



Re-defining the System Boundaries of Human-Centred Design

Tjark Gall, Flore Vallet, Sylvie Douzou, Bernard Yannou

► To cite this version:

Tjark Gall, Flore Vallet, Sylvie Douzou, Bernard Yannou. Re-defining the System Boundaries of Human-Centred Design. 23rd International Conference on Engineering Design (ICED21), Design Society, Aug 2021, Gothenburg, Sweden. pp.2521-2530, 10.1017/pds.2021.513 . hal-03319886

HAL Id: hal-03319886

<https://centralesupelec.hal.science/hal-03319886>

Submitted on 13 Aug 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

RE-DEFINING THE SYSTEM BOUNDARIES OF HUMAN-CENTRED DESIGN

Gall, Tjark (1,2);
Vallet, Flore (1,2);
Douzou, Sylvie (2,3);
Yannou, Bernard (1)

1: Université Paris-Saclay, CentraleSupélec, Laboratoire Genie Industriel, 3 rue Joliot-Curie 91190 Gif-sur-Yvette, France;

2: IRT SystemX;

3: EDF Research & Development

ABSTRACT

Most services and products are designed in response to the needs, desires or expectations of humans. A variety of methodologies grouped by the term Human-Centred Design (HCD) have been deployed to formalise and improve this process, ranging from user-centred to participatory practices. However, the approaches' consideration is primarily limited to individuals in their respective space and time.

To examine these system boundaries in detail and address potentials for adaptation, this paper reviews dominant HCD methodologies, categorises them and highlights their respective characteristics. Further, concepts and methodologies from related fields are studied for potential contributions to HCD. This results in a proposed re-definition of the system boundaries of HCD by integrating spatio-temporal impacts on humans through an extended social, environmental and economic scope.

The different studied approaches and varying impact assessments are exemplarily applied to the case study of urban mobility, in particular human-centred, scenario-based design approaches. However, the described methods and concepts are kept generic to ensure the applicability across various domains of design practice.

Keywords: Human centred Design, User centred design, Design methodology, Participatory design

Contact:

Gall, Tjark
CentraleSupélec
Industrial Design Laboratory (LGI)
France
tjark.gall@centralesupelec.fr

Cite this article: Gall, T., Vallet, F., Douzou, S., Yannou, B. (2021) 'Re-Defining the System Boundaries of Human-Centred Design', in *Proceedings of the International Conference on Engineering Design (ICED21)*, Gothenburg, Sweden, 16-20 August 2021. DOI:10.1017/pds.2021.513

1 INTRODUCTION

A variety of design methodologies interacting in some way with humans can be grouped through Human-Centred Design (HCD). The term is constituted of the meaning of the word – design with the human, or human characteristics at the core, complemented with the definition of being foremost a non-linear, impact-driven approach and process which solves problems by involving humans in the process and creating outcomes which are responding to the human's expectations ([IDEO, 2015](#)).

Multiple HCD approaches have been developed, such as user-centred, people-centric, inclusive or participatory design. They are applied across various design disciplines such as product and service design, architecture, or urban planning. Yet, they vary significantly in their characteristics and consider the human to varying degrees and with different methods.

Products and services which result from these design processes exist in an environment of interconnected systems in which small changes can have significant impacts. The design of the wheel enabled fuel-based cars and the now significant climate burden and traffic fatalities. However, the design of the first wheel did not cause all subsequent. Hence, while some impacts cannot be anticipated, others are consequential. We focus on the latter. A systematic assessment can be employed to measure these impacts, both in the immediate user environment as well as in more distant places or times.

The urgency of a more systemic thinking towards more sustainable and inclusive design and planning is anchored in the United Nations' Sustainable Development Goals ([UN, 2015](#)), the Paris Agreement ([COP21, 2015](#)), estimations for the irreversible tipping point of the global climate, various Corporate Sustainable Responsibility strategies ([IPCC, 2014](#)), among many others. Additionally, concerns of direct and indirect societal impacts of product and service arise globally (e.g., as outlined by [Rifkin, 2011](#)).

This paper intends to explore how far current HCD approaches consider these systemic impacts and if HCD can expand its fields of application towards more sustainable and inclusive design by re-defining its system boundaries. The research question originates from the context of urban mobility, the domain which will be used throughout the paper for examples, and act as initial case for potential application.

To address the question, the paper is structured in three major parts, followed by discussion and conclusion. First, current HCD methods are described and analysed to reach a preliminary understanding of lacks and potentials for adaptation. Subsequently, concepts and methods from other fields are introduced which can contribute to the discussion. Third, the proposed extended systemic view is applied to the case study of urban mobility to highlight its potential use cases.

2 CURRENT METHODS

This section provides an overview over existing approaches from the design and planning field and an initial classification. The extended definition and description of each type can be found after the classification. The focus lies on approaches directly linked to a varying level of interaction or influence on humans. We group methods with similar approaches and use to the most common name. Existing classifications and frameworks are the foundation for the following ([Sanders and Stappers, 2008, 2014](#); [Buur and Matthews, 2008](#)).

