording of program theory ‘mechanisms’ employed and how effects and their sustainment are conceived. Program theory offers a way to make explicit “the underlying assumptions about how programs are expected to work” [72] and seeks to achieve this by formulating the causal relations between the planned inputs, activities of the process, and the effects that are expected to result. In doing so, it reveals that a more nuanced understanding of PD in particular, and participatory practices in general, may be obtained by considering the configuration of mechanisms and effects.

This paper is structured as follows: In section two, we briefly review previous effort to characterise PD. Section three presents our characterisation of PD based on program theory, structured around field studies, workshops, participatory prototyping, infra-structuring and evaluation. In the concluding parts of the paper we draw together the insights from section three and discuss their significance for HCI research.

2 RELATED WORK

Over the years, there have been several efforts to define participatory design and its nature (e.g. [34, 65, 75]). Among the most

recent and comprehensive accounts is the Handbook of Participatory Design, where PD is defined as a process of “investigating, understanding, reflecting upon, establishing, developing and supporting mutual learning between multiple participants in a design process” [76]. One of the most systematic overviews of PD is provided by Halskov and Hansen [40] who extract five fundamental aspects (politics, people, context, methods, products) based on a survey of 102 research papers published in the Participatory Design conference series from 2002 - 2012 in combination with a literature review of core PD anthologies.

In PD, participants typically undertake roles of users and designers where designers “strive to learn the realities of the user’s situation while the users strive to articulate their desired aims and learn appropriate technological means to obtain them” [76]. In this respect, PD does not differ significantly from other approaches to user participation such as co-design [74], contextual design [3], or user-centered design [69]. These approaches all, to some extent, share the value of user participation in the design process. However, PD understands the design process as a pursuit of effects that reach beyond technological products. For PD, outputs from the design process comprise both tangible and intangible products, such as knowledge, new working procedures, and organisational arrangements that help sustain the effects created from design. This focus is rooted in PD’s political origin, emphasising democracy, empowerment, skilfulness and quality of process and product [6]. As such, PD has always emphasised people’s right to participate in the shaping of the world in which they act [76] and insisted that design should create lasting gains for participants. The political aspect of PD work is foregrounded in much PD literature as a distinct quality. To serve as background for our characterisation of PD based on program theory, we now briefly review three ways in which PD has previously been characterised.

First, the early characterisations of PD reflected the distinctly *political and ideological* basis of the trade-union projects undertaken in Scandinavia during the 1970’s and 80’s. The issues of workplace democracy, skilfulness and empowerment were addressed in a series of anthologies [6, 27, 70] providing ideological and theoretical grounding in, among other things, Marxist ideology and the work of Paulo Freire [32]. While the political strand of PD arguably declined after the Scandinavian projects, recent years have seen the political agenda re-surface within the PD community and in neighboring communities such as Interaction Design and Children. Within the Interaction Design and Children Community, scholars have addressed the issues of empowering children in a digital society (e.g. [47]) and within the Participatory Design conference series, a plethora of politically activist projects are reported in the literature (e.g. [80]).

As second approach to characterising PD has been to explore the *nature of participation* and to conceptualise the way in which users take an active role in the design process. In the early Scandinavian projects, the participatory practices, such as workshops and enacted scenarios, were employed as a consequence of the political and ideological basis. In the years to follow, these participatory practices found their way to several other research communities and into industry, while their ideological origin did not enjoy similar proliferation. The nature of participatory practices has been addressed from many perspectives. Early conceptualisations included

Wittgenstein's idea of 'language games' to describe the meeting between designers and users [27], and Activity Theory to describe tensions and contradictions in design activity. The nature of participatory practices has also featured in HCI-communities, most notably perhaps Mullers analysis of 'hybridity' [65] and Vines et al.'s work on 'configuring participation'[83].

A third kind of PD characterisation, has revolved around *structuring and organising the methods and techniques* of PD. While obviously related to the nature of participation described above, this strand of work is primarily concerned with more or less formalised methods and their place and function in a design process. The degree of formalisation of methods in PD varies greatly as does the importance ascribed to formal methods among PD practitioners. Early efforts to document PD practices, such as Greenbaum and Kyng [34] and Schuler and Namioka [75], reflect a diverse and somewhat informal approach to the issue of methods. More structured overviews have been presented over the years, categorising methods in term of the knowledge they create [53], their place in the process [66, 68] and their form and context [73].

In this paper, we suggest a fourth approach to characterising PD in order to highlight the links between the aims of PD, the effects PD seeks to achieve, and the role of participatory activities. We suggest that these connections are PD's central characteristics and explain why it is problematic when PD is presented as primarily a political or ethical program, as a question of participation, or as a collection of methods and practices. Indeed, several other design approaches could be argued to share these features, and PD be seen as merely a regional or disciplinary subfield. However, this would, in our view, fail to capture PD's specific contribution to design and the development and use of technology. Thus we apply program theory, which we will unfold in the next section, as a framework through which to bring the central characteristics of PD to the fore.

