Stuart A. Cockbill, Loughborough School of Design and Creative Arts, Loughborough University, UK
Andrew May, Loughborough School of Design and Creative Arts, Loughborough University, UK
Val Mitchell, Loughborough School of Design and Creative Arts, Loughborough University, UK

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The Assessment of Meaningful Outcomes from Co-design: A Case Study from the Energy Sector

Abstract Even though co-design is a well-accepted approach for designing to meet user needs, what influence it has on design outcomes remains unclear. This article presents the co-design process of a prototype energy advice service. We evaluate the impact this process had on the outcome over time, demonstrate how co-design generated informative insights, and identify the benefits and challenges of employing a co-design process to design and develop meaningful content for future 'information-intensive' services. A theoretical framework, a "think aloud" approach, and systematic data coding, enabled us to uncover user perceptions of the evolving design qualities. This meaning-making co-design process enabled user needs to surface and be iteratively addressed. As the content of the reports became increasingly tailored, and the users' familiarity with the topic increased, the process highlighted further evolving and underlying information needs. This confirms the value of adopting a content first approach when designing information intensive services and foregrounding meaning making within the complex energy demand reduction context.

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Co-design
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Emails
Stuart A. Cockbill
(corresponding author)
s.cockbill@lboro.ac.uk

Andrew May
a.j.may@lboro.ac.uk

Val Mitchell
v.a.mitchell@lboro.ac.uk

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Introduction and Background

Co-design is a broad term: it usually describes the act of designers, end users, and other actors combining their views, skills, and perspectives at various stages of the design process in ways that influence the outcome.[1] The increasingly pervasive practice of using co-design philosophies, methods, and tools to engage potential users, citizens, and stakeholders when designing innovative products and services[2] illustrates an ongoing shift from market-centered to people-centered design, a trend that Jeremy Myerson has referred to as scaling-down.[3] To some authors,[4] co-design evolved out of user-centered design, when designers began to introduce creative techniques to further inspire design processes, rather than relying on traditional research techniques such as questionnaires, lab tests, and focus groups to garner user insights. Liz Sanders and Pieter-Jan Stappers,[5] distinguish between *user-centered design* and *participatory approaches* to design. Within the area of the latter, "the notions of co-creation and co-design have been growing."[6] Co-designing researchers and designers see end users as active collaborators – not the passive participants of traditional user-centered design practices – and use creative, generative tools collaboratively with users to further their design projects. Co-design shares the participatory design mindset – it treats end users as equals and real people. It also has designers shift away from a more traditional "lone creative genius" role toward acting as catalysts and facilitators[7] of collaborative design activities that explore peoples' tacit knowledge and latent needs[8] at a deep level.

As innovation is no longer considered solely the result of market forces or technological advancements,[9] co-design is commonly used to innovate future products, services, and platforms – both public and private – by carefully exploring user needs within specific contexts.[10] It might take on the job of *sensemaking* or *meaning making*[11] at the "fuzzy" front end of design processes, when design research merges with concept development.[12] One benefit offered by co-design as a form of meaning making[13] is that it helps to determine "what should or should not be designed,"[14] perhaps because it goes beyond just listening to what people say and observing what they do and arrives at a deeper set of dynamic user insights. Another great benefit to co-design practice appears to be its ability to reveal the unmet needs and future aspirations of everyday people[15] – perspectives that can be used to inform more strategic, desirable, and sustainable designs.

Two of the broadest benefits associated with co-design are its apparent ability to both generate design concepts that are original and valuable for users,[16] and improve product quality overall.[17] Val Mitchell and her colleagues[18] have shown that a co-design approach can facilitate a larger number of design ideas in comparison to a non-co-design approach, and Peter Magnusson[19] has found that innovations suggested by users during co-design-based activities are significantly more original than those generated by professional service developers. Marc Steen and his colleagues,[20] meanwhile, have compiled a list of several benefits offered by co-design when applied in service design settings. These range from project-level benefits – such as better knowledge of end users' needs, and the generation of more original and valuable ideas from users' perspectives – to creating a better fit between services and customer or user needs and enabling better service experiences and higher service quality.

Despite the general consensus that it is beneficial for end users to be intimately involved in the design of products or services that they may come to use, there have been repeated calls for more concrete evidence of the influence of such involvement.[21] Few studies have assessed, at a finer and multi-faceted level of granularity, what effect the involvement of end users has on the actual design outcome under development. Some studies[22] have shown the advantages of co-design and "with users" approaches by comparing them in experimental settings

1 Peter Bradwell and Sarah Marr, *Making The Most of Collaboration: An International Survey of Public Service Co-design* (London: Demos/Price Waterhouse Coopers, 2008), 17, available at https://www.demos.co.uk/files/CollabWeb.pdf.

2 Maria Camacho, "Christian Bason: Design for Public Service," *She Ji: The Journal of Design, Economics, and Innovation* 2, no. 3 (2016): 259, DOI: https://doi.org/10.1016/j.sheji.2017.02.002.

3 Jeremy Myerson, "Scaling Down: Why Designers Need to Reverse Their Thinking," *She Ji: The Journal of Design, Economics, and Innovation* 2, no. 4 (2016): 298, DOI: https://doi.org/10.1016/j.sheji.2017.06.001.

4 For example, see Francesca Rizzo, "Co-design versus User Centred Design: Framing the Differences," in *Notes on Doctoral Research in Design: Contributions from the Politecnico di Milano*, ed. Luca Guerrini (Milan: FrancoAngeli, 2010), 132.

5 Elizabeth B.-N. Sanders and Pieter Jan Stappers, "Co-creation and the New Landscapes of Design," *CoDesign* 4, no. 1 (2008): 5–7, DOI: https://doi.org/10.1080/15710880701875068; Elizabeth B.-N. Sanders and Pieter Jan Stappers, *Convivial Toolbox: Generative Research for the Front End of Design* (Amsterdam, the Netherlands: BIS Publishers, 2012), 18–19.

6 Sanders and Stappers, "Co-creation and the New Landscapes of Design," 6.

7 Camacho, "Christian Bason: Design for Public Service," 259.

8 Froukje Sleeswijk Visser et al., "Contextmapping: Experiences from Practice," *CoDesign* 1, no. 2 (2005): 119–49, DOI: https://doi.org/10.1080/15710880500135987.