Most notably, [Sanders and Stappers \(2008\)](#) developed a matrix divided into 'led by design' vs. 'led by research' on one axis and 'user as subject' vs. 'user as partner' on the other. User-centred design approaches are situated on the passive, research-led side, encompassing usability testing, human factors and ergonomics, applied ethnography, lead-user innovation, and contextual inquiry. On the other hand, participatory design research falls onto the active side, including generative design research and 'Scandinavian.' The latter refers to one of the first participatory practices centred around 'deep commitments to democracy and democratisation; discussions of values in design and imagined futures; and how conflict and contradictions are regarded as resources in design' ([Gregory, 2003](#)).

Building on their categorisation, the following classification utilises two parameters which are described below. One focusses on the impact on different types of humans, the second on the level of participation in the design process. The individual human is put at the centre for both.

For the context of the paper, we identified humans of three types. First, the ‘user human’ (or group thereof) who is the product or service’s user and can be an active stakeholder of the design process. Second, the ‘non-user human’, which is part of the same immediate society, referring to the group of humans in a homogenous spatio-temporal context. The second may be exposed to the impacts of the designed product or service. In some cases, the latter may also be indirectly involved through, e.g., surveys whose outcomes inform the final product but whose participants do not become users themselves. Third, the ‘distant human’ which is part of humankind but not of the direct society. This can be distant in time and/or space. The group of the first two types, including users and non-users, constitutes the society. Combined with the latter, this is referred to with humankind in Figure 1.

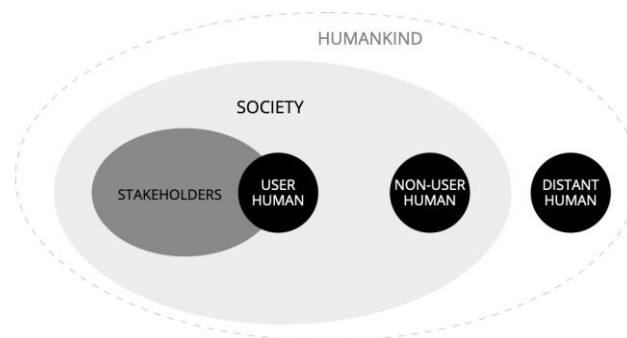


Figure 1. Relation between types of humans, society, and humankind

The second dimension of classification addresses the level of participation in the design process as proposed by [Sanders and Stappers \(2008\)](#). This is relevant for two reasons. First, the definition of HCD focuses on the integration of humans in the process as a core element. Second, the level of participation of humans may relate to the impacts of the product or service and is, therefore, central for the purpose of this paper. Hence, we categorise the approaches ranging from no participation, to co-creation, and finally decentralised design (user designs independently, described in detail below).

Building on these two categories, Figure 2 portrays the different HCD approaches. The x-axis portrays a qualitative assessment of the different approaches’ range of impact on humans, ranging from the user human on the left, to humankind on the right. On the y-axis, it shows the range of typical levels of participation, ranging from no/low participation to high levels of participation.

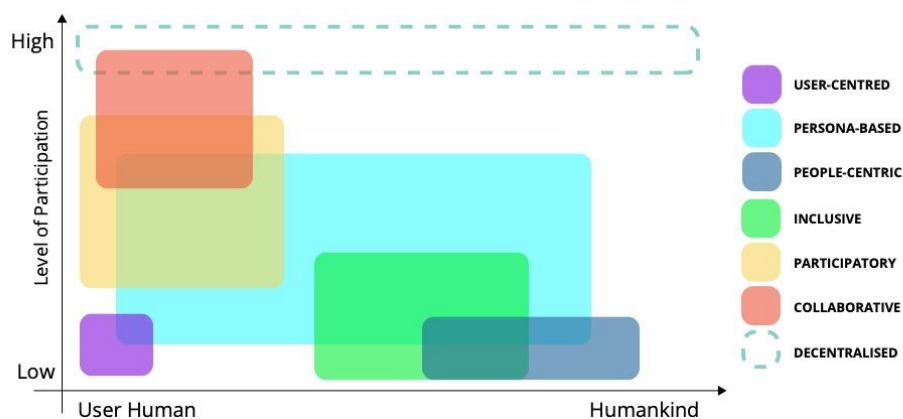


Figure 2. Human-centred design approaches

While the arrangement in Figure 2 is not irrefutable, it can lead to three observations: 1) More active HCD processes are likely to focus on impacts on user humans; 2) Approaches more focused on humankind are less likely participative; 3) None considers fully the impacts on humankind, even less so from the more participatory approaches. Excluded from this is decentralised design, which is most participative but does not necessarily considers anyone but the designing human itself. Yet, if everyone

has the same capability of designing for themselves, it could lead to a democratic representation of each human, hence humankind at large. However, as it is not a widespread method, it cannot be fully considered. To expand on the characteristics, the following section describes and compares the methods.

