A CRITICAL REVIEW OF DATA DEMOCRATISATION AND ITS ADOPTION IN DESIGNING BUILT-ENVIRONMENTS

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Abstract. Data democratisation aims to empower the stakeholders in a problem domain and engage them in participating in decision-making by providing access to all relevant data. Its application in multiple fields, such as information systems, healthcare, business, and policymaking, can guide us to develop a novel approach to design democratisation informed by data to enhance the stakeholders' participation in creating built environments. In this paper, we identified the basic principles and attributes of data democratisation through a systematic literature review and existing tool analysis to identify potential system features supporting data democratisation. Both guided us in developing a conceptual framework for data-informed design democratisation. We propose a set of practical recommendations for interactive system development for this purpose. Our study aims to contribute to expanding the knowledge in the field of design-data democratisation and offers guidance for leveraging stakeholder engagement for design.

Keywords. data democratisation, built environment design, design decision-making, urban design, architecture, public engagement.

1. Introduction

This paper investigates data democratisation and develops a conceptual framework for democratising built-environment design by making data central for assessing alternatives and sharing insights. Data democratisation generally refers to making data accessible and available to all stakeholders, empowering them to participate in decision-making (Hyun et al., 2020; Awasthi & George, 2020; Lefebvre et al., 2021). 'Built environment' refers to human-made structures, such as buildings and urban spaces, which impact our environment. The approach encourages data accessibility for engaging a broader group of non-specialist stakeholders in decision-making beyond analysts and decision-makers within an organisation, group, or community. This inclusive approach aims to achieve equity by enabling the public to observe, analyse, and leverage data for active participation (Awasthi & George, 2020).

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We propose that adopting data democratisation in the practices involved in creating built environments can foster the designers' ability to identify and address design challenges to create more liveable and responsible environments. By relying on the collective intelligence of diverse stakeholders, they can gain insights into the issues that may directly impact the stakeholders' lives. To articulate data democratisation and its potential functions in creating and selecting design alternatives by engaging the design stakeholders, we introduce the term "data-informed design democratisation" and design data democratisation" synonymously. The term explicitly addresses how data about design decisions can be transparent, accessible, and utilised for consensus building. The overarching goal is a democratic and equitable environment.

In the business domain, the reports highlight the significance of democratising data across an organisation to facilitate the effective use of data analytics, driving positive organisational outcomes by all stakeholders (Hyun et al., 2020). A notable example of the application of data democratisation is evident in public policy initiatives, which aim to encourage inclusivity and collaboration by creating means for citizen participation, thereby reinforcing democratic ownership (Skelcher & Torfing, 2010). In this context, citizens and decision-makers assume distinct yet complementary roles guided by shared rules and tools (Ruijer et al., 2017). Even though the concept of data democratisation has been discussed continuously in several domains (Wang & Yang, 2021; McLaughlin & Young, 2018; Krishnamurthy & Awazu, 2016), there has been no explicit discussion of data democratisation in built environment design. Therefore, one of the goals of this study is to explore answers to the following questions:

> Q1: What are the principles of data democratisation that can guide the development of a conceptual framework for data-informed design democratisation for developing built environments?
>
> Q2: What are the approaches to data democratisation and tools relevant to data-informed design democratisation in developing built environments?
>
> Q3: How can the framework developed be adopted in creating tools that can support design-data democratisation by engaging design stakeholders?

To illustrate the problem context, let us consider a design project, such as a neighbourhood playground, community centre, school, bridge, or a new building-complex development where numerous layers of decisions are to be made. Typically, alternative design ideas are generated and evaluated within limited contexts. We assert that such decisions can be improved by understanding, testing, verification, improvement, or transformation using the insights gained through directly involving the stakeholders. By sharing the design data on platforms tailored for presenting design alternatives, we can enable the stakeholders to view and comment on data. The data may be related to performance, such as cost, sustainability, scope of work and schedules, area, proposed functional compositions, or form, such as alternative spatial compositions, façade design, style, and shadow studies. It is necessary to note that this perspective partially differs from participatory design, as discussed in design literature. Design-data democratisation represents a high-level perspective that encourages stakeholder engagement from a social-interaction perspective rather than enabling their direct involvement in design, necessitating disciplinary expertise and knowledge.