3 CHARACTERISING PD USING PROGRAM THEORY

Program theory comes out of the field of evaluation, and despite its name, it is not a theory as such, but an approach or framework aimed at developing specific models of how programs or project are assumed to work through detailing the causal relations between inputs, processes and effects in those programs [72]. The aim is to make evaluations more precise and increase learning, since making processes explicit enables investigations into why a project or program did or did not work. Our aim here is not to evaluate, and we will instead make use of the framework of program theory to make explicit, in a systematic way, why and how PD works towards its goals and aims. Program theory models are usually developed individually for specific programs and can be developed in different ways and take on various forms. An often used approach is to depict program theory diagrammatically as a relationship between **input**, **process**, and **effects** [72] and this is also the form that we apply here, as it provides a useful overview of the basic concepts. We define these concepts in the following way:

Input refers to the tangible and intangible resources needed to initiate and complete a program or project.

The **process** describes the actions completed by participants using available resources. What, how and where are appropriate

questions. In terms of process, we distinguish between *mechanism* and *activity*.

- *Mechanism*: describes the general, underlying principles that generate effects. In terms of the process, it may be regarded as the fundamental entity that creates causality between input and effect. It is, so to speak, the active ingredient (see [41] for discussion).
- *Activity*: describes the particular way or the medium through which the mechanism is brought into action. The distinction is similar to the distinction between the active ingredient and the excipient in drugs (see [56] for elaboration).

In program theory we may distinguish between three kinds of **effects** [72]:

- *Output*: Tangible and intangible products emerging from the program. Outputs in themselves offer no indication of the derived benefits, but refer to immediate product of the process. We can inquire about the amount of output by listing products and we can discuss the quality of the output (e.g. robustness of a products or clarity of a new procedure).
- *Outcome*: Short and midterm effects of the program. Outcomes are not products but the derived consequences, benefits, drawbacks etc. of the program. Outcomes may be identified as causal consequences of the program and the outputs.
- *Impact*: Longer term effects of the program. While a program may deliver outcomes on its own, impacts are typically achieved in conjunction with other programs or initiatives. A program may thus be regarded as one among several contributors to impact. It is often difficult to establish causality between an individual program and an impact.

Diagrammatically, the relationship between input, process and effects may be depicted as show in figure 1. In figure 2 we have arranged the typical activities that are performed in PD into five overarching categories: Field studies, workshops, prototyping, infrastructuring and evaluation. These are generally undertaken to address central PD concerns such as: 1) How do we bring knowledge about use practices and context into the PD process? 2) How do we facilitate the encounter between professional designers and participants? 3) How do we enable the collaborative exploration of alternatives? 4) How do we assess the qualities of a design product and the outcomes emerging from the design process? And, finally, 5) How to secure that the results achieved during the project can be sustained after the project ends?

At a glance, these five categories of typical activities resemble design activities well-known to HCI, such as those outlines by Preece et al. [71](establishing requirements, designing alternatives, prototyping, evaluation). Also, at an activity level, they may appear similar to other participatory practices. However, in the following sections we will unpack how PD differs by looking at each of these five categories in terms of the mechanisms employed and they way in which these are realised to create effects. For each of the five categories, we provide a general program theory analysis, a sample of PD studies as a resource for HCI practitioners and finally two specific examples. The examples are chosen to highlight how a PD approach can be implemented throughout the design process, and the overall picture emerging from section 3 should be regarded as a Weberian ideal type. As such, it will most likely appear almost

INPUT	PROCESS		EFFECTS		
	Mechanism	Activity	Output	Outcome	Impact
Tangible and intangible resources needed.	The fundamental principle generating effect	The medium or way in which the mechanism is brought into action	Immediate tangible and intangible product emerging from the process.	Short- and medium term effects. Derived consequences of the output.	Long term effects of the program or project.

Figure 1: A diagrammatic illustration of program theory.

INPUT	PROCESS		EFFECTS		
	Mechanism	Activity	Output	Outcome	Impact
		Field studies Workshops Prototyping Infrastructuring Evaluation			

Figure 2: Five overarching categories of activities in PD.

utopian, and few if any PD projects will employ all elements in practice. Further, the activities mentioned do not necessarily capture the full range of PD methods and practices presented in current literature, nor do we claim that the methods mentioned are superior to others: They serve as examples of how the mechanisms of PD are activated with the aim of creating particular effects.

3.1 Field Studies

We define field studies as a category of activities in which qualitative methods are applied as the means to study current practices, contexts and domains of the potential users of a system [7]. Field studies in general include techniques such as observation, interviews and video analysis with users. The output is domain knowledge and problem analysis to foresee how a design process can resolve or change the existing use practice for the better. The focus in PD field studies is not only on gathering data, but also on facilitating mechanisms of collaborative reflection on current practice and initiating mutual learning between designers and stakeholders. By collaboratively reflecting on current practice, new design openings potentially emerge from the participatory process and sometimes long-term relationships between designers/researchers and stakeholders. Providing the venue and means to critically reflect on everyday practices and the opportunities these embody, is done with the intent of supporting outputs such as new visions and ideas, and eventually the outcomes that emerge from realising these ideas. Importantly, the output related to knowledge about current practice is an an output intended for participants themselves and not only a material for designers to work with. As such, the mechanisms employed in field studies are used specifically to have effects related to empowerment and agency among participants.