9 Pieter Jan Stappers et al., "Designing for Other People's Strengths and Motivations: Three Cases Using Context, Visions, and Experiential Prototypes," *Advanced Engineering Informatics* 23, no. 2 (2009): 174–83, DOI: https://doi.org/10.1016/j.aei.2008.10.008.

10 Elizabeth B.-N. Sanders and Pieter Jan Stappers, "From Designing to Co-designing to Collective Dreaming: Three Slices in Time," *interactions* 21, no. 6 (2014): 24–33, DOI: https://doi.org/10.1145/2670616.

to non-co-design approaches and activities. Thorsten Roser and his colleagues[23] have reported on the use of key performance indicators as objective measurements of the impact of co-design, such as the number of successful products or patents created. Other studies have taken more reflective and interpretive approaches, for example looking for participant values embedded in the outcomes,[24] or by purely observing what happened during small-scale or informal experiments.[25] To date, despite calls for improved evaluation metrics and more concrete evidence of the impact of co-design,[26] there has been only limited pursuit of empirical (as opposed to anecdotal) evidence of the results of co-design.

The question remains, then: how best to investigate and assess co-design benefits and outcomes? Some authors have argued against the imposition of objective scientific measurement, claiming that it runs counter to the essence of design research.[27] This has resulted in a range of approaches being taken and a great deal of seemingly anecdotal commentary on the benefits and outcomes of co-design. A good example of this is an informal experiment by Froukje Visser and Victor Visser[28] demonstrating that using the same users at multiple points during a co-design process results in deeper and richer levels of feedback. Other authors have attempted to increase the rigor and transparency in co-design practice through more detailed and structured reflective methods. Examples include Maarten Van Mechelen and colleagues' GLID method,[29] a detailed approach to identifying participant values embedded in participatory design project outcomes, and Laura Malinverni, Joan Mora-Guiard, and Narcis Pares's[30] use of multimodal analysis and theoretically defined evaluation criteria to capture and analyze children's contributions to participatory design workshops.

A few researchers have used experimental designs to assess co-design processes empirically. One example is Peter Magnusson,[31] who investigated whether end users or professional service developers can ideate more innovative solutions for mobile phone services using a quasi-experimental approach. Another is in the work of Val Mitchell and her colleagues,[32] who used pre-defined metrics (innovativeness, frequency) to assess and compare concepts generated by distinct co-design and non-co-design user groups. There is also the work of Jakob Trischler and his colleagues,[33] who used a real-world comparison to demonstrate that design concepts generated by co-design teams can be high in user benefit and novelty, as opposed to those created by an in-house professional team and a team solely comprised of users. These studies illustrate the complexities of experimentally assessing co-design – especially how seeking internal validity at the expense of external validity can potentially jeopardize the naturalistic nature of user involvement.[34] The small number of these studies also shows that few have attempted to rigorously assess outcomes or changes in resulting design outcomes as a direct result of co-design processes.

And what metrics are there to evaluate the impact of co-design on design outcomes? There is the reflective framework[35] devised by Christopher Frauenberger and his colleagues to improve the rigor and accountability of participatory design approaches, but they have not scientifically validated its constructs in practice. And Roser and colleagues[36] fail to describe the theoretical basis underlying their key performance indicators. Evaluation metrics for outcomes are often quite vague, measuring "improved product quality"[37] or ideas that are "valuable" to users.[38] It is difficult to determine whether any co-design assessment metrics have verifiably linked the attributes of design outcomes to the practices themselves. What is needed are suitable measurement constructs – ones that are clearly defined and also carefully tailored to suit particular design outcomes and their contexts.

This article is based on a wider research project[39] investigating the design and development of information-intensive services[40] within the context of sustainable

11 Jon Kolko, "Sensemaking and Framing: A Theoretical Reflection on Perspective in Design Synthesis," in *Proceedings of the 2010 Design Research Society (DRS) International Conference: Design & Complexity*, ed. David Durling et al. (Montreal: University of Montreal, 2010), 614–23, available at http://www.drs2010.umontreal.ca/proceedings.php; Yoko Akama and Alison Prendiville, "Embodying, Enacting, and Entangling Design: A Phenomenological View to Co-designing Services," *Swedish Design Research Journal* 1, no. 1 (2013): 29–41, DOI: https://doi.org/10.3384/svid.2000-964x.13129.

12 Sanders and Stappers, "From Designing to Co-designing."

13 Akama and Prendiville, "Embodying, Enacting, and Entangling."

14 Sanders and Stappers, "Co-creation and the New Landscapes of Design," 3.

15 Visser et al., "Contextmapping."

16 Per Kristensson and Peter R. Magnusson, "Tuning Users' Innovativeness during Ideation," *Creativity and Innovation Management* 19, no. 2 (2010): 155, DOI: https://doi.org/10.1111/j.1467-8691.2010.00552.x.

17 Thorsten Roser et al., *Co-creation: New Pathways to Value* (Washington, DC: Promise Corporation, 2009), available at http://www.portugalglobal.pt/PT/RoadShow/Documents/2016/GuimaraesCo_creationNewPathways_to_value_An_overview.pdf.

18 Val Mitchell et al., "Empirical Investigation of the Impact of Using Co-design Methods When Generating Proposals for Sustainable Travel Solutions," *CoDesign* 12, no. 4 (2016): 205–20, DOI: https://doi.org/10.1080/15710882.2015.1091894.

19 Peter R. Magnusson, "Benefits of Involving Users in Service Innovation," *European Journal of Innovation Management* 6, no. 4 (2003): 235, DOI: https://doi.org/10.1108/14601060310500940.

20 Marc Steen, Menno Manschot, and Nicole De Koning, "Benefits of Co-design in Service Design Projects," *International Journal of Design* 5, no. 2 (2011): 53–60, available at http://www.ijdesign.org/index.php/IJDesign/article/view/890.

household energy retrofitting. The aim was to enable householders to make sense of their energy use and the available energy savings options, so they could make informed decisions about how best to improve the energy efficiency of their homes. We used co-design to facilitate householders' greater exploration, understanding, and use[41] of energy consumption related information as part of an iterative process to design and refine an energy advice service via, at that stage, a paper-based report.

Our aim with this article is twofold: 1) to provide an approach to analyzing how the quality of a service design evolves over time, and 2) to demonstrate, through fine-grained quantification, how researchers can most effectively study the influence of a meaning-making based co-design process on the iterative design and development of service content.