Promoting inclusive access to open data constitutes a foundational element in democratising design. This approach hinges on creating novel platforms or tools designed to empower stakeholders to interpret and extract meaningful insights from the expansive pool of design data. These tools must be tailored to present stakeholders with data directly relevant to their interests and preferences, thereby encouraging the exchange of diverse perspectives, idea generation, inquiries, and discussions through interfaces that support data-informed social interactions.

Recognising the limitations inherent in pre-selected design data and its views, it becomes crucial to develop adaptable tools for engaging stakeholders. Such initiatives are instrumental in establishing flexible frameworks that cater to diverse scales, ranging from neighbourhoods to broader entities such as cities or expansive geographies. Consequently, the cycle of design democratisation within a project unfolds across iterative phases, encompassing development, proposal, discussion, and refinement. The critical stages in this cycle, namely the proposing and discussing phases, constitute the core of the design democratisation framework, staging a dynamic process that drives the evolution of inclusive design practices.

By questioning the underlying rationale for data democratisation, we conducted a literature review to elicit its general principles and create a conceptual framework for design-data democratisation for creating built environments. We investigated the tool features and the principles of data democratisation. Finally, we sought opportunities for system development to realise design data democratisation. By taking this systematic stand, our study hopes to advance the conceptual understanding of design-data democratisation and the development of tools and workflows that will help define a data-informed, collaborative, and creative design environment.

2. Literature Review

2.1. METHODOLOGY

Through a systematic literature review method (Kitchenham, 2004), we surveyed the research and practice on data democratisation by questioning its adoption for inclusive design decision-making. The method we followed applies to the kind of review we conducted in this study, as demonstrated in similar ones shared in the literature (Stapic et al., 2012; Ahmad et al., 2014). In a six-step process, we defined the research questions, established a review process, determined paper selection and quality criteria, and specified data compilation, analysis, and synthesising processes. We aim to learn from the general data democratisation research and apply the lessons learned to identify potential and concerns for the solutions relevant to design-data democratisation for creating built environments. Our three objectives are:

- Explore the current state of the art in data democratisation concerning the existing approaches and tools.
- Summarise the existing literature concerning data democratisation and the lessons learned to create a conceptual framework for design-data democratisation.
- Discuss how the lessons learned could be used for design-data democratisation in built environment design.

2.2. LITERATURE REVIEW

We surveyed the recent literature on data democratisation relevant to the study objectives (listed above). We identified studies that explicitly include the relevant keywords such as "data democratisation," "democratising the data," and "data accessibility." We searched more than two digital libraries as Charrois (2015) recommended for similar studies: ACM Digital Library, IEEE Digital Library, Sage Publications, ScienceDirect, and CUMINCAD. We reviewed each paper to decide if it extensively discusses data democratisation or merely as a subtopic. Additionally, we categorised them based on their relevance to our review objectives. Articles not addressing data democratisation were excluded from the study, while those deemed relevant were retained for further examination. The limitations of this review can include the availability of literature, the possibility of publication bias, and the inclusion criteria selection resulting in the exclusion of relevant studies. We have not considered the inclusion of literature on data democratisation with analogous concepts and attributes, albeit under different terminologies and languages other than English.

2.3. SELECTION CRITERIA AND QUALITY ASSESSMENT

We selected the papers through four iterative steps (Figure 1). Initially, we identified 233 articles (reduced to 199 after eliminating duplicates) using the keywords "data democratisation," "democratisation of data," and "data accessibility." Then, we separated 69 articles focusing on data democratisation as a supportive topic or the primary focus. Next, we examined the full texts, concentrating on their objectives, conclusions, and methodologies to refine the selection, such as removing the ones emphasising its technical aspects (Yoder, 2019; Espinosa et al., 2014). Finally, we selected 35 papers through a thematic analysis. We questioned the system features that can facilitate data democratisation processes and interactions. To ensure the quality of the studies, we followed a three-level: (a) prioritised the papers on data democratisation, system presentations, and application domains; (b) set preferences to select the papers that had undergone a review process; (c) selected the papers published in reputable venues following rigorous research standards.