Field studies may be conducted several times during a project to inform workshops, prototyping, infrastructuring and evaluation, which in turn may inform field studies. Studying practice and real-life use situations is a central tenet of PD practice, and ethnographic methods have played a prominent role in the development of PD, both through the adoption of concrete techniques such as

interviews and participant observation, as well as by promoting the active engagement with users in their contexts. Ethnographers were part of the early foundational work on PD research and practice [5]. According to Blomberg and Karasti [8] the encounter between US-trained anthropologists and Scandinavian PD researchers meant that the question of the appropriate relation between studying and involving participants in design came to the fore. Based on this, PD as a field has imported and developed methods for studying the practice and context of potential users highlighting, for instance, the use of video for understanding practice [79], contextual design [3] and scenarios as representations of current practice [20]. In addition to such specific techniques, design anthropology [37] offers an approach to integrating design and anthropology into a new and more interventionist form of field studies aimed at design. In PD, fieldwork is preferable carried out in the mode of participant-observation engaging with people, and not in the mode of external observer, and mutual learning most often is an inherent outcome. There are however, ways to enhance and augment this, and in the following examine two such activities - ‘Design with the Feet’ and ‘Video Card Game’ - in detail.

3.1.1 Design with the Feet. One way to actively pursue collaboration during fieldwork beyond standard participant-observation is provided by Kanstrup et al. [50] who present a review of how walking can be used as a way to immerse oneself in the field and establish relationships in PD processes as well as a general framework for understanding walking-based methods in PD. According to Kanstrup et al. [50], walking has a long history as a technique of inquiry, and importing it into PD means recognising the potential for using it to foster mutual learning, for boosting the effectiveness of PD efforts, and for triggering design by making explicit the dialectics of tradition and transcendence. They point to several walking-based approaches to field studies in PD: Walking observations, walking interviews, bimbbling (walking around aimlessly), proto walks and transect walks. However, they primarily address transect walks: A systematic walkthrough of an area, for instance a rural village, to identify resources important to the local community. Researchers and residents collaborate on creating shared maps of resources of the immediate area, before walking a route around the neighbourhood marking and discussing the resources in the general vicinity. Afterwards, the map is used for a collaborative effort in working through and reflecting on the traditions and opportunities of the area, acting as triggers for design opportunities. The walking-based methods described by Kanstrup et al. [50] are useful for field studies in PD, because in addition to a focus on the real-life situations of the participants of a given area, they are a way of making participants and researchers reflect collaboratively, and they put user-participants in the role of experts in their own lives and practices. Furthermore, using the maps as triggers for design means that the participants have a strong influence on the design process with respect to which aspect of the context is important and why. The activity thus promotes mutual engagement and ownership among participants through the mechanism of collaborative reflection.

3.1.2 Video Card Games. A crucial feature of field studies is the analysis of the data generated. Whereas this process is often carried out by the researcher solitary within anthropology, PD often

strives towards making this process collaborative in order not to position the researcher as the authority on knowledge related to other people's lives. One example of this is the Video Card Game developed by Buur and Soendergaard [19], which is a workshop format where video recordings from field studies are analysed collaboratively with users. Based on small video clips of practice, cards are then created by printing a keyframe from each clip on a card. These cards are used to conduct a qualitative analysis of issues within the design domain, identifying potential solutions and linking them to concrete situations of practice. In another example using the same method, Buur et al. [18] conducted a number of design events (ethnography, ideation and mock-ups), using videotaped material as a way of involving users in the project. Buur et al. [18] describe how they involved the users in both the collection of data and the interpretation of the field studies, through the use of the Video Card Game. In other examples, Buur et al. [18] discuss how they used video footage as a tool for interpreting the results of a mock-up test. In this case, many of the design activities involved were explicitly designed to support user involvement in interpretation or decision-making.

Design with the Feet and the Video Card Game enable participants to co-author material from use situations which is then interpreted and analysed by participants, giving them influence in the design process. As opposed to being sources of data, the participants have a say not only in what data is collected and how, but also in how this data is interpreted. Giving such responsibility to participants reflects a specific view of them as experts in their own practice and having them participate directly means that the field studies becomes a way of eliciting joint reflections as part of a mutual learning process rather than sampling data. In terms of program theory, these activities thus employ mechanisms related to co-authoring and collaborative reflection. The outputs are domain knowledge and problem analysis and this output is directed both at designers and users. The desired outcome includes mutual engagement, ownership of the process, and empowerment to reshape their own practice, while impacts may be the development of long term relationships in terms of design and research.

3.2 Workshops

By 'workshop' we refer to an intensive design event in which participants with different backgrounds meet and exchange knowledge and ideas about current or future practices. In terms of program theory, stakeholders are the primary input to workshop activities as they engage as experts in their daily life being professionals or private users. For PD, the central challenge pertaining to workshops is often to support and scaffold the managing of power relations and a shared understanding of current practice between diverse stakeholders. This is considered important not only to create useful design ideas but to create commitment and alignment between stakeholders. Accordingly, the outputs of a workshop include knowledge of current practice, visions for the future, and specific design ideas. In terms of outcome and impact, workshops, and the outputs they generate, play an important role in PD as they are a venue for creating the ideas that will eventually lead to gains

for participants, but also a format that spurs the creation of personal and professional relationships that are considered vital for the sustainability of the project (see also section on infrastructuring).