Methods

Research Context

This work was conducted in the context of a smart home trial experience. The trial was intended to encourage private householders to consider energy retrofitting measures by providing them with timely energy consumption feedback as part of an information-intensive service design process.

Energy retrofitting – the practice of renovating or refurbishing an existing structure to make it more energy efficient – is a complex problem area. Householders are faced with a wide range of potential retrofit options, all of which have varying costs, payback periods, installation technicalities, appearances, direct and indirect benefits, and so on. The invisible nature of energy is also a difficult concept for people to grasp, and often results in people disregarding energy use[42] when going about everyday domestic tasks. Providing householders with information about domestic energy consumption not only raises their awareness about their energy consumption,[43] it may even spur them to consider investing in retrofit technologies and measures.[44]

The Design Outcome: Energy Advice Reports

The design outcome at the center of this study was a personalized, information-based energy advice report (Figure 1), which itself was a component of the overall service design process. Creating and providing the reports enabled researchers to explore one way for the householders to make sense of their household energy consumption data. Provision of energy feedback data, including "disaggregated" data showing the energy consumption of specific appliances and even domestic activities,[45] is a widely accepted means of engaging householders in energy use management.[46] Such provisions have even prompted investment in retrofit technologies and measures.[47] However, the impact of providing energy feedback is often disappointing – actual savings are often much less than anticipated, and the decision making process is affected by factors beyond rational choices and cost considerations.[48]

Along similar lines to earlier work by James Pierce and Eric Paulos,[49] Tobias Schwartz and his colleagues[50] argue for a phenomenological approach to both enabling understanding energy consumption practices and designing energy feedback services. According to them, people need services that enable them to "create meaning with regards to the measured data." Technology, they conclude, should "help people contextualize information and support the construction of connections between consumed energy units and events in life."[51] According to this thinking, energy providers seeking to inspire greater responsibility among their consumers would be wise to provide householders with creative, personal tools that enable them to account for and explain their consumption practices. This article reports on an exploration of how households might make sense of and use

21 Deborah Szebeko and Lauren Tan, "Co-designing for Society," *Australasian Medical Journal* 3, no. 9 (2010): 584, DOI: https://doi.org/10.4066/amj.2010.378; Wayne D. Hoyer et al., "Consumer Cocreation in New Product Development," *Journal of Service Research* 13, no. 3 (2010): 293, DOI: https://doi.org/10.1177/1094670510375604; Steen et al., "Benefits of Co-design in Service Design Projects," 59.

22 Magnusson, "Benefits of Involving Users in Service Innovation," 228–38; Kristensson and Magnusson, "Tuning Users' Innovativeness"; Mitchell et al., "Empirical Investigation."

23 Roser et al., *Co-creation*.

24 Maarten Van Mechelen et al., "The GLID Method: Moving from Design Features to Underlying Values in Co-design," *International Journal of Human-Computer Studies* 97 (January, 2017): 116–28, DOI: https://doi.org/10.1016/j.ijhcs.2016.09.005.

25 Froukje Sleeswijk Visser and Victor Visser, "Re-using Users: Co-create and Co-evaluate," *Personal and Ubiquitous Computing* 10, no. 2–3 (2006): 148–52, DOI: https://doi.org/10.1007/s00779-005-0023-x; Laura Malinverni, Joan Mora-Guiard, and Narcis Pares, "Towards Methods for Evaluating and Communicating Participatory Design: A Multimodal Approach," *International Journal of Human-Computer Studies* 94 (October, 2016): 53–63, DOI: https://doi.org/10.1016/j.ijhcs.2016.03.004.

26 Szebeko and Tan, "Co-designing for Society," 584; Hoyer et al., "Consumer Cocreation in New Product Development"; Steen et al., "Benefits of Co-design in Service Design Projects," 59.

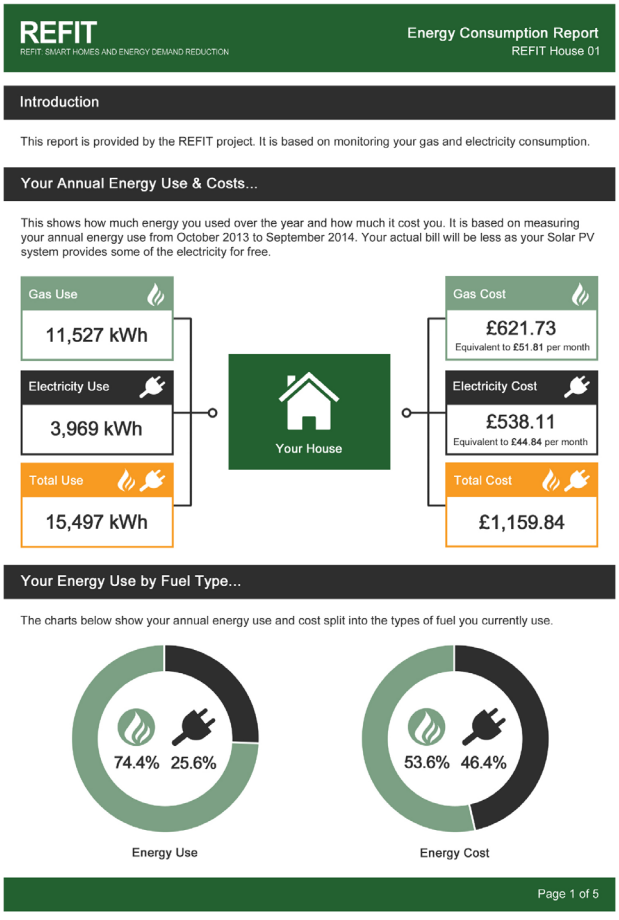
27 William Gaver, "What Should We Expect from Research through Design?" in *CHI '12 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (New York: ACM, 2012), 937–46, DOI: https://doi.org/10.1145/2207676.2208538.