2.1 User-Centred Design

User-centred design can be defined as ‘an iterative design process in which designers focus on the users and their needs in each phase of the design process’ in which ‘design teams involve users throughout the design process via a variety of research and design techniques, to create highly usable and accessible products for them.’ ([Interaction Design, 2020](#)). The approach is often linked to user interface design and other sub-fields which intend to be responsive and/or predictive, e.g., through the use of market analyses or weak signals. The approach can be supplemented by concepts such as future users ([Gregory, 2003](#)), lead user/early adopters/lighthouse customer ([Buur and Matthews 2008](#)), or methods such as customer journeys. Empathic or compassionate design add an additional dimension ([Seshadri et al., 2019](#)).

2.2 Persona-Based Design

Another approach, building on user-centred design, is persona-based design. Initially developed by [Cooper \(1999\)](#) as user personas for software development, teams within Microsoft extended the application and set out foundations which find their application until today ([Pruitt and Grudin, 2003](#)). User personas have been extended in various ways, for examples towards future or anti personas ([Fergnani, 2019](#), [Fergnani and Jackson, 2019](#); [Fuglerud et al., 2020](#); [Miaskiewicz and Kozar 2011](#); and [Salminen et al., 2020](#)). They can be developed in various ways depending on available information, resources and requirements profiles. These can be through focus group, survey-based ([Schäfer et al. 2019](#)) or big-data based ([Stevenson and Mattson, 2019](#)). While personas bear potentials, a challenge is that they can never represent the diverse reality. However, they can contribute to more accentuated representation of users. Additionally, they can ensure that statistically underrepresented groups such as people with disabilities are considered through a disproportional portrayal. While this approach is traditionally either a variation of user-centred or HCD, it can be seen as a more inclusive and participatory approach depending on the chosen process ([Vallet et al., 2019](#)). If personas are co-created but only used by designers, it can be an inclusive process. If the created personas inform a collaborative design process, it can merge the strengths of various tools.

2.3 People-Centric Design

People-centric design is a variation of user-centred design with a stronger focus on the people and the public perspective. It originates from the field of urban design, spearheaded by Danish architect and urbanist Jan [Gehl \(2011\)](#) in the 1960s. He studied public spaces in Italy through a multi-disciplinary lens, leading to a renaissance of concepts such as human-scale and human-friendly cities in times of car-dominated urban transformations. His work constituted the European pendant to Jane [Jacobs \(1961\)](#) pioneering work to re-focus cities on people through a list of recommendations which remain valid until today. Since then, conceptual subsidiaries arose, e.g., child-friendly design. In a broader sense, people-centric design can be grouped with design anthropology ([Buur and Matthews, 2008](#)).

2.4 Inclusive Design

Inclusive design highlights that each ‘design decision has the potential to include or exclude customers’ and focuses on ‘the contribution that understanding user diversity makes to informing these decisions’ ([University of Cambridge, 2020](#)). While often used to design for people with disabilities, this would be more accurately accessible design. Further, inclusive does not equal inclusionary design. The former allows everyone to participate, whereas the latter refers to prioritising the diversification and consideration of unique groups ([Reis Santos, 2021](#)). Compared to the previous approaches, inclusive design shares many similarities but adds the importance for individuality in observing and including people’s needs in design processes to reach good outcomes for all groups.

2.5 Participatory Design

Participatory design refers to design processes in which the user directly participates. This can manifest in a variety of ways, from short opinion surveys at the start of the process to an ongoing consultation. Other concepts with a similar meaning are citizen/user/stakeholder engagement, among others ([Bertolini](#)

2020). While participatory design is centred on the active involvement of people, the design process remains separate and only informed by the participation process. Therefore, participation can sometimes become a mere box to tick or mandatory element without integration of the results in subsequent steps.

2.6 Collaborative Design

The next level of active involvement is co-design, co-creation, or co-production. The prefix ‘co’ refers to collaborative, or the simultaneous, open, and horizontal collaboration between designers/experts and users/citizens. Extended conceptualisations thereof include the co-production as part of co-creation, e.g., through storytelling (Gall and Haxhija, 2020), or practices of mediation, negotiation, and consensus finding (Watson, 2002, 2003). While it goes under various names, co-design and co-creation found widespread use and are often jointly developed with initiatives towards open science, citizen science, or citizen observatories. While the user plays a significant role, the designer remains a central figure as facilitator, mediator, or translator (of knowledge) (Sanders and Stappers, 2008 and Verloo 2019).

2.7 Decentralised Design

Lastly, and less formally defined, an approach of decentralised design has been added in response to current trends such as decentralised or newly re-localised production as well as the concept of prosumers (acting as both producers and consumers), enabled by new technologies and values (e.g. Kropotkin, 1902; Rifkin, 2011). The proposed addition describes a process in which no designer or external expert is actively involved in. The role of a facilitator is rendered substitutable, for example due to improved interaction with machines through simplified processes. While this does not apply in many cases yet, it might in the future. A common example is the potential of decentralised design and production enabled through 3D-printing (Urry, 2016). However, decentralised design describes a field broader than the existing maker movement and other initiatives that evolved around 3D printing. When imagining design approaches of the future, the concept of post-automation can add another layer, describing the period where most essential functions would be automatised and people at large would have access to design and production facilities, an abundance of time and interest or even need to create and produce artifacts.