PD workshops use a range of mechanisms to provide participants with creative or playful means for negotiating visions for the future and for managing power relations. As an example, Brandt [16] introduces design games as a mechanism for engaging stakeholders in participatory workshops. Also, workshops using theatre methods and magical props have been developed as a way to create a workshop format for playful collaboration and ideation [17]. Dindler and Iversen [24] present fictional inquiries in which users are engaged in a shared narrative space between the existing and a fictional space. According to the authors, this somewhat fictional workshop space is an activity, which bypasses conventions in the existing use practice in a fun and engaging way. In recent years, emphasis has been put on PD workshops including vulnerable users. Makhaeva et al. [60], for example, suggest to conduct workshops through 'Handlungs-spielraum' to engage children with autism (See also [49, 57, 59] for workshops with vulnerable users). Many of these mechanisms for spurring creative or playful engagement are shared among participatory approaches such as PD, co-design, or user centred design to foster new ideas or new insights. Mechanisms are altered to accommodate certain contextual or situational needs. As an example, the Interaction Design and Children research community has developed several workshop mechanisms specially targeted at engaging children in PD workshops [2, 36, 85]. Here, gamification or playful collaboration as a mechanism for exchanging ideas is proposed as particularly powerful when engaging children in design. Walsh [84], for instance, introduces a distributed PD approach engaging users in an online workshop in which the computer game *MineCraft* is utilised for sharing concerns and ideas among participants distributed over geographical locations.

Workshop methods come in many variations in relation to the participants, content and contexts in which the method is applied. Future workshop is one of the most well-established workshop formats in PD. It was originally developed to help citizen groups have a say in decision-making processes of public planning [48], but has for several year been applied within PD [52]. In the following, we look in more detail into Future Workshop and Inspiration Card Workshops in order to exemplify how the key participatory mechanisms and effects are utilised in PD workshops.

3.2.1 Future workshops. A Future Workshop is a design method where a homogeneous group of participants sharing a common problematic situation, generate a vision for the future and address how that vision can be realised [64]. Future Workshops are particularly interesting in relation to understanding PD mechanisms and effects as they take emerging problems that people are facing in their daily life as an important input. By positioning participants as experts in their own lives and providing them with legitimacy and agency in respect to which vision to pursue and how, designers are ideally balancing power relations among participants. Balancing power relations is a mechanism that can potentially lead to a stronger commitment and ownership among and perhaps a shared vision for the future.

Future Workshop aims at mutual learning as a project output. This is obtained through a three phases structure: the critique phase,

the fantasy phase, and the implementation phase. In the critique phase participants explore problematic situations encountered in their context. In the fantasy phase participants envision an ideal future and by temporarily ignoring resource limits or technical constraints the goal is to design ideal alternatives, which may potentially have the impact of improving the quality of their own (work) situation. In the implementation phase the visions are adapted to the participants real-world context and an implementation plan is made in order to ensure outcomes and impact.

By collaboratively and step-wise progressing from problematic situations to ideal futures, the participants learn from each other and develop a coherent vision. The accomplishment of the workshop (a shared vision) is directly dependent on the PD mechanism of balancing power relations. All participants must dare to share their personal perspectives and concerns as a starting point, and designers cannot foresee the results as they depend on the participants individual contributions. As such, mutual learning is tightly connected to the designers' ability deal with power relations among participants.

3.2.2 Inspiration Card Workshop. Inspiration Card Workshop is a collaborative ideation method based on combining domain cards and technology cards [39]. Designers and participants from the design domain create new concepts by combining technology and domain insights [39]. The method is an ideation event, aimed at exploring design alternatives and fostering viable design concepts. In terms of mechanisms, the method accentuates collaborative ideation and game elements in the form of physical props (cards). In terms of output and outcomes, the ambition of the workshop is to spur creativity and hence novel design concepts, but also to position every stakeholder in a legitimate role as a design-participant. The manipulation and combination of knowledge (domain and technology) using cards, provides a simple mechanisms for inviting all stakeholder to take part. It is considered important that all stakeholders are part of the ideation to create ownership of the design ideas and to ensure that all stakeholder gain knowledge about the design domain and the opportunities and constraints identified. In addition to an initial preparation phase and a subsequent processing phase, an Inspiration Card Workshop consists of three main phases: Introduction, combination and co-creation, and presentation of concepts. From a PD perspective, the creation of domain cards and technology cards with images is particularly important. Domain cards represent knowledge about the context being designed for and since participants are considered experts, the cards are ideally created or proposed by the people from the domain. Technology cards represent specific applications of technology, and including technology cards beyond the domain being designed expands the design space in order to explore design alternatives.

3.3 Prototyping

The prototype as an object has its origin engineering and manufacturing where they are used to demonstrate features or to obtain a full, formal specification of the future system. Floyd [30] argued that prototyping as part of PD should be considered as a process. In conventional prototyping users are only rarely actively involved in the design and modification of prototypes and hence only have limited influence on the future system [12]. This is also discussed by

Lim et al. [58] who highlight how HCI and interaction design seem to focus more on prototypes for evaluation than for exploration. In PD, prototyping is a collaborative activity in which stakeholders jointly imagining future products and practices by use of a variety of design materials. The idea of prototyping as a process where users and designers have equal power relations and both participate actively and creatively, drawing on their different qualifications, has been a hallmark of PD from the outset [12, 28]. From the lens of program theory, inputs for prototyping activities are people and their knowledge, mock-ups, prototypes and other design materials which are manipulated through collaborative processes. As such, prototyping inputs in PD does not differ significantly from other prototyping activities in user-centered design or in co-design. Stakeholders collaboratively produce and modify interactive representations of design ideas negotiating values and concerns during the process. However, a central mechanism of PD prototyping activities is for participants to gain hands-on experience with future technology, ranging from shorter prototyping session to long-term deployments. Prototyping sessions are not only an exploration of issues related to the product, but also a means for exploring future use practice. A core mechanism in PD prototyping is a collaborative 'rehearsal of the future' [38] in addition to specific product features or functions. The desired output of prototyping is thus both modified prototypes and knowledge about how this will work in a future practice and how procedures and practices will need to be changed to be aligned with a new design. This knowledge output may take on various forms such as scenarios, reports or plans for action. In this way, a prototype may be considered both a tangible input and, as a modified prototype, a tangible output of the prototyping activities. In PD prototyping, basic mechanisms include hand-on-experience, modifying the prototype during the prototyping session, and conducting the session in a simulated future work situation, or in a real use situation. In terms of outcomes and impacts, prototyping is important in order for participants to gain knowledge for critical reflection, and provide users with concrete experience of the future design in order for them to specify demands for it [10]. This impact is quite unique for PD prototyping activities and a hallmark of PD as such.