28 Visser and Visser, "Re-using Users," 151.

29 Van Mechelen et al., "The GLID Method," 121, 126.

30 Malinverni et al., "A Multimodal Approach," 53–63.

31 Magnusson, "Benefits of Involving Users in Service Innovation," 234–35.



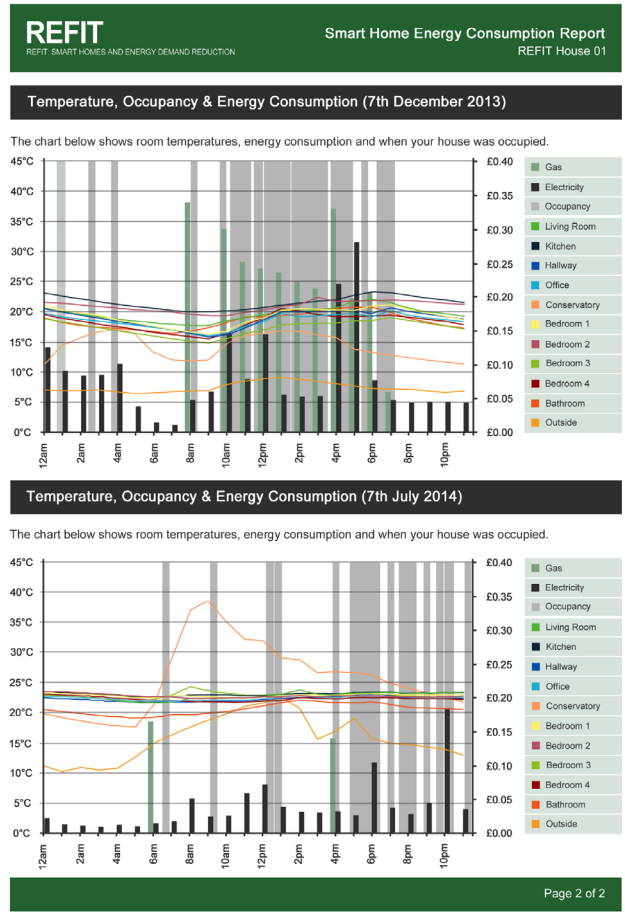


Figure 1 Example pages from the personalized, paper-based energy advice reports. © 2019 by Stuart A. Cockbill, Andrew May, and Val Mitchell.

their energy consumption data in order to make decisions about energy-related retrofits. The process was grounded on a well-established principle of interaction design: prioritize content design[52] before designing interactive[53] digital (information) services. Researchers designed a series of low fidelity prototypes – paper reports – to present the content of a to-be-designed energy information service. Because the consumers did not need to learn to navigate a digital artefact, the content remained center stage at this early but fundamental stage of the service design. Each household had already received feedback on their home's energy performance via an Energy Performance Certificate and home energy audit conducted at the beginning of the project,[54] so the researchers decided to create the content prototype using the same accessible and familiar format.

Personalization

Energy data available for experimentation can take two forms: "dummy" datasets, which are composed of representative, realistic data that acts as a placeholder for the purposes of design; and real, actual, personalized datasets obtained from data holders and used with the permission of data subjects. Using personalized as opposed to dummy energy data was essential to exploring how householders made sense of this data in the context of their everyday lives.[55] From a co-design perspective, the idea of personalization challenges the traditional and typical design vs. use relationship, where "first designers design, then users use."[56] Instead, personalized materials enable individualized participation, allowing designers to grapple with the needs and experiences of different people with various abilities, and eventually work towards design outcomes that embed different participants' idiosyncrasies and interests.[57]

Measures

We adopted the information relevance criteria set out by Carol Barry and Linda Schamber to determine quality from the householders' perspective.[58] This framework drove the qualitative coding of the householder's comments on their energy advice reports *after* data collection, rather than a structured, more experimenter-driven process during data collection. We selected the framework for five reasons: (1) it identifies the inherent qualities of information that impact on its use, (2) it is widely-accepted in the information sciences literature, (3) it is consistent with several other frameworks,[59] (4) it differentiates quality into multiple facets, and (5) it offers relevant and contextually suitable metrics that enabled assessment of our design outcomes. The information attributes of interest are shown in Table 1.

Table 1. Information quality assessment criteria from the framework that drove data coding.*

	Quality Attributes		
1	Accessibility	8	External Verification
2	Accuracy, Validity	9	Quality of Sources
3	Affectiveness	10	Scope
4	Availability of Information	11	Specificity (to User's Needs)
5	Clarity	12	Summary, Interpretation & Explanation
6	Currency	13	Tangibility
7	Detail, Depth	14	Volume

* Carol L. Barry and Linda Schamber, "Users' Criteria for Relevance Evaluation: A Cross-Situational Comparison," *Information Processing and Management* 34, no. 2/3 (1998): 219–36.

Through ongoing interaction with the householders, we predicted that the quality of the energy advice reports would be impacted across the 14 attributes, for example by becoming better tailored to individual or household needs and becoming clearer and more understandable.

The Co-design Process and Study Procedure

The study comprised three household visits (Figure 2). Visit 1 included a home energy audit and creative workbook activity to sensitize the householders[60] to the research domain. The creative workbook elicited detailed consideration of the householders' own lifestyles, aspirations and future plans, and their energy consumption and energy-related behaviors. We explored these aspects via questions on the topic and various drawing activities. The tasks were often completed by the entire family unit, which often sparked reflective discussions on energy use across the household.

Visit 2 was a follow-up to Visit 1. We discussed the results, before the householders created a picture of their current energy saving intentions by sorting through a deck of 42 cards. The cards were designed to encompass and explain the wide range of possible retrofit options. The deck provided a visual stimuli for householders to discuss the advantages, disadvantages, and feasibility of each measure, as well as their short- and longer-term lifestyle and housing plans. The cards led to debate, further queries, and consensus or conflict among householders. The householders then discussed their personalized energy advice reports with each other and the researchers before re-drawing their personal energy saving intention "picture" by conducting the card sorting activity again. The visit closed with a dialogue around how the energy advice reports could be improved, based on the "meaning" made by the participants and their desire for further understanding.

32 Mitchell et al., "Empirical Investigation," 216–17.

33 Jakob Trischler et al., "The Value of Codesign: The Effect of Customer Involvement in Service Design Teams," *Journal of Service Research* 21, no. 1 (2018): 75–100, DOI: https://doi.org/10.1177/1094670517714060.

34 For example, see Kristensson and Magnusson, "Tuning Users' Innovativeness," 156.

35 Christopher Frauenberger et al., "In Pursuit of Rigour and Accountability in Participatory Design," *International Journal of Human-Computer Studies* 74, (2015): 93–106, DOI: https://doi.org/10.1016/j.ijhcs.2014.09.004.

36 Roser et al., *Co-creation*.

37 Ibid.

38 Kristensson and Magnusson, "Tuning Users' Innovativeness," 155.

39 For more detail on the content, and development of the energy advice reports, and the sources of energy data used, see Tom Kane et al., "Heating Behaviour in English Homes: An Assessment of Indirect Calculation Methods," *Energy and Buildings* 148 (August 2017): 89–105, DOI: https://doi.org/10.1016/j.enbuild.2017.04.059.