Another analogy can be drawn to approaches such as bottom-up, community-led, or grassroots design (Seyfang and Smith, 2007). Compared to approaches by larger organisations or institutions, they start like decentralised design on a very small local scale. However, they intend to scale up. This can be seen as a variation or potential consequence of decentralised design, which in itself just focuses on the design process of an individual for an individual or a very small group (such as the family).

2.8 Discussion of methodologies

Comparing the seven design approaches described, they share the interaction with humans in some way. The first address the human primarily as user and intend to increase the understanding of expectations and needs, the latter involve the human actively in the design through participation, co-design, or even by becoming the designer themselves. Important are two key characteristics: 1) While all have relevant key characteristics, none of the described methods can be seen as holistic. Thus, in most cases choosing one does not suffice. 2) None of the main approaches (excluding decentralised design) considers impacts on user humans, non-user humans and distant humans simultaneously.

3 EXPANDING THE SYSTEM BOUNDARIES

This chapter discusses two topics. First, it shows three potential expansions of the system boundaries of HCD. Second, it elaborates on the potentials of an expansion of the respective expansions and introduces existing concepts and theories which may be utilised to incorporate an extended impact consideration.

3.1 Ways of expanding

If we return to the point of departure of HCD we are at the consideration of impact on and involvement of the human, or more precisely the different types thereof. As shown before, this can take different shapes. In the most common version, the focus is strongly on the ‘user human’ at the present time. For example, a vehicle is designed based on the needs – and possibly with participation – of a certain group of humans which will be the users of the product. Currently, this is the common HCD system boundary.

A first expansion of the system boundary would add the temporal element and include future impacts on the same human user. For example, a vehicle may fulfil the current needs of a user by being comfortable, convenient, and suitable for various use cases. However, over the long term it may lead to negative impacts, such as deteriorating health due to reduced movement and pollution, or financial stress due to a short product lifetime (see, e.g., price of poverty).

The second expansion can be the considerations of non-user humans of the same society. Reusing the example of the vehicle, an added electric vehicle may lead to an increased risk of traffic accidents and less available space for others, but also lead to positive impacts such as decreasing air pollution.

The third expansion can be the integration of distant humans in both space and time. This includes international as well as intergenerational variance. Example of this field are manifold, ranging from those involved production in distant countries, to next generation's exposure to increased climate risks.

3.2 Potentials of expanding

HCD is a suitable tool, even more so with the expanded conceptualisation. For traditional HCD, the fulfilment of human needs as users is oftentimes at the centre of product and service design. Many of these needs can be categorised according to the Hierarchy of Needs, developed by Maslow in 1943. While it has been criticised for a missing consideration of the role of the community in fulfilling needs, among others, it continues to highlight different levels of importance of needs for individual human. Hence, the pyramid serves the goal of pointing out one of the primary reasons for expanding HCD: Can a design process be called human-centred if the resulting design object serves the highest need of self-actualisation of a small group but directly or indirectly hinders the actualisation of basic, physiological needs for a larger group, e.g., through a large environmental footprint or endangering/evicting marginalised groups?

Any comparative consideration between different positive and negative impacts on different groups raises a question of justice. Hence, to assess and compare impacts between groups of humans, the fulfilment of one human's needs should not negatively impact the capability of a non-user human ([Rawls 1971, 2001](#); [Sen, 1979](#); [Nussbaum, 2003](#)). This justice perspective between individuals or groups in one location can be extended by the perspective of international and intergenerational injustice ([Glottzsch and Baumgärtner, 2012](#)). These take disparities between regions, e.g., the Global North and South, as well as today and the future into account ([Althor et al., 2016](#)).

In the particular case of environmental impacts, the methodology chosen to design, and its resulting product or service can have a significant global impact on the environment. In order to assess these impacts, a variety of tools has been created from private and public sector since the early beginnings of encouraging sustainable practices ([WCED, 1987](#)). These include a restrictive policies, environmental and social labels and certifications, as well as Corporate Social Responsibility (CSR) strategies. While these mechanisms bear a potential in assessing impacts, they focus on immediate impacts of production but are no systematic element of the design process. In the case of eco-design, a holistic assessment of environmental impacts is incorporated in the design phase; however, excluding social impacts. Lifecycle assessment (LCA), or variations such as social-LCA or consequential LCA address the same challenge in the planning phase with a broader consideration, while concepts such as 3P (People, Planet, Profit), the Triple-layered Business Canvas or the more integrated Flourishing Business Canvas do so on from a business perspective.