The diversity in the prototyping approaches can be seen in the areas of application used for prototyping. For example, Cederman-Haysom and Brereton [22] report on using prototypes to involve dentists in creating UbiComp concepts for dental practice, and Hertzum and Simonsen [42] demonstrated how the long-term deployment of prototypes in work contexts might lead to deeper understanding of the effects of the prototyping session. Clement et al. [23] demonstrate how prototyping is utilised in an urban setting, engaging the public in significant issues relating to privacy and security. Here, prototyping is used not only as a way of designing a new artefact with potential users, but more importantly to enable critical reflection and raise political reflections among citizens.

In the following, we examine two prototyping examples, Cooperative Prototyping and Prototyping as Reflection in order to exemplify the prototyping practice in PD.

3.3.1 Cooperative Prototyping. In Cooperative Prototyping, prototypes are used to establish situations where both users and designers participate actively and creatively, drawing on their different

qualifications [12]. To facilitate cooperation, a vital mechanism is that users get hands-on experience and that the prototypes are easy to modify, so that breakdowns caused by bad or incomplete design solutions can rapidly be turned into improved designs by changing the prototype, and the fluent work-like evaluation of the prototype can be re-established. Modifying the prototype during the prototyping session encourages future users to influence the design by stating ideas for improvement [12].

As preparation, the working group must establish a common understanding of the aims of the process, the status of the intermediate products, and the role of prototyping in the overall design process. Ideally, cooperative prototyping session should be performed by a small group of designers and users with access to flexible technology resources, including tools for the rapid development and modification of prototypes. It is important that the working group comprises skilled user representatives [12]. With respect to context, conducting the session in a simulated future work situation, or in a real use situation, promotes first-hand experience with how the design will work in practice and how practice will likely change. The output of the prototyping process is a modified prototype, but just as important is the knowledge generated that allows users to critically reflect on their practice. Cooperative prototyping aims at being a mutual learning process rather than an evaluation, exploring both design options as well generating new understandings of technology and work practices to people, who are not participating directly. To plan a prototyping session, the designer considers the purpose of the prototyping session, how stable the prototype should be in advance, to what extent in-session modifications should be possible, in which settings to perform the session and how to evaluate and document the results. Such inputs create conditions for participants to influence the design decisions during the prototyping session [12].

3.3.2 Prototyping as Reflection. Whereas the concern in collaborative prototyping is to create a shared understanding of the object of design, another concern within PD prototyping methods is the focus on the changed practices that future technology might cause. Here, prototyping is used to provide the foundation for the effect of spurring discussion and reflection on the changed practices. An example of this kind of prototyping approach has been suggested by Hutchinson et al. [45] and further discussed by Westerlund [86]. Here, the researchers installed collaboratively developed low-tech prototypes in the homes of the participants in the InterLiving project. The prototypes were ‘used’ for some weeks to provide the participants with hands-on experience and first-hand insights into the changes that the prototypes might cause. Afterwards, the researchers initiated several workshops in the homes to reflect upon the results from the prototyping events. Based on these discussions, the researchers developed running prototypes to install in the homes followed by a new iteration of shared reflection and discussion. In this way, Westerlund et al. [86] focus on the knowledge outcomes of the prototyping sessions to spur discussion and to reflect upon future practice among participants. Prototyping sessions reveal the sometimes invisible arguments for or against a new technology, and invites non-professional designers to critically reflect on technologically mediated futures. In this way, prototyping as reflection demonstrates the fundamental PD idea of

providing users with experience of the future design so that they may be better equipped to pose demands for it.

In the preceding three paragraphs, we have focused on PD methods prescribing certain ways of conducting design with participants, the mechanisms that these use and how these relate to the desired effects. In the following two sections, *infrastructuring* and *evaluation*, we will focus on PD practices that are not disseminated in PD literature as specific instructions or methods but are equally important in terms of understanding PD.