40 Chiehyeon Lim et al., "From Data to Value: A Nine-Factor Framework for Data-Based Value Creation in Information-Intensive Services," *International Journal of Information Management* 39 (2018): 121–35, DOI: https://doi.org/10.1016/j.ijinfomgt.2017.12.007.

41 Visser et al., "Contextmapping."

42 Tang Tang and Tracy A. Bhamra, "Changing Energy Consumption Behaviour through Sustainable Product Design," in *DS 48: Proceedings DESIGN 2008, the 10th International Design Conference*, ed. Dorian Marjanovic et al. (Glasgow: The Design Society, 2008), 1359–66, available at https://www.designsociety.org/publication/26725.

43 Tom Hargreaves, Michael Nye, and Jacquelin Burgess, "Making Energy Visible: A Qualitative Field Study of How Householders Interact with Feedback from Smart Energy Monitors," *Energy Policy* 38, no. 10 (2010): 6118, DOI: https://doi.org/10.1016/j.enpol.2010.05.068.

44 Karen Ehrhardt-Martinez, "A Comparison of Feedback-Induced Behaviors from Monthly Energy

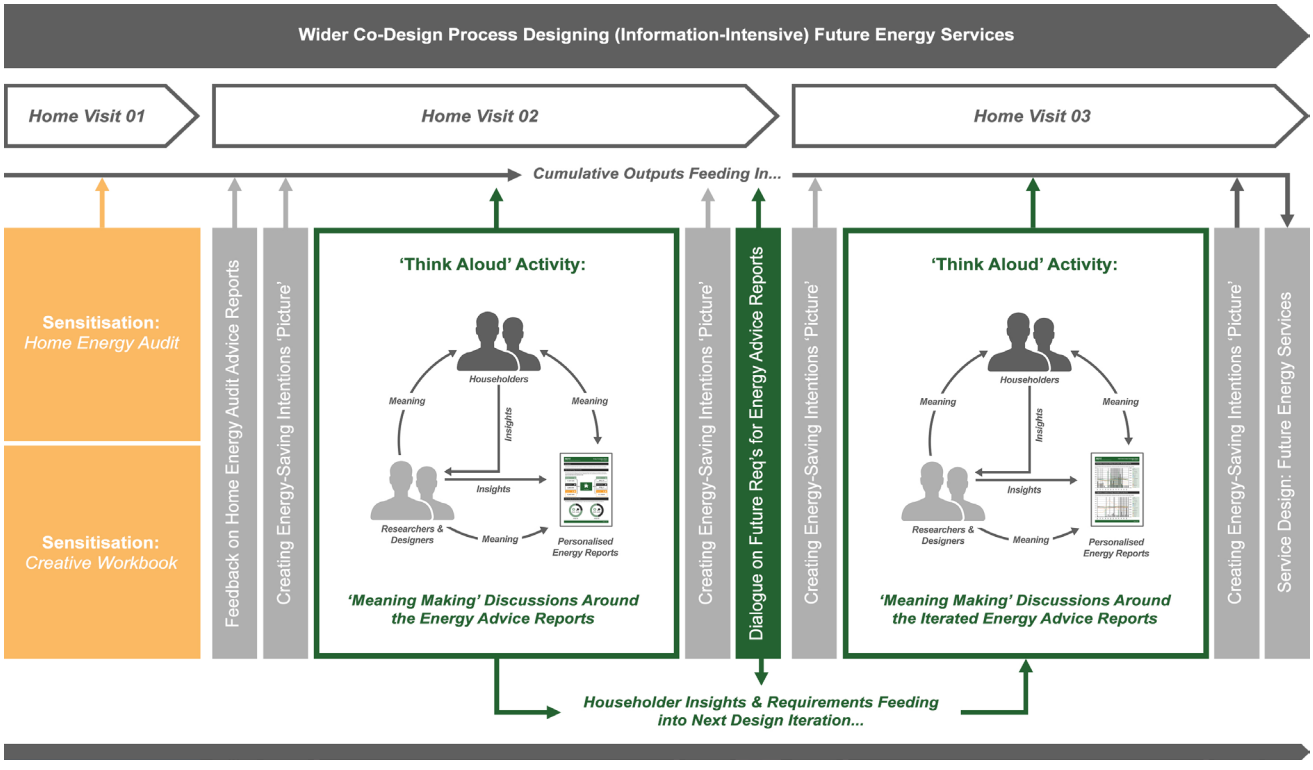


Figure 2 The wider co-design process, with the activities focused on in this article highlighted in green. © 2019 by Stuart A. Cockbill, Andrew May, and Val Mitchell.

Visit 3 followed the same procedure as Visit 2, only this time we used a newly-designed iteration of the energy advice report – based on the insights gained from the householders – as the visual prompt for our discussions around their understanding of their energy use, and current and future energy saving intentions.

In light of the difficulties related to investigating the benefits of co-design, we needed an approach that would enable some kind of valid assessment of its impact on the design outcomes whilst limiting the extent to which the collaborative, householder-focused nature of the co-design activities were compromised. To collect the data, we prompted a dialogue around the energy advice reports with the householders that would reflect their sense of the reports' meaning – comments on positives and negatives, format and content, elements that were particularly interesting and useful, and elements that were not understood. In comparison to a more standard experimenter-led usability evaluation, the rationale behind this approach was that free response – via a "think aloud" approach[61] – rather than specific questions and rating scales would better allow what was most salient to the households, and to individual householders, to emerge. This avoided the potential drawback of strengthening internal validity at the expense of external validity – a pitfall highlighted by Per Kristensson and Peter Magnusson[62] that was directly experienced by Mitchell and her colleagues during their research in the sustainable travel domain.[63]

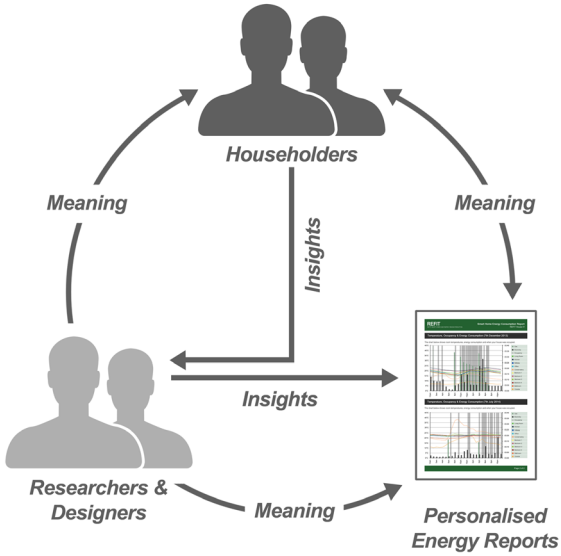


Figure 3 Interactions during the co-design process between the householders, their energy information, and the facilitators. © 2019 by Stuart A. Cockbill, Andrew May, and Val Mitchell.

