Supporting End-User Development by Transforming Participatory Design into Meta-Design

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Abstract

Our contribution explores the concept of meta-design as a framework that augments participatory design (PD) for supporting end-user development (EUD). Participatory design emphasizes the active involvement of users in the initial stages of the design process, fostering collaboration and ensuring that the final product meets user needs. End-user development empowers users to create, extend, and adapt software artifacts by fostering human problem-domain interaction, promoting evolutionary design and personalization. Meta-design integrates these two approaches by providing tools, environments, and processes that enable continuous user involvement and system evolution. Our contribution explores how meta-design facilitates the transition from collaborative initial design to sustained user-driven development, ensuring that systems remain flexible, relevant, and user-centred. We illustrate how meta-design not only enhances user empowerment and system adaptability but that the dynamic, ongoing collaboration between users and designers will create socio-technical environments focused on the "unfinished" and consider that design problems have no stopping rule, thus remaining open and fluid to accommodate ongoing change.

Keywords

Meta-design, Participatory Design, End-User Development

1. Introduction

In a world that is not predictable, improvisation, evolution, and innovation are more than a luxury: they are a necessity. Humans are not only rational and goal-oriented; they are also irrational and driven by local circumstances and situated actions. The design of socio-technical environments must cope with wicked problems, and this is not a matter of getting rid of the emergent, but rather of including it and making it an opportunity for more creative and adequate solutions to problems. User-centered and participatory design approaches (whether

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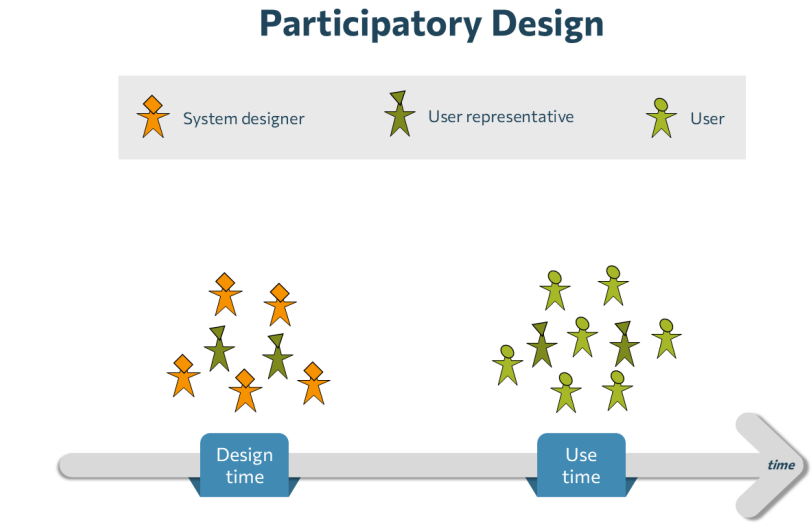
done for users, with users, or by users) have focused primarily on activities and processes taking place at design time.

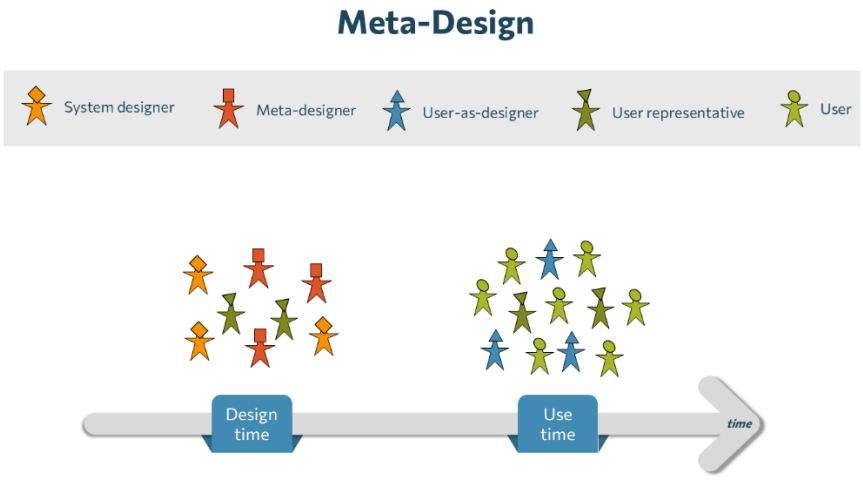
In Participatory Design (PD) [1], user representatives play an active role in design workshops where task analysis is carried out and usage scenarios and early prototypes are created. However, PD does not consider that any system developed to cope with an unforeseen future must change accordingly at use time. These considerations led to the conception of End-User Development (EUD) as encompassing methods and techniques that empower end users to carry out these changes locally whenever they consider them necessary [2][3][4].