3.4 Infrastructuring

By ‘infrastructuring’ we refer to the PD activities in which researchers and participants collaboratively establish the social, organisational and technical arrangements that will secure that the results achieved during the project can lead to sustainable outcomes [51]. Whereas sustainability is measured after the project ends, participatory infrastructuring points to the fact that these practices are deeply embedded in the process as it unfolds [11]. In terms of program theory, participatory infrastructuring is embedded in design activities that allow sustainability issues to be addressed in the design processes as it unfolds. Participatory infrastructuring takes as its inputs the variety of stakeholders who are capable of securing a long-term impact through participation and commitment in the design process. The mechanisms of participatory infrastructuring include the relational expertise enacted by the designers and the formation of informal ‘knotworks’ and formalised networks established through activities such as workshops and collaborative prototyping. Relational expertise is the capability of bringing people together and providing them with conditions for collaboration and the means for taking on responsibility for a shared design task [25]. The output of participatory infrastructuring may be tangible artifacts such as written reports endorsed by the various stakeholders, a reorganisation of existing work flows, or a new physical space. It may also include more intangible outcomes such as networks of people. Long term impact is ideally obtained by integration of PD output and outcome into a future practice in which participants are capable of sustaining the outcome within an organisational structure. As compared to participatory activities, such as field studies, workshops and prototyping, participatory infrastructuring is less well-described within HCI. Below we provide a more detailed account of infrastructuring and exemplify from successful infrastructuring practices from PD projects.

As argued in previous sections, PD has a concern for securing that participants and future users enjoy lasting results from the process. Bødker [9] argues that, in PD, it is important to put the organisation and its people in a position where experiences can be used beyond the individual project. Effects may take on many forms such as skills or increased democratic influence. Also, sustainability of project achievements may range from merely maintaining what has been accomplished to more ambitious aims of scaling up achievements [46]. The notion of infrastructuring has surfaced relatively recently in the PD literature although the ideas stretch back to Star and Ruhleder [78]. As such, the term is still used in a variety of ways within PD [51] without a single settled understanding. Here, we use the term in a broad sense to cover the various social, technical and organisational constellations that are created

to secure that projects achievement may be sustained or developed beyond the project.

The early work within PD identified the need for continuing design in use by creating platforms that could be tailored and adapted over time. This concern for open and adaptable technical platforms have since remained a focus for PD. Beyond the need for adaptable technical systems, authors have also explored the significance of social infrastructures in terms of sustainability. In their work, Carroll and Rosson [21] demonstrate the importance of strong social networks within communities, and Dindler and Iversen [25] discuss more broadly the need for a relational expertise among PD practitioners. In terms of the organisational efforts needed to create infrastructures for sustaining project achievements, PD emerged from an explicit political agenda of user empowerment and democratisation [6]. As such, organisational structures to support these political ambitions have pervaded parts of the PD literature. Among the most recent contribution to this strand of work is Kyng's [55] discussion of not only the sustainability of project results, but also about the challenge of maintaining democratic control of these results. In terms of practices and methods, it is hard to identify specific methods that have infrastructuring as their sole purpose. Rather, it may be argued that concerns for infrastructuring and sustainability may be more or less articulated within the established activities discussed above. For example, workshops and cooperative prototyping may address the organisational structures that will support sustainability or address technical infrastructures. In terms of program theory, one can characterise participatory infrastructuring in the following way: The input is the various stakeholders who, individually or together, hold the power to adapt, reject or develop new initiatives into a new practice, as well as the relational expertise enacted by designers (and other participants) through activities of creating knotworks and networks to sustain the project output (artifacts, documents, scenarios, etc.), outcomes (e.g. decision to continue to fund the process) and impact (e.g. better work life quality through new technology and re-organisation). Dindler and Iversen [25] make the case that much of the work going on within and between workshops and meetings is relational work in which participants build and consolidate the networks that will support the project outcomes and impact beyond its completion. The notion of commons has also been suggested as a way of articulating the role that people and institutions play in sustaining outcomes [62]. Below, we highlight two recent cases that illustrate infrastructuring in PD.

3.4.1 Living Labs. Arguably one of the best examples of successful infrastructuring PD practice is the work in the Living Lab at Malmø, where researchers have demonstrated a design approach based on community engagement promoting democratic dialogue in order for users to gain influence on how to improve quality of life [29]. Rather than considering design as a clearly delineated project, the Living Lab approach draws on ideas of infrastructuring to promote long-term engagement and thus long-term effects, building trust and establishing venues for democratic dialogues about the future. The work in the Malmø Living Lab initiative very literally embodies the core PD ideas of political engagement and empowerment in their pursuit to design alternatives in collaboration with communities. It does not report any specific PD methods

or instructions for infrastructuring. Rather, the establishment of the social, organisational and technical infrastructures is obtained through PD processes in which stakeholders, together with experienced designers, create knotworks and networks by using a variety of methods from the PD catalogue.

3.4.2 Fablab@school. Somewhat similar to the work in the Living Lab, Bødker et al. [11] and Smith and Iversen [77] discuss the fablab@school.dk project. Here, designers engaged children, teachers, principals and educational policy makers to develop a digital fabrication initiative in formal education. The accounts from fablab@school.dk highlight participatory infrastructuring as an important prerequisite for a successful project outcome. In this project, infrastructuring is closely connected to the designers ability to transform loosely coupled knotworks of participants, with different approaches to the design project and on very different levels of authority (such as students, teachers and policy makers), into a sustainable network to support a common cause. Activities that help the transformation of knotworks into sustainable networks are described as PD backstage work including the messy and less photogenic activities that occur before, between and after the participatory workshops such as phone calls, public hearings, meetings and coordination activities. According to Bødker et al. [11], relational expertise as the mechanism of participatory infrastructuring involves conflicts and negotiations, straightforward technical development, strategic discussions among designers, and strategic engagement with participants on all levels of authority in and beyond the organisation.