We acted as facilitators, guiding the householders through any aspects of the energy advice reports they found difficult to grasp using generic crib sheets for each report. Throughout, we remained aware of the extent of our input and were careful to prompt rather than lead the discussions. Figure 3 sets out how we staged

the interactions among the researchers (ourselves, acting as facilitators), the householders, and the energy advice reports during collaborative activities. We carried out each sequence of sessions separately with each household, which comprised couples in most cases, but also one group of four, and two individuals.

Sampling and Data Collection

Consistent with Bjarki Bjorgvinsson[64] and Ingrid Mulder and Pieter-Jan Stappers,[65] the sample design we used in this study set out to represent a broad cross section of the public based on key factors that would influence reactions to information-based energy advice reports and promote a certain depth and breadth of results. These factors included (1) varied household compositions, to capture different householder's perspectives on their data; and (2) varying levels of expertise with technology, to capture a breadth of judgments in terms of level of engagement and understanding. To ensure that we recruited a range of participants with differing levels of interest and engagement with energy saving – in other words, both interested and disinterested householders – the study was deliberately advertised as a "smart homes study" with no specific mention of energy saving at the recruitment stage.

Ten households were recruited to the study in Loughborough, Leicestershire, UK and the surrounding area (see Appendix A). The households included empty nesters – older couples whose children have left home – people with young or school age children, and people with older children. Where possible, the study attempted to include as many householders from the individual households as possible. The study comprised 20 individual householders participating either individually (n = 2 households), in pairs (marital couples; n = 7 households), or as a small group (parents and their older children; n = 1 household). They were incentivized by receiving (with the option to keep) a set of smart home sensors, monitors, and displays installed at the beginning of the trial, alongside retail vouchers at various points during the study.

The entire study was conducted over a period of 14 months, on the basis that re-using participants at multiple points during a collaborative design process can elicit deeper and richer levels of feedback.[66] The data collection intervals were designed to ensure the project team had sufficient time to analyze the personal energy data and update the content within the energy reports based on the insights generated during the activities, and to allow the households ample time to consider their energy saving options. Although this study was longitudinal in nature, the smart home field trial only allowed for a single period of personal energy data to be collected and integrated into the energy advice reports. This enabled us to focus on how to tweak the data to increase meaning, but limited our ability to make statements in relation to the currency attribute. We conducted several pre-test and pilot studies, which resulted in minor refinements such as rephrasing repetitive sounding questions.

Analytic Approach & Coding Criteria

The data we gathered during each visit included audio recordings, photographs, and facilitator notes. We transcribed the relevant sections of audio recordings from each household visit verbatim. We then coded elements of the transcripts that contained householders' responses to their energy advice reports using a qualitative content analysis based on Barry and Schamber's information relevance framework quality attributes.[67] We coded child sub-nodes under each of these, representing positive and negative comments relating to the parent content node.

We made an important distinction between *explicit* comments and *implicit* ones, and the child sub-nodes we further divided accordingly. People typically apply multiple processes when evaluating information in their environment. Some of these

Reports, Online Feedback, and In-home Displays," in *Proceedings of the 2012 ACEEE Summer Study on Energy Efficiency in Buildings* (Washington, DC: American Council for an Energy-Efficient Economy, 2012), 60–74, available at https://aceee.org/files/proceedings/2012/data/papers/0193-000244.pdf.

45 Lina Stankovic et al., "Measuring the Energy Intensity of Domestic Activities from Smart Meter Data," *Applied Energy* 183 (December, 2016): 1565–80, DOI: https://doi.org/10.1016/j.apenergy.2016.09.087.

46 Tom Hargreaves, "Beyond Energy Feedback," *Building Research & Information* 46, no. 3 (2018): 332–42, DOI: https://doi.org/10.1080/09613218.2017.1356140.

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52 Dave Clark, "Content Strategy: An Integrative Literature Review," *IEEE Transactions on Professional Communication* 59, no. 1 (2016): 7–23, DOI: https://doi.org/10.1109/tpc.2016.2537080.

53 Jesse James Garrett, *The Elements of User Experience: User-Centered Design for the Web and Beyond* (Berkeley: New Riders Publishing, 2010), 57.

54 For example, see "Energy Performance Certificates," Energy

evaluations are conscious, intentional, and controlled (explicit) and others that are unconscious, unintentional, and automatic (implicit).[68] While we did the coding, it also became clear that for some attributes – such as accessibility, clarity, detail/depth, scope, and volume – the householders made comments relating either to the energy advice reports in general *or* to specific features of the reports. This distinction was also captured in the coding. We took a "negotiated agreement" approach to data analysis: after the lead researcher coded one transcript, it was duplicated with the coded text segments highlighted and the codes removed for a second researcher either to assign codes to or add coding wherever necessary. The individual coding was compared, and any disagreements we negotiated such that the lead researcher was able to code the remaining data.[69]

Results

Figure 4 shows a summary comparison of the number of householder references to the 14 information quality attributes within the Barry and Schamber[70] framework. It uses the same vertical scale for all attributes, compares responses during Visit 1 and Visit 2, distinguishes between positive (green) and negative (red) assessments, and explicit (dark shading) versus implicit (light shading) references. There are clear differences in responses across the attributes, in terms of overall responses, positive vs. negative comments, explicit vs. implicit references, and changes over time. We outline the main effects here, focusing on those attributes with the greatest number of comments.

Specificity to Users' Needs

Over time, we noted a positive impact on this attribute, which included statements related to meeting users' individual needs, and comments about other users' needs. The clearest result was the reduction in negative comments such as

> #H10: "…but what's missing from that report, thinking about it, is at the appliance level."

This suggested that the collaborative meaning-making process was beneficial as it more closely aligned the energy advice reports to the householders needs, but also led directly to new queries and potential for further iteration.