Design and human activities can influence each other in both directions. HCD can be responsive, predictive, as well as normative on humans' activities. Simplified, 'good' design can enable 'good' activities and 'good' activities can result in more demand and support for 'good' design. Or vice versa. In the ABC framework of social change ([Shove 2010](#); Attitude, Behaviour, Choice), attitude influences the behaviour which informs the choices made. To achieve changing activities, a change of attitude is needed. There is no complete grasp of the workings of attitude yet: Individual and community dynamics, their expectations, actions and behaviours all play a role. Individual attitudes rival with competitive or collaborative ones which build on principles of mutual aid (Kropotkin, 1902). Crucial is the bidirectional relation and potential lock-ins due to path dependency and self-reinforcing systems ([Shove 2010](#)).

4 THE CASE OF URBAN MOBILITY

This section describes the case of urban mobility as the field from which our consideration of HCD system boundaries originated to show how their extension could contribute to existing processes, in particular in the context of urban mobility futures. The outlined case will be developed further in the future to test and apply the extended definition in a specific context and showcase its contribution.

In particular, we focus on human-centred, scenario-based approaches to design, prepare, and plan for the future. Scenarios are used as one of the alternative-building methods of futures studies ([Inayatullah, 2013](#)) to inform and guide decision makers by creating normative or descriptive alternatives, expanding cognitive limitations from bounded realities, and formulating relatable and plausible future narratives (see [Crawford 2019](#) and [Weidema et al. 2004](#)). Initiated by [Shell \(1971\)](#) in the 1960s and made public in the subsequent decade, scenarios started as a tool to prepare businesses for (future) trends or shocks (such as the 1973 oil crisis). Quickly taken on by academia ([Kahn and Wiener 1967](#)), other business sectors and think tanks around the globe, today scenarios-based approaches can be found in a variety of sectors ([Budman and Khan, 2018](#)).

In the case of mobility, resource-based scenarios similar to the original Shell case persist, expanded by scenarios focusing on emerging technologies, socio-economic trends, and changing behaviours, among others. Mostly in relation to the latter, the HCD perspective becomes highly relevant. While some scenarios are focusing on specific groups of the (future) population and tailor the developed scenarios accordingly, primarily through user-centred approaches, others are involving participatory practices, e.g., by utilising persona-based approaches. The proposed combination with scenarios shall contribute to the field of innovation and policy design; both by preparing for future events and by building robust policies, products and services which react and survive in a wide range of potential future environments.

In this context, the distinction between users, objects and subjects, and involved stakeholders becomes quite quickly complex: The greenhouse gas contributions of the transport sector are with 22% at the second place after heating, while 1.35 million people are killed on roadways annually ([Climate Watch, 2020](#); [CDC 2020](#)). In Paris, road infrastructure takes up 27 % of space in urban areas, 57% thereof for cars ([Héran and Ravalet, 2008](#)). Further, it uses a variety of scarce resources in production ([Metabolic, 2019](#)), and create negative externalities for the society through lost productivity due to traffic, estimated at up to \$14bn per annum in Paris alone (Cebr, 2014). Hence, the impacts of a century of fuel-based vehicle transportation are globally significant for societies today (e.g., through air pollution and sea level rise) and will be even more so in the future. This led to strong call for the reduction of transport-related emissions and the transformation of mobility patterns in the Paris Agreement ([COP21, 2015](#)), UN Sustainable Development Goals (2015) and New Urban Agenda (UN-Habitat, 2016).

With this in mind, we can apply the HCD framework in this context. A product such as a car or a service such as shared riding services can be developed using a highly user-centred design approach and participatory practices, but still remain detrimental for a significant portion of today's and tomorrow's society. Hence, the extended system boundaries of the HCD approach bears various advantages for urban mobility if coupled with strong sustainability and inclusivity objectives. This would, for example, include localised elements such as accessibility ([Soja 2009, 2010](#)), social mobility, and spatialised impacts of climate change. On the other hand, global impacts can be considered through, e.g., Life Cycle Assessment (ISO 14040:2006), guided by climate objectives ([COP21, 2015](#), [Bigo, 2020](#)), and build on principles of eco-design, resource efficiency, circular economy, and up-/recyclability. The 3P framework (People, Planet, Profit) commonly used in the field of sustainability assessments, can provide inspiration for methodological approaches. Economic impacts for external parties can be further examined through an assessment of system externalities.