3.5 Evaluation

The final category of activities, evaluation, comprises the participatory activities in which users and stakeholders assess the qualities of a design product and the effects emerging from the design process. Whereas HCI evaluations will typically focus on usability or user experience issues relating to a technological product, PD evaluations will additionally include effects in the form of new organisational structures, new skills developed or knowledge acquired by users through the process. In terms of outcome and impacts, PD evaluations will typically include questions concerning the derived consequences of the new products and an assessment of potential long term impact. Also, evaluations may include participants taking part in defining the evaluation criteria themselves and measuring the participants' personal gains from their participation. Whereas the actual evaluation results may be considered the output of evaluation, outcomes of PD evaluations can be co-decisions about continuation of a project or initiation of a new project initiatives. PD will, in this way, ideally include participants in important decisions regarding project management, impact and future directions.

No overall evaluation framework for PD exists, and since informal evaluation is a build-in feature of many PD activities, through the focus on collaborative activities, systematic and formal evaluations are rare. However, several frameworks have been proposed to guide such evaluations. Early work by Kensing et al. [54] suggest concrete methods for evaluating PD projects highlighting the importance of evaluating both process and products within organisational contexts. Merkel et al. [63] stress the importance of also accounting for indirect and long-term changes within communities

when evaluating PD. More recently, Bossen et al. [13] proposed eight aspects through which to evaluate a PD project: 1) Influence on the project and product, 2) Personal gains from participation, 3) New quality of work, new possibilities discovered, or more influence on own work conditions, 4) New areas of competence acquired, 5) Subsequent shifts in career or choice of education, owing to the project, 6) Extent of new outlook on technology or personal practices, 7) Overall assessment of participation in project, and 8) Newly emerged opportunities in general.

An early example of systematic evaluation is provided by Thoresen [81], while a recent example can be found in Hertzum and Simonsen [42]. Examples of evaluating impact through retrospective interviews with participants can be found in Bossen et al. [13] and Garde and van der Voort [33] (for overview of PD evaluations see [14]). Within formal evaluations in PD, there is a strong tendency for them to be conducted by researchers setting the criteria and arriving at the conclusions. Thus, there is an opportunity for PD to do more in terms of evaluations in which projects participants themselves take part, such as in ‘responsive evaluation’ or ‘developmental evaluation’ [35]. To illustrate the scope of evaluations in current PD work, we highlight two different evaluation frameworks focusing on effects and accountability respectively.

3.5.1 Effect-driven IT development. Hertzum and Simonsen [42] measure their PD work by the degree to which the project outcomes match the ambitions that were expressed by the involved stakeholders during initial PD activities. The PD perspective is highly present in this framework, as the outcome of a design process is measured against the participants’ initial conception of the desired effect of a design. In this way, participants play a crucial role in evaluating the final outcomes of the process. The actual effect of the system is assessed through qualitative and quantitative evaluation sessions using conventional research methods such as observation, interviews, questionnaires and in some instances location tracking. Focus is on real-use evaluation of effects rather than on evaluating the system in terms of usability (see also [43, 44]). Thus the concept of effect-driven IT development directs the design and implementation processes towards outcomes and impact defined by the involved stakeholders.

3.5.2 Evaluating Rigour and Accountability. Frauenberger et al. [31] provide a framework for evaluating PD projects based on the issues of rigour and accountability. Accountability is understood in terms of linking collaborative work with decisions and outcomes in a transparent way, whereas rigour is understood as internal validity within the process. The authors propose four lenses (epistemology, values, stakeholders and outcomes) that may be used to examine how PD qualities are attuned to each other in a given process. The authors propose four questions for each lens that may guide the evaluation. This framework pursues a concern for evaluating indirect and long-term outcomes regarding the knowledge that is created, how PD’s values are pursued and achieved, how participants are involved, and what the outcomes are as seen by various stakeholders.

Formal, systematic evaluations have, so far, not received extensive attention in PD, perhaps because the interactions between users, designers and researchers provides ongoing feedback and

thus a kind of informal evaluation. However, as the examples provided above show, there are ways in which evaluations can be conducted with a focus on furthering PD’s aims, and these can even be conducted in participatory ways as demonstrated by Hertzum and Simonsen [42]. [42] show.

4 DISCUSSION

Table 3 summarises the characterisation presented in the previous section in terms of inputs, mechanisms, activities, outputs, outcomes and impacts. The list is by no means an exhaustive account of PD, but serves to highlight distinct features as presented in the previous section.

Our analysis complements previous efforts to unfold PD and its specifics (e.g. [34, 65, 75]), and answers a call from within the HCI community for more nuanced and precise conceptions of different participatory practices [82, 83]. We show how PD shares many design-oriented activities with other approaches well-known to HCI, such as user-centered design and co-design, but also how it differs from these through its distinct mechanisms and strived-for effects.

Program theory provides a useful tool for characterising the distinct qualities of design approaches, in this case PD, and the logics and rationale that drive these. The relatively fine-grained nature of the framework that distinguishes made between, for example, outputs and outcomes is a double-edged sword. The main quality is that it promotes concise and detailed accounts of the proposed causalities and entities of a process. This allows for critical scrutiny of specific projects and design approaches generally. However, in some instances it may prove difficult to determine whether something is, for example, an outcome or an impact. While precision is of course important we would suggest that absolute precision in applying the concepts should not be the main concern when using program theory. As suggested by Bickman [4], program theory is, in its essence, an approach to understanding processes and making enquires and it is the approach that we believe is useful for understanding design processes.