The householders' needs evolved as exposure to new information helped to enhance their understanding. For example, one householder realized that they needed to know what a "base load" was only after they had been exposed to the term. Initially, they didn't know they had this latent need – it evolved through the co-design process:

> #H06: "I would definitely like to know what base load is, how they calculate a base load and how they calculate 'unknown,' that would be really useful to me."

Accuracy and Validity

There was a positive impact over time on this attribute. The extent to which the information in the reports was deemed "correct" appeared to improve. By adding selected details to the reports, the users were able to extract more meaning from the data, resulting in an increase in the positive comments related to accuracy. The increased detail enabled the householders to better assess whether the information was "right" – meaning in line with their recollected energy experiences – and identify places where they believed anomalies in the content were present:

> #H06: "But I can't think of any reason, even with the old system, I would have had a gas spike at quarter to 6.…"

Saving Trust, last modified August 1, 2019, https://www.energysavingtrust.org.uk/home-energy-efficiency/energy-performance-certificates.

55 Schwartz et al., "Uncovering Practices."

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58 Carol L. Barry and Linda Schamber, "Users' Criteria for Relevance Evaluation: A Cross-Situational Comparison," *Information Processing and Management* 34, no. 2/3 (1998): 219–36, DOI: https://doi.org/10.1016/s0306-4573(97)00078-2.

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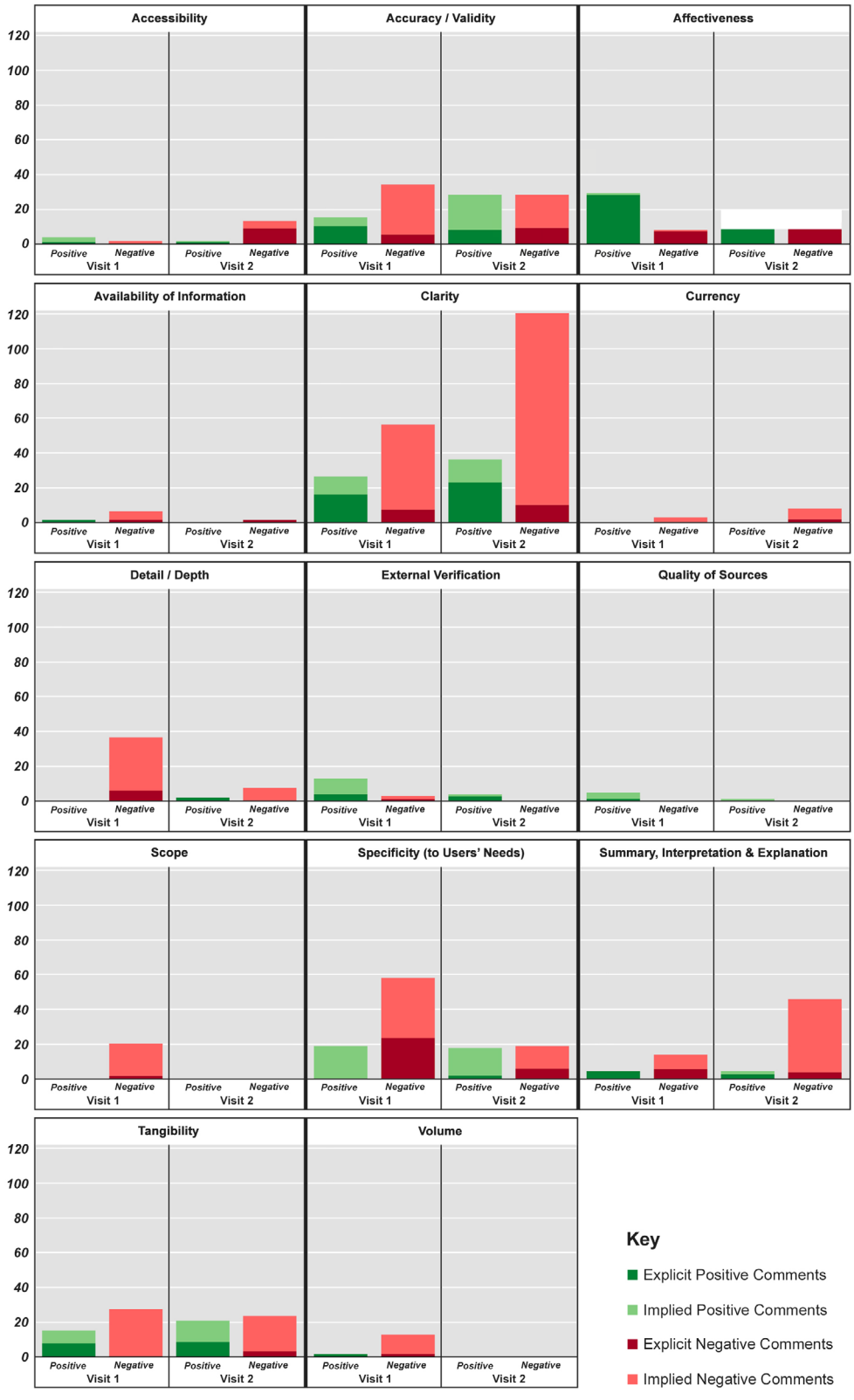
63 Mitchell et al., "Empirical Investigation," 216–17.



64 Erling Bjarki Bjorgvinsson, "Open-Ended Participatory Design as Prototypical Practice," *CoDesign* 4, no. 2 (2008): 98, DOI: https://doi.org/10.1080/15710880802095400.

65 Ingrid Mulder and Pieter Jan Stappers, "Co-creating in Practice: Results and Challenges," in *Proceedings of 2009 IEEE Technology Management Conference* (Piscataway: IEEE, 2009), 1–12, DOI: https://doi.org/10.1109/ITMC.2009.7461369.

66 Visser and Visser, "Re-using Users," 151.

67 For a more detailed overview of these, see the table in Appendix B.

68 Mahzarin R. Banaji, "Implicit Attitudes Can Be Measured," in *The Nature of Remembering: Essays in Honor of Robert G. Crowder*, ed. Henry Roediger et al. (Washington, DC: APA, 2001), 117–49. Cited in Brian A. Nosek, "Moderators of the Relationship between Implicit and Explicit Evaluation," *Journal of Experimental Psychology* 134, no. 4 (2005): 566, DOI: https://doi.org/10.1037/0096-3445.134.4.565.