Crucial is to emphasise that the extended conceptualisation does not devalue the importance of existing human- and user-centred approaches. The increasing application of participatory and co-creative methods is supposed to actively contribute to fulfilling broader objectives as well by widening the activated knowledge base and considering more diverse impacts on different, participating groups. For example, the multi-layered stakeholder approach ([Spickermann, 2014](#)) can be used to bring experts from different fields together, all with their respective set of intentions and expertise. In the case of future

scenarios, the Delphi method as an expert consensus and dissensus building tool already exists, which can lead to the activation of experts representing societal interests (Kahn and Weiner, 1967, [Julsrud and Uteng, 2015](#), Schuckmann 2012). If framed as such, most existing tools can be easily extended. For example, collaborative design approaches such as design workshops with preceding capacity development for participants, design competitions, hackathons, or gamified approaches can include the societal perspective. Online or offline platforms for voting, ranking, or exclusionary selection (Jean et al., 2019), or particular participatory budgeting (Burón Garcia and Sánchez Mora, 2019) can be used with tailored value indices. The application of the latter showed for example in Paris that community choices can favour socially inclusive solutions ([Cabannes, 2017](#)). Also, prioritisation methods such as traditional cost-benefit or advanced cost-effectiveness, or multi-criteria analyses, action planning, and value buckets have been extensively applied in similar contexts and can bridge the gap to HCD. Hence, the tools are there – and with broadened scope of objectives – bear various new fields of application.

5 DISCUSSION

The objective of this paper was to explore a re-definition of the system boundaries of HCD to increase its fields of application on larger impacts while keeping the human at the centre. While we believe that the proposed adaptation can contribute to the field of research and application, a variety of other classifications do exist and have contributed significantly to the field of research as well as this paper. Yet, many approaches are limited to narrow sectors or have been developed with a specific goal. Additionally, many papers refer to similar methodologies or concept with different names or use the same name for different ones. Therefore, we believe that the proposed approach and its multi-disciplinary perspective can improve the applicability, replicability and further development. While we intended a classification independent of fields of application, the outcome is nevertheless influenced by urban mobility literature. Hence, a subsequent validation and extensions in other fields would highly benefit the quality. To revise the point of departure, an adapted definition is proposed:

Human-Centred Design is an inclusive design approach for products and services which puts humans' needs in the centre, involves them actively through co-creation, and assesses the systemic impacts on humans in present and future societies.

We believe that this definition can contribute to the design practice by encouraging the consideration of impacted humans, instead of users and active participants alone. HCD provides a valuable conceptual foundation to integrate broader perspectives from other fields. This allows to integrate, for example set sustainability objectives, into the design process to impact decisions early on.

6 CONCLUSIONS

HCD is a broad field of methodologies and concepts with a variety of linked approaches. While we attempted to include the most relevant concepts and terminology, we do not claim comprehensiveness over all user-/human-based approaches. Further, the approach is work-in-progress based on ongoing research in the field of scenario-based urban mobility futures. The described approaches, tools, and shortcomings thereof shall be nevertheless seen as independent from the field of application.

With this paper, we intend to argue that expanded view of system boundaries of HCD can further increase its utility in design practice. The proposed framework will be further developed and tested as part of the ongoing research in the field of future urban mobility scenarios. The next steps shall validate the presented classification and will test the extension of HCD system boundaries when applying the mentioned existing approaches and associated tools. Lastly, studying possible future roles of decentralised design further bears potential to expand the concept and should be explored further.

ACKNOWLEDGMENTS

We thank the valuable feedback from the two anonymous reviewers. This research was carried out as part of the Anthropolis Chair of IRT SystemX and is part of ongoing research at the Design Engineering Laboratory (LGI) of Centrale Supélec, University Paris-Saclay.