EUD requires an approach to designing systems that is different from PD. The concept of *meta-design*, introduced in HCI by Gerhard Fischer in 1999 [5], aims to set the social and technical conditions that allow end users to become co-designers of their digital artifacts at use time rather than merely consumers of them. The relationship between meta-design and EUD was deepened in a 2004 paper published in the Communications of the ACM [6]. This seminal paper defines meta-design as the set of "objectives, techniques, and processes for creating new media and environments allowing 'owners of problems' (that is, end users) to act as designers." One of the fundamental objectives of meta-design is the creation of socio-technical environments through which end users can engage in the continuous development of the systems they use. That paper linked the success of EUD within organizations to the level of user motivation, the existence of effective EUD tools, and management support. All this was described by the authors as obtainable with the introduction of meta-design, which is a framework that is able to increase user motivation and decrease learning and organizational costs. Seeding, Evolutionary Growth, and Reseeding (SER) [7] was proposed as a process model, which postulates that systems are created as seeds (representing *underdesigned systems*), which evolve over time and alternate between periods of end-user development (evolutionary growth) and periods of developer-initiated restructuring (reseeding).

Figure 1 shows the transformation of PD (a) into meta-design (b) through the involvement of further stakeholders. At design time, in PD, system designers and user representatives collaborate to develop the system, while in meta-design also meta-designers are involved. Meta-designers and system designers have distinct roles and knowledge requirements, reflecting their different focuses and approaches to design. Meta-designers prioritize user empowerment and system adaptability, requiring interdisciplinary knowledge and strong facilitation skills. In contrast, system designers focus on creating robust, efficient systems with in-depth technical expertise and a strong emphasis on optimization and performance. Both roles are essential for creating effective, user-centric systems, and their collaboration can lead to innovative and adaptable solutions. At use time, in PD, users (including user representatives) use the system just for their personal or work activities; on the other hand, in meta-design, the developed system will evolve in the hands of a few users (indicated as users-as-designers in Figure 1(b)), who are in charge of continuous system design through EUD.



(a)



(a)

Figure 1: The transformation of participatory design into meta-design.

Given these observations, we argue that meta-design may augment participatory design to support end-user development by involving users at both design and use time, focusing on each use situation as a potential design situation that may exploit EUD methods to foster users' participation. Indeed, the solution of ill-defined problems requires what Alexander called an unselfconscious culture of design [8]: the closeness of contact between user-as-designer and product allows constant rearrangement of unsatisfactory details, thanks to the "talk back" of the partial solutions [9]. By putting owners of problems in charge, the positive elements of an *unselfconscious culture of design* can be exploited in meta-design by creating systems that support people in working on their tasks rather than requiring them to focus their intellectual resources on the system itself.

The rest of the paper explores the dual nature of meta-design, its social perspective and its technical one. Combining these two perspectives is fundamental to design usable and modifiable systems.

2. Meta-Design for End-User Development: A socio-technical perspective

The dual nature of meta-design, the social on the one hand and the technical on the other needs to be fully understood to exploit the potential of EUD and motivate end users to participate in system design both at design and use time. Therefore, we propose a socio-technical perspective of meta-design and we address the social and technical parts separately before uniting them in an example scenario.

2.1 The social perspective of meta-design

When considering the sociality of meta-design, the following key concepts have been suggested in previous work: rich ecologies of participation, cultures of participation, conviviality, and co-evolution of users and systems.

Meta-design supports rich ecologies of participation possibly at different levels of design abstraction and at different times in the process of testing and improving a solution. Different stakeholders can be motivated and engaged through mechanisms and infrastructures that favor communication and mutual understanding. Thus, meta-design leads to or attracts cultures of participation: all stakeholders, according to their own needs, skills, and knowledge, are called on to enrich the system with contents and functionalities that reflect their point of view, possibly capitalizing on others' knowledge. An example is the Scratch online community that fosters cultures of participation through its user-friendly visual programming language. It encourages collaborative projects by allowing users to remix and build upon each other's work, promoting a culture of shared creativity, and fostering learning to code. This unique approach enhances conviviality within the community.

Meta-design supports design at use time, which is when the users become aware of their needs and more proficient in system usage. This implies not only an evolutionary growth of the system according to the SER model but also a *co-evolution* of users and systems [10]. User and system co-evolution does not only lead to content and functionality changes, but new forms of social interactions and shared understanding can be created, extended, and adapted [11][12], so that the synergy of technical and social environments can increase *convivial* interaction [13].