The description and analysis of PD in section three is meant to demonstrate how PD strives for its aims and effects (outputs, outcomes, and impact) in processes of design, development and appropriation of technology. This does not mean that all PD projects use all mechanisms and pursue all possible effects in all phases. Obviously, there are practical and organisational restraints in every project and though there are ideals to strive for (e.g. democracy and empowerment), PD practitioners are not naïve. However, the concrete examples of methods and practices serve to illustrate how PD activities embody mechanisms such as mutual learning, and collaborative reflection. The insights from Section 3 may be articulated in four general statements concerning PD methods and practices. Altogether, the four statements constitute PD as a distinct participatory approach in HCI.

- PD seeks to make choices and alternatives available to participants in design and use of technologies and thus, ultimately, works towards empowerment and democracy.

Based on its political foundation, PD is fundamentally concerned with the empowerment of people through active engagement throughout the design process. This strive for impacting people’s quality of

INPUT	PROCESS		EFFECTS		
	Mechanism	Activity	Output	Outcome	Impact
Users	Collaborative reflection	Field studies	Social infrastructure	Mutual engagement	Long terms relationships/networks
Designers		Workshops	Technological products	Personal and professional skills	Democratic influence
Stakeholders	Collaborative ideation	Prototyping	Problem analysis	Competence	Quality of (work) life
Design materials	Balancing power relations	Infrastructuring	Design alternatives	New (work) practices	
	Mutual learning	Evaluation	Domain knowledge	Organizational structures	
	Knotworking		Modified prototype		
	Networking		Action plans		
	Design games		Scenarios		
			Evaluation results		

Figure 3: A program theory analysis of PD mechanisms and effects.

life is arguable shared among many participatory approaches, but in PD, however, empowerment and democracy is supported through legitimate access to decisions in the design process and by engagement in the framing of the entire design process. In his description of PD, Bansler [1] states that empowerment is not merely obtained by developing new and better technology with users. Immaterial outcomes such as insights into the design of technology, opening up to various design decisions and solutions, and a legitimate access to the decision-making process are of equal importance. In our analysis, we described how mutual learning and collaborative reflection in field studies and collaborative prototyping stimulates ownership and admits access to the design process. Moreover, gaining legitimate access to knotworks and networks with policy makers and fellow professionals as part of infrastructuring mechanisms is considered to be an potentially important outcome for users.

- Knowledge about use context and practice emerges from mechanisms of collaborative reflection and is as much of value to users as it is to designers.

Knowledge about use context and practice is included in almost every design approach securing that the new design will ultimately meet the needs of future users. Context knowledge is obtained by engaging in activities such as user interviews, observations, surveys and similar activities in which designers gain first hand insights into the use context. In PD, knowledge about use context and practice is considered as also emerging from a dialogical process in which designers, users and other participants collaborative work on topics related to the use context. Consequently, subtle mechanisms of dialogue are carefully integrated into participatory activities such as participant observations (field studies), inspiration card workshops (workshops), collaborative prototyping (prototyping) and living labs (infrastructuring). Moreover, the knowledge emerging from field studies is not only considered an output that designers can use to create products, but something that is inherently valuable to users in their understanding, reflection upon and development of their own practice.

- Outcomes, impact and their sustainability is pursued through the design process using mechanisms such as knotworking, networking and the establishment of organisational structures.

Creating and sustaining outcomes and impact is a shared concern within different approaches in HCI. In HCI reserach, it is often the case that outcomes and impacts are primarily dependent on the quality of the technological product. PD shares a concern for the quality of products, but devotes additional resources into the infrastructuring mechanisms such as knotworking and networking. As such, PD not only focuses on the development of the digital artefact, but also includes a focus on the organisational structures and immaterial aspects of change by integrating the development of these infrastructures into the process. For example, in the f-lab@school.dk project, network activities including engagement on many levels of authority (from pupils to politicians) was part of the project. Workshops engaging teachers from many schools focused on integrating digital fabrication technology into education and, more importantly, establishing a community of practice among the educators that would sustain the initiatives taken.

- PD evaluation is concerned with all changes related to project outcomes and impact, including an assessment of the participants' personal gains

Whereas much HCI evaluation in concerned with usability, usefulness and user experiences issues, PD includes metrics related to participants' gains from engaging in the design process. This may include new organisational structures, new skills developed or knowledge acquired. Bossen et al [13] reports from a study of long term impacts and personal gains from engaging in a PD project. Here, the project evaluation includes questions related to the participants ability to influence the project, personal gains, new areas of competence acquired and subsequent shifts in career or future training path owing to the project. While much evaluation in PD projects is informally incorporated in the design process through its participatory shaping, there seems to be opportunities to develop more formal evaluations with user participation [14].

5 CONCLUSION

PD is not merely a collection of participatory methods or about having an ethical standpoint in design, but an approach to generate effects related to democracy, empowerment, and quality of process and product. These are, ideally, pursued using mechanisms such as continued collaborative reflection and ideation, knotworking and balancing power relationships. While seemingly similar to other participatory approaches in terms of the activities, PD is distinguished by its mechanisms and the way in which effects are pursued. Our claim is not that PD is superior to other approaches, but that the increased interest in participation at HCI should be matched by an increased nuance in our understanding of the concept. The contributes of this paper to HCI research is an understanding of how PD works and how it may be understood as more than a collection of techniques or a matter of configuring user participation.

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