REFERENCES

- Althor, G., Watson, J. E. M. and Fuller, R. A. (2016), Global mismatch between greenhouse gas emissions and the burden of climate change. *Scientific Reports*, Vol. 26/20281. <https://doi.org/10.1038/srep20281>
- Bertolini, L. (2020), "From "streets for traffic" to "streets for people": can street experiments transform urban mobility?", *Transport Reviews*, pp. 1-20. <https://doi.org/10.1080/01441647.2020.1761907>
- Bigo, A. (2020), *Les transports face au défi de la transition énergétique. Explorations entre passé et avenir, technologie et sobriété, accélération et ralentissement*. PhD Dissertation. Chaire Energie et Prospérité.
- Buur, J. and Matthews, B. (2008), "Participatory Innovation", *International Journal of Innovation Management*, Vol. 12/03, pp. 255-273. <https://doi.org/10.1142/S1363919608001996>
- Burón García, J. and Sánchez Mora, M. (2019), D3.2: Delivery of the citizen participation playbook. [online] +CityxChange. Available at: <https://cityxchange.eu/knowledge-base/> (24/11/2020).
- Cabannes, Y. (2017), "Participatory Budgeting in Paris: Act, Reflect, Grow", *Another city is possible with Participatory Budgeting*. Montréal/New York/London: Black Rose Books, pp. 179 – 203.
- CDC (2020), "Road Traffic Injuries and Deaths – A Global Problem". <https://www.cdc.gov> (03/12/2020)
- Cooper, A. (1999). *The inmates are running the asylum*. Macmillan.
- COP21 (2015), "Paris Agreement to the United Nations Framework Convention on ClimateChange", Dec. 12, 2015, T.I.A.S. No. 16-1104.
- Climate Watch (2020), "Historical GHG Emissions", [online] <https://www.climatewatchdata.org> (03/12/2020)
- Crawford, M. M. (2019), "A comprehensive scenario intervention typology", *Technological Forecasting & Societal Change*, Vol. 149/119748, pp. 1-27. <https://doi.org/10.1016/j.techfore.2019.119748>
- Budman, M. and Khan, B. (eds.) (2018), "Making the future of mobility", *Deloitte Insights*, Deloitte series on the future of mobility.
- Fernani, A. (2019), "The future persona: a futures method to let your scenarios come to life", *foresight*. <https://doi.org/10.1108/FS-10-2018-0086>
- Fernani, A. and Jackson, M. (2019), "Extracting scenario archetypes: A quantitative text analysis of documents about the future", *Future & Foresight Science*, Vol. 1/2, pp. 1-14. <https://doi.org/10.1002/ffo2.17>
- Fuglerud, K., S., Schulz, T., Janson, A. L. and Moen, A. (2020), "Co-creating persona scenarios with diverse users enriching inclusive design", In: Antona M., Stephanidis C. (eds) *Universal Access in Human-Computer Interaction*. Springer, Cham. https://doi.org/10.1007/978-3-030-49282-3_4
- Gall, T., Haxhija, S. (2020), "Storytelling of and for Planning: Urban Planning through Participatory Narrative-building", 56th ISOCARP World Planning Congress, virtual, November 2020-February 2021.
- Gehl, J. (2011), *Life Between Buildings: Using Public Space*. Sixth Edition. London: Island Press.
- Glotzbach, S. and Baumgärtner, S. (2012), "The Relationship between Intragenerational and Intergenerational Ecological Justice", *Environmental Values*, Vol. 21, pp. 331-355. <https://doi.org/10.3197/096327112X13400390126055>
- Gregory, J. (2003), "Scandinavian Approaches to Participatory Design", *International Journal on Engineering Education*, Vol. 19/1, pp. 62-74.
- Héran, F. and Ravelet, E. (2008), *"La consommation d'espace-temps des divers modes de déplacement en milieu urbain Application au cas de l'Ile de France*. Lille: PREDIT.
- IDEO (2015), *"A Field Guide to Human-Centred Design"*, 1st Edition.
- Inayatullah, S. (2013), "Future Studies: Theories and Methods."
- Interaction Design (2020), "User Centered Design", [online]. <https://www.interaction-design.org/literature/topics/user-centered-design> (25/11/2020).
- International Organization for Standardization (ISO) (2006), "ISO 14040:2006: Environmental management – Life cycle assessment – Principles and framework."
- IPCC (2014), "Climate Change 2014 Synthesis Report", Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.
- Jacobs, J. (1961), *"The Death and Life of Great American Cities"*, New York (NY): Random House; 1961.
- Julsrud, T. E. and Uteng, T. P. (2015), "Technopolis, shared resources or controlled mobility? A net-based Delphi-study to explore visions of future urban daily mobility in Norway. *European Journal of Futures Researches*, Vol. 3, pp. 1-13. <https://doi.org/10.1007/s40309-015-0069-6>
- Kahn, H. and Wiener, A. J. (1967), *"The Year 2000: A Framework for Speculation on the Next Thirty Years*. Macmillan Publishing.
- Maslow, A. H. (1943), "A theory of human motivation", *Psychological Review*, Vol. 50/4, pp. 370-396. <https://doi.org/10.1037/h0054346>
- Metabolic (2019), *"Metal Demand for Electric Vehicle: Recommendations for fair, resilient, and circular transport systems"*, Amsterdam: Metabolic.
- Miaskiewicz, T. and Kozar, K. A. (2011), "Personas and user-centered design: How can personas benefit product design processes? *Design Studies*, Vol. 32/5, pp. 417-430. <https://doi.org/10.1016/j.destud.2011.03.003>