2.2 The technical perspective of meta-design

The technical perspective of meta-design is about the phenomenon of 'design for designers' in that it aims to address the existing/latent design trade-off between the generality of programming languages and the specificity of systems designed to support users' tasks in an application domain. The spectrum depicted in Figure 2 illustrates these concepts. The leftmost component represents general-purpose programming languages, which are used to develop software systems for any application domain. However, such languages are hard to learn, and this could represent a barrier for end users, who are often not motivated enough to learn them.

On the other end of Figure 2 are the over-specialized systems, which are easy to use but cannot be easily (or at all) modified by the users (e.g., mission-critical systems like flight controllers).

In between the two endpoints lies the domain of meta-design, which comprises variable participation and learning effort by end users and fosters different types of EUD activities that are mainly related to software programming. Specifically, EUD methods and techniques allow the creation, extension, and adaptation of digital artifacts. EUD comprises End-User Programming (EUP), which originated in the examples and studies of Nardi [14] and Cypher [15] and is intended to make programming easier for users through specific tools like spreadsheet macro editors [16], script languages [17], or visual programming environments like Scratch [18]. Scratch allows users (primarily children and young people) to create programs by simply dragging and dropping program blocks that look like puzzle pieces in different colors and shapes into different block assemblies (small programs) according to the syntax of a programming language. EUP is usually focused on code creation only, and for this reason, it requires some learning effort (e.g., to choose the right code blocks).

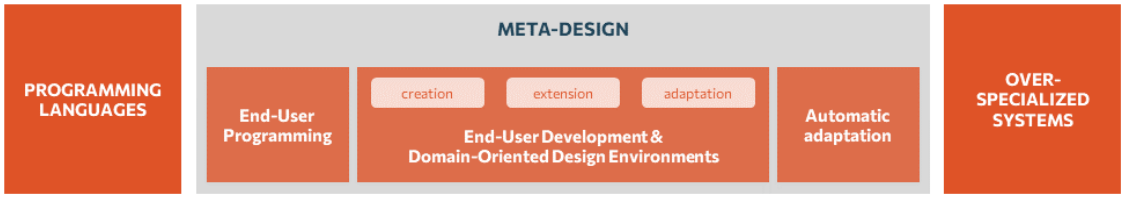


Figure 2: Meta-design and programming: a spectrum of possibilities.

To overcome these limitations, EUD methods have been proposed to enable the *creation of* digital artifacts that do not require users to learn any specific programming language but basically to interact with a software environment built on application domain knowledge, where domain concepts are mapped into visual components. Two examples are the domain-oriented design environments (DODEs) [19] and the software shaping workshops (SSWs) [20], which have been proposed to model specific domains (kitchen design and mechanical engineering, respectively); in both approaches, users (domain experts) can design new systems or parts of systems that other users (end users) can (re-)use and adapt to perform their tasks.

Most EUD environments can only enable the *extension* and *adaptation* of digital artifacts. Let us consider a smart home design scenario: inhabitants in their role of users-as-designers in households can extend or adapt the behavior of their smart home by controlling the installed smart devices to accommodate unexpected needs. Such activities can usually be performed using a graphical interface to define a set of trigger-action rules to determine the activation/deactivation of devices when some condition or event occurs [21].

2.3 An example scenario of smart home configuration and adaptation

To provide a wider view of meta-design to empower end users, we recall the smart home scenario. To set up a smart home, one may choose between two options that we can name *Call the expert* (option 1) or *I will do it by myself* (option 2).

With option 1, the solution is to call an engineer and a professional electrician to design and configure a smart home tailored to the user's requests. Households can participate in the configuration by describing their preferences and habits and hopefully by testing the smart home behavior before the professionals leave the house (ending the design and implementation phase). However, if something changes in the household's life or users discover in the long term that some smart home behaviors are ineffective, a new intervention from professionals is required. This option reflects what happens when a PD approach is adopted.

Alternatively, with option 2, one must address the problem using an ecology of methods (e.g., online step-by-step guides, YouTube videos, friends, and family), tools (sensors and smart appliances available on the market), frameworks (e.g., Samsung, Xiaomi Mi Home, Google Nest), and software applications for rule definition (provided by the tools manufacturer or general ones, such as IFTTT[1]). With this approach, users may act as *pro-ams* [22] (i.e., people working as professionals in a field where they are not experts but just amateurs) to design, create, build, and customize over time (*evolutionary growth*) their own smart home, without the intervention of professionals or by reducing their intervention to only unsurmountable problems (*reseeding phase*). In this case, a meta-design approach is adopted, which promotes social conditions and technical aspects to make the households appropriate and shape their smart home over time.