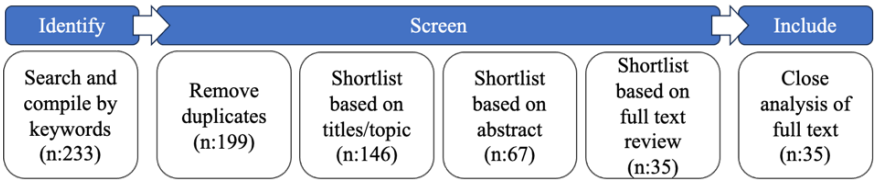

Figure 1. Literature review through identification, screening, and inclusion (c.f. PRISMA, 2020)

2.4. DATA COMPOSITION, ANALYSIS AND SYNTHESIS

We created three broader categories of principles of data democratisation and segregated literature accordingly: data accessibility, stakeholder empowerment, and insight sharing (Table 1). We first analysed the general principles for data democratisation and tools recommended in the select papers while considering publication type (journal, conference, workshop), year, and venue.

Table 1. The three principles of data democratisation are compiled from the literature, considering their approaches and tools.

Principles	Approaches and Tools	Sample Papers
Data Accessibility	Tools for non-specialists Broader data access Training for analytics Skills development Digital data access Data catalogues	Awasthi et al. (2020); Lefebvre et al. (2021); Samarasinghe et al. (2022); Eichler et al. (2022); Fahey (2014); Samarasinghe & Lokuge (2022); Sawicki & Craig (1996); Lefebvre & Legner (2022); Treuhaft (2006); Hinds et al. (2021); Kross et al. (2020); McLaughlin & Young (2018); Butler et al., (2023)
Stakeholder Empowerment	Open data movement Datafied publics Economic incentives Demographic representation ML Feature	Baack (2015); Chou et al. (2014); Patel (2020); Kapadia et al. (2023); Wang & Yang (2021); Krishnamurthy & Awazu (2016); Batarseh & Yang (2020); Lane (2021); Howard (2012); Takang & Amaechi, (2023)
Insight Sharing	Collaboration tools Data literacy Community-driven Innovation Open data pr inciples Data sharing culture	Knudsen et al. (2018); Davies (2010); Howard, A. (2012); Knudsen et al., (2018); Wu et al., (2021); Díaz et al., (2018); Labadie et al., (2020); Koch, (2021); Bhargava et al., (2015); Amerian, (2021); Yoon et al., (2018); Ponea & Ponea (2020)

3. Democratisation Principles for Design

Although data democratisation is defined differently across various disciplines, enough commonalities among them converge at three domain-agnostic principles. Building on these principles, we grounded a conceptual framework of data-informed design democratisation for built environment design.

3.1. DATA ACCESSIBILITY

Data accessibility emphasises enabling diverse stakeholders to find, access, understand, and use data. Organisations embracing the data democratisation culture provide their employees access to their data to break the silos to ask questions and support data-informed decisions (Awasthi & George, 2020). Adopting this principle to engage communities and the public for the built environment design can generate valuable insights for design for verified outcomes and create an inclusive and community-centred position to design. Lefebvre et al. (2021) argue that the complexity of data sets can limit data accessibility and advocate for a dedicated platform to mediate data filtration and presentation. We have yet to find a consensus on how design data for the built environment could be leveraged to engage stakeholders. However, many domains like healthcare, visual analytics and business have already started building consensus on using data by developing interactive dashboards for non-specialists (Wang et al., 2021; Knudsen et al., 2018; Hyun et al., 2020; Samarasinghe et al., 2022). We should consider developing new types of media for design stakeholders to access design proposals with their data. Such media should facilitate participation in data-informed discourse, carry familiar features for immediate data access, and give control to the users' diverse interests in data and skills to interpret them.