- Nussbaum, M., 2003. Capabilities as fundamental entitlements: Sen and Social Justice. *Feminist Economic*, 9/2-3), pp. 33-59. <https://doi.org/10.1080/1354570022000077926>
- Pruitt, J. and Grudin, J. (2003). "Personas: Practice and Theory", Conference on Designing for User Experiences, San Francisco, June 2003, Association for Computing Machinery, New York (NY), pp. 1-15. <https://doi.org/10.1145/997078.997089>
- Rawls, J. (1971), "A Theory of Justice", Cambridge: Harvard University Press.
- Rawls, J. (2001), "Justice as Fairness. A Restatement." Cambridge: Harvard University Press.
- Reis Santos, M. (2021), "Learning from Global Best Practices: An Overview of Urban Land Policies and Inclusionary Measures for Affordable Housing", forthcoming.
- Rifkin, J. (2011), "The Third Industrial Revolution", London: Palgrave Macmillan.
- Salminen, J., Santos, J. M., Jung, S.-G., Eslami, M. and Jansen, B. J. (2020), "Persona Transparency: Analyzing the Impact of Explanations on Perceptions of Data-Driven Personas", *International Journal of Human-Computer Interaction*, Vol. 36/8, pp. 788-800. <https://doi.org/10.1080/10447318.2019.1688946>
- Sanders, E. B.-N. and Stappers, P. J. (2008), "Co-creation and the new landscapes of design", *International Journal of CoCreation in Design and the Arts*, Vol. 4, pp. 5-18. <https://doi.org/10.1080/15710880701875068>
- Sanders, E. B.-N. and Stappers, P. J. (2014), "Probes, toolkits and prototypes: three approaches to making in codesigning", *CoDesign*, Vol. 10/1, pp. 5-14, <https://doi.org/10.1080/15710882.2014.888183>
- Schäfer, K., Rasche, P., Bröhl, C., Theis, S., Barton, L., Brandl, C., Wille, M., Nitsch, V. and Mertens, A. (2019), "Survey-based personas for a target-group-specific consideration of elderly end users of information and communication systems in the German healthcare sector", *International Journal of Medical Informatics*, Vol. 132/103924, pp. 1-7. <https://doi.org/10.1016/j.ijmedinf.2019.07.003>
- Sen, A. (1979), "Equality of What?", The Tanner Lecture on Human Values. Stanford University, 22 May 1979. Transcript available at: https://tannerlectures.utah.edu/_documents/a-to-z/s/sen80.pdf (02/12/2020).
- Seyfang, G. and Smith, A. (2007), "Grassroots Innovations for Sustainable Development: Towards a New Research and Policy Agenda", *Environmental Politics*, Vol. 16/4, pp. 584-603, <https://doi.org/10.1080/09644010701419121>
- Schuckmann, S. W., Gnatzy, T., Darkow, I.-L. and von der Gracht, H. A. (2012), Analysis of factors influencing the development of transport infrastructure until the year 2030 – A Delphi based scenario study", *Techn. Forecasting & Social Change*, Vol. 79, pp. 1373-1387. <https://doi.org/10.1016/j.techfore.2012.05.008>
- Shell Group Planning (1971), "A Probabilistic Approach to the Forecasting of Upstream-Government Take on Crude Oil Exports: 1970-1985", PL/52.
- Shove, E. (2010), "Beyond the ABC: Climate Change Policy and Theories of Social Change", *Environment and Planning A: Economy and Space*, 42/6, pp. 1273-1285. <https://doi.org/10.1068/a42282>
- Soja, E. (2009), "The City and Spatial Justice", *Spatial Justice* Vol. 1/2009, pp. 1-5.
- Soja, E. (2010), "Seeking Spatial Justice." Minneapolis, University of Minnesota Press.
- Spickermann, A., Grienitz, V. and von der Gracht, H. A. (2014), "Heading towards a multimodal city of the future? Multi-stakeholder scenarios for urban mobility. *Technological Forecasting & Social Change* Vol. 89, pp. 201-221. <https://doi.org/10.1016/j.techfore.2013.08.036>
- Stevenson, P. D. and Mattson, C. A. (2019), "The Personification of Big Data", *International Conference on Engineering Design ICED19*, Delft, August 2019. <https://doi.org/10.1017/dsi.2019.409>
- United Nations (2015), "Draft outcome document of the United Nations summit for the adoption of the post-2015 development agenda. Transforming our world: the 2030 Agenda for Sustainable Development."
- University of Cambridge (2020), "Inclusive Design Toolkit", University of Cambridge [online]. <http://www.inclusivedesigntoolkit.com/> (03/12/2020).
- Urry, J. (2016), "What is the Future?", Cambridge, UK: Policy Press.
- Vallet, F., Puchinger, J., Millonig, A. and Lamé, G. (2020), "Tangible futures: Combining scenario thinking and personas - A pilot study on urban mobility", *Futures*, Vol. 117/102513, pp. 1-26. <https://doi.org/10.1016/j.futures.2020.102513>
- Verloo, N. (2019), "Captured by bureaucracy: street-level professionals mediating past, present and future knowledge", In: Raco, M. and Savini, F. (eds), "Planning and Knowledge: How New Forms of Technocracy Are Shaping Contemporary Cities". Policy Press, pp. 75-89.
- Watson, V. (2002), "Do We Learn from Planning Practice? The Contribution of the "Practice Movement" to Planning Theory", *Journal of Planning Education and Research*, Vol. 22 (2), pp. 178-187. <https://doi.org/10.1177%2F0739456X02238446>
- Watson, V. (2003), "Conflicting Rationalities: Implications for Planning Theory and Ethics", *Planning Theory & Practice*, Vol. 4/4, pp. 395-407. <https://doi.org/10.1080/1464935032000146318>
- WCED (1987), "Report of the World Commission on Environment and Development: Our Common Future."
- Weidema, B.P., Ekvall, T., Pesonen, H.-L., Rebitzer, G., Sonnemann, G.W. and Spielmann, M. (2004), "Scenarios in life cycle assessment". Society of Env. Toxicology and Chemistry, Brussels/Pensacola.