The speed of technology evolution and the need for adaptation to changing needs and unforeseen requirements lead to the second option being considered the most successful in several situations. In this case, meta-design does not only encompass technology or software environments but everything that is needed to turn a *non-electrician-nor-engineer* into a pro-am that acts as a professional while installing, configuring, and expanding a smart home. More generally, the second option is preferable, or even mandatory, for meaningful problems, as emergent phenomena at both individual and group level, that are ill-defined [23] and, therefore, cannot be delegated to professionals because they are not understood well enough to be described in detail. Finally, the two options can be combined, whereby one would call an expert (option 1) after having done their own local adaptation (option 2) for a while to solve a problem, but a new contingency came up that one wishes to pass over to the expert.

3. Discussion and Conclusion

Participatory Design focuses on user involvement during the initial design phase, but while it brings valuable user perspectives to the table, it does not account for the ever-changing nature of the world and users' needs. This is where meta-design steps in: it focuses on creating the social and technical conditions that allow users to become co-designers throughout the entire system's lifecycle. Meta-design involves users in the creation process at design time, like PD, and equips them with the tools and knowledge to carry out EUD activities at use time. This paper fosters the idea of adopting meta-design by augmenting PD to support EUD.

However, meta-design does not come for free but might determine some pitfalls.

The first one regards the fact that users do not always enjoy the fact that modern tools empower (or enforce) them to do many tasks by themselves, tasks that were previously done by skilled domain workers serving as agents and intermediaries [24]. While this shift provides

[1]https://ifttt.com

power, freedom, and control to customers (e.g., banking can be done at any time of the day with ATMs, and from any location with the Web), users might consider performing tasks by themselves as not very meaningful and sometimes difficult, and would be more than content with just playing a consumer role (e.g., elderly people have difficulty coordinating keystrokes on small devices). Proper socio-technical mechanisms should be designed to engage users and motivate them to participate in such activities.

Another pitfall of meta-design is that it might create an inherent tension between standardization and improvisation. Every modification applied by a user on a system implies costs because the system must be maintained over time. Each time an update of the system is delivered by its provider, there is a risk that the custom modifications might have to be adjusted or re-implemented. Finding the right balance between standardization (which can suppress innovation and creativity) and improvisation (which can lead to a Babel of different and incompatible versions) has been noted as a challenge in open-source environments where forking has often led developers in different directions. The reseeding phase of the SER models tries to address this problem.

With regards to the smart home scenario presented before, a further potential pitfall might arise when EUD methods are applied in a multi-user environment. Such an environment is meant to support collaboration among family members or housemates but potentially leads to conflicts between the individual choices and configuration of the shared environment and its smart devices. The resolution of such conflicts can be seen as a wicked problem for which a unique and always valid solution cannot be specified a priori; the resolution of these conflicts, in fact, depends on the specific situation and needs negotiation between all involved users that goes beyond the interactive system and tools [25].

The introduction of artificial intelligence (AI) technologies, in light of the substantial development that has taken place in the last few years, might help identify possible solutions to overcome the above-mentioned issues. The way the integration of AI and meta-design should be implemented is still to be explored and discussed, especially for what concerns the management of design trade-offs.

We started exploring this theme in the last three editions of the CoPDA (Cultures of Participation in the Digital Age) Workshop series[2]. The 2022 edition considered the role that AI should play in empowering people in their daily personal life and work, including performing EUD activities [26]. In 2023, the CoPDA workshop focused on Computational Fluency as the mastery and appropriation of computational concepts that allow individuals to address new and wicked problems creatively; the integration of AI and meta-design may contribute to developing socio-technical environments that can help nurturing, encouraging, and promoting these abilities [27]. Finally, the CoPDA 2024 workshop edition discussed the "end user" concept, investigating the multi-faceted roles that end users can play in the digital age and envisioning future scenarios and possibilities for end-user roles and experiences in the context of emerging technologies and cultural changes [28].

However, several open issues are still to be addressed. Some of them are:

[2] https://copda.unibs.it/

- What are the design trade-offs related to the balance between the potential value of end-user contributions and the effort necessary to create socio-technical environments that motivate end users to contribute over long periods of time?
- How do we encourage participation and collaboration to address wicked problems whose meaning is an emergent phenomenon at the group level rather than at the individual level?
- How may one support user's critical thinking when AI is integrated with meta-design?
- How to keep human control over AI-based systems that help them create, extend or adapt digital artifacts (namely, performing EUD)?

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