3.2. EMPOWERMENT OF DESIGN STAKEHOLDERS

Empowering stakeholders with tools and data can promote community involvement in planning and policy initiatives, as argued by Sawicki et al. (1996). Similar positive impacts of tools for data democratisation in organisational growth have been argued by Bandari (2020). We assert that the tools for data democratisation in built environment practices can also yield comparable effects to those observed in other domains, empowering design stakeholders to inform decisions rather than being constrained by designs over which they have limited control. Baack et al. (2015, p 5) claim that "sharing raw data should help citizens better understand and control their governments and be more active and engaged in their local communities." Similarly, Zeng et al. (2018) highlight that empowering people to access data should be a priority for many organisations to improve inclusiveness in decisions. These arguments can justify the objectives of public engagement in built environment design, where public engagement can make the design democratic through an equitable design process.

There are two main challenges for empowerment: first, whether the daily data consumption cases can transfer to making sense of the data presented as part of built environment design, and second, whether their representations could be simple enough that the data can be used to motivate feedback sharing. These challenges mean that some stakeholders may be excluded, causing a split between those with data handling skills and those without, creating a divide within the community. Simplified methods of reviewing design data, such as interactive data dashboards commonly used in daily activities, can be a starting point for helping most stakeholders understand the proposed designs, fostering discussions, and enabling decision-makers to consider diverse voices. The simplification of data access can be learned from everyday examples, such as finding and setting radio channels, energy bills, and banking statements, featuring familiar visualisations like bar charts, line graphs, pie charts, or heatmaps.

3.3. COLLABORATION AND INSIGHT-SHARING

The literature we reviewed emphasises that knowledge sharing and collaboration between specialist and non-specialist users of data is an essential element of data democratisation (Lefebvre et al., 2021; Samarasinghe et al., 2022a; Samarasinghe et al., 2022b). The literature identifies that collaboration and data sharing could be achieved through open data platforms, data catalogues, analytical platforms, and dedicated visualisations. However, this is still limited and accessible to specialist users of data (Lefebvre et al., 2021). In built environment design, information and insight sharing and collaboration refers to exchanging ideas among the stakeholders, including the designers. However, this will require specialised 'social media-like' systems tailored for non-specialists to leverage their prior experiences and for specialist users to present designs and receive feedback on various design concerns. This principle can enhance data-informed collaboration between designers and other stakeholders, facilitating discussion and data-informed idea generation.

3.4. A DATA-INFORMED DESIGN DEMOCRATISATION FRAMEWORK

Building on these principles, we present a design democratisation framework (Figure 2). The principles collectively determine the success of the democratisation process. The framework includes three groups of factors. The first, the moderators' group, provides technology and data literacy influencing the impact of data democratisation. As the second group, the mediators include dedicated platforms for specialists and non-specialists, providing data awareness programs and fostering a data-sharing culture. Together, they aim to operationalise the third group, accessibility, empowerment, and collaboration, as the core factors for data-informed design democratisation.

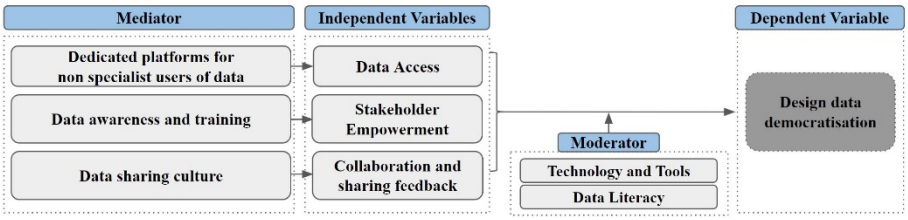

Figure 2. A conceptual framework for design data democratisation proposing dedicated platforms as mediators and data literacy as moderators for the success of design data democratisation.