69 John L. Campbell et al., "Coding In-depth Semistructured Interviews: Problems of Unitization and Intercoder Reliability and Agreement," *Sociological Methods & Research* 42, no. 3 (2013): 298, DOI: https://doi.org/10.1177/0049124113500475.

70 Barry and Schamber, "Users' Criteria for Relevance Evaluation."

Figure 4 Summary comparison of the number of references to the 14 information quality attributes. © 2019 by Stuart A. Cockbill, Andrew May, and Val Mitchell.

Detail and Depth

There was also a clearly beneficial impact on this factor. The collaborative process led to reports with more personalized energy data content, and this resulted in a substantial reduction in negative statements in relation to this attribute. Positive comments were also made, for example:

> #H13: "Yeah, there's definitely more detail and I like the comparison, although you know, the other houses might not."

Since the primary aim of the co-design process was to work towards more individually-tailored information content, the results show it was useful in improving quality in terms of detail and depth.

Tangibility

In comparison with the above, there was a more marginal, but still positive increase relating to this attribute – the extent to which the information was judged as "real." There were both positive and negative comments, but overall a net positive benefit resulted from design iteration – the positive comments increased in frequency and negative comments decreased. In addition, there was little direct negative criticism; instead, queries tended to focus on perceived discrepancies or anomalies between the data and the householders' recollection of their reality. An example of this is

> #H01: "Couldn't understand how we used that amount of gas on Friday 13th December, since we weren't here. Last year … Friday 13th December we weren't here, yeah, so how come we used that amount of gas?"

Clarity

While there was positive impact over time in relation to the above attributes, there were also several attributes where negative comments increased. The clarity attribute saw the greatest number of coding references (n = 245) and an overall negative impact over time. This attribute had four components: clarity of data, clarity of supporting information, overall clarity, and scope for improvement. The majority of the householders' implicit comments focused on the specific content presented, and their explicit comments related to clarity at an overall level. For example,

> #H18: "Because they were so, sort of, detailed, it was quite, you couldn't take it in…"

The inclusion of more complex energy data without sufficient supporting information appeared to reduce clarity from the householder's perspectives, but in doing so highlighted further underlying needs to be addressed in future iterations. These included the needs to clarify data sources, detail the rationale behind what was being presented, and define technical terms.

> #H06: "Ah, so the daily energy cost is a snapshot of one week? Not an average over the period…. Uh, why did you do that, rather than take an average of the same period?"

Summary, Interpretation, and Explanation

There was a substantial negative impact over time on this factor. Providing greater detail increased the reports' specificity (described above) but created a parallel need for further support to enable the householders to grasp the new information.

> #H06: "How do you differentiate between base load and unknown?"

Affectiveness

We saw a reduction in positive comments and an increase in negative ones in relation to this attribute. "Affect" refers to the householders' expression of emotions such as pleasure, enjoyment, disappointment, and so on when presented with the energy advice reports. The factor therefore includes general expressions related to the energy advice reports themselves, and also more specific comments about aspects of energy usage.

> #H06: "And you see the scary thing to me is that, you know, things like dishwasher, washing machines, cost per month is insignificant compared to base load[71] and unknown. Now, that actually isn't telling me anything, it's worrying me now."

Most affective comments – positive and negative – were linked to specific aspects of the information content and its significance for the householder, as opposed to general comments about the process and the overall presentation format of the report. This suggests that the collaborative process with the householders generated sufficient engagement to elicit specific and considered emotional responses. The predominance of initial positive emotional responses subsequently reduced over time, alongside an increase in negative comments. The reduction in "delight" during the study was interpreted as a reduction in "perceived newness" (which determines an individual's reaction)[72] of the energy advice reports, alongside concerns raised by certain householders about spurious energy consumption patterns or anomalies in their energy use data shown via the additional, more complex energy data.

Other Attributes

There were seven attributes where there were fewer than 10% of the total number of comments coded, when compared to Clarity (N = 245). Although these still indicate impact within the context of this study, we assume that they convey less authority than the findings described above. A clearly positive impact occurred in relation to *Scope*, as can be seen in Figure 4, with a reduction to zero of initially negative comments relating to this construct. A similar positive impact was found in relation to *Volume*, and, to a lesser degree, *Availability of Information*, with this latter finding only supported by eight coding references. There were indications of a negative impact over time in relation to *Accessibility*, shown by an increase over time of the negative comments related to the effort required to extract information (and "meaning") from the reports. A similar result was found for *Currency* – how up to date the data was perceived to be – but this could have been influenced by the way data were incorporated into the study (see the section entitled Limitations). There were reductions in positive comments relating to *External Verification* (whether what the householders received was consistent with other information or perceived as an improvement to what was provided by other sources) and a similar result for *Quality of Sources* (their perceived reputability). This latter attribute only comprised a total of six coded comments.

Discussion

The results presented above, outlining fluctuations in the perceived qualities inherent to the energy advice reports, have a number of implications relating to the co-design process.

71 "Base load" here refers to the level of background electricity consumption (including standby and always on components), and "unknown" refers to the components of consumption that could not be measured due to lack of a metering device.

72 Everett M. Rogers, *Diffusion of Innovations*, 5th ed. (New York: Free Press, 2003), 12.

How Co-design Impacts Design Outcomes

The co-design process, centered on collaborative meaning making, clearly had impact on the various quality attributes ascribed to the design outcome – the reports did seem to be perceived as "better" in some, but not all, respects. The key findings were that the collaborative meaning making process enhanced the reports' conformity with user needs; improved the scope, volume, detail, and depth of the information provided; and increased the accuracy of the energy data contained. Immersion in the context of energy use – an often "invisible" phenomena – during the process increased the salience and tangibility of the subject matter for the householders and advanced their learning.[73] This enabled them to extract, generate, and associate meaning to what had been otherwise imperceptible data[74] through the use of our paper-based prototypes, which made the invisible, visible.[75]

The study has shown how user needs developed over the course of the co-design process (shown where quality judgments changed) as they made "meaning" from their energy data. The collaborative process enabled the householders to uncover and express their underlying tacit knowledge and latent needs – in keeping with the findings of Froukje Visser and her colleagues[76] – prompted by the ongoing provision of more detailed information/data from individual electrical appliances or room occupancy and temperature sensors. Future requirements were revealed, which in turn supported the development of future iterations of the design outcomes, for example the need for more sophisticated supporting information to aid understanding of the increased detail presented.

The study demonstrates that the