4. Considerations for Tool Development for Data Democratisation

4.1. SIMPLIFIED INTERFACES AND VISUALISATIONS

Simplification is essential for data accessibility and empowerment. To achieve acceptable systems, we recommend focusing on user-centric personalised interfaces that can reduce the threshold in using interactive visualisations for non-specialists while enabling data-literate users to explore the design choices presented freely. For these, providing the stakeholders with customisation options, allowing them to switch between different views, and rapid filtering to focus on the relevant data are among the essential system features. These features can be implemented by simplifying functions for drag-and-drop, interactive and continuous filtering, view-switch gestures, fluid dashboards, and default to advanced layout choices when viewing alternatives.

4.2. INTERACTIVE FEATURES FOR COLLABORATION

This consideration focuses on the stakeholders' interaction with each other while they are also actively engaging with the proposed design data. Akin to social web style features as an integral part of design data views, the system features for collaboration should make annotations, comments, and marks on design data available to express and share stakeholders' opinions on the proposed design solutions. D-ART (Alsalman & Erhan, 2022) is an example of how such interaction can be achieved for a small group of stakeholders. The interfaces should empower users to provide real-time feedback and allow them to share insights visible to others. These system features can be implemented, e.g., as annotations on data points or geometry, discussion threads, notifications, following other stakeholders, tracking proposed changes, voting and rating, direct messaging, snapshot sharing, and synchronised viewing.

4.3. ON-DEMAND AND PERIPHERAL DATA-AIDS

Some degree of data literacy is desirable for the cultivation of data democratisation. The systems should consider multi-model media providing on-demand or peripheral aid features as activate help for accessing or interpreting data. Such as, if a user chooses to see the cost of a building proposal, the system can enable the users to gesture or voice initiate data retrieval and generate a custom visualisation showing the cost and form in context. The same interaction can be applied to comparing two or more proposed solutions. The users should be able to query design data without complex functions. Highly flexible design data dashboards should be considered so stakeholders can learn about the system while navigating and interpreting design data.

5. Discussion

Data democratisation has been discussed as a novel approach in Information Systems (70%), Business Informatics (10%), Data Management (10%), and Medicine (10%) disciplines for enhancing decision-making. One concern emerging from these discussions is providing access to data for specialists and non-specialists. The concern stresses the importance of empowering a wide range of users, enabling them to understand, find, access, and use data to break the barriers and provide inclusion. Its primary function is mainly focusing on collaborative decision-making. This highlights the value of a culture that promotes data sharing and diversity. By removing data silos and enabling self-analysis and sharing of data, we encourage collaboration and insight exchange amongst the stakeholders. This process facilitates cross-functional insights leveraging diverse perspectives for data-informed, robust decision-making. The removal of obstacles to data exploration and insight sharing is one of the significant challenges for data democratisation. Addressing it requires avoiding limited accessibility while allowing the stakeholders to explore and interact with data freely. The success of these efforts will depend on usable and acceptable tools with user-friendly data exploration and visualisation.

The data access, empowerment, and collaboration for insight-sharing principles can guide adopting tools that can broaden data access, provide self-service access to data, and ensure the inclusion of different user groups. Empowering users is achieved through promoting data literacy and offering self-explanatory analytics tools. Collaboration creates communities fostering a data-sharing culture. By embracing these principles, the practices in built environment design can foster a data-informed collaborative decision-making culture, leveraging collective insights.

The users' data awareness and literacy and the complexity of data could be the two salient limitations of our approach, in addition to the challenges for designing visualisation systems for non-expert data users, which are yet to be known. Moreover, overcoming cultural barriers to data-sharing may take time and effort. Our next step is to leverage our understanding of data democratisation to develop design-data-centric social web applications to enhance public engagement in built environment design. We plan to experiment with the data-driven discourse on design alternatives that can empower its stakeholders and actively encourage diverse groups to engage in decision-making as envisioned in other disciplines. We aim to create an inclusive platform that promotes informed collaboration, knowledge sharing, and decision-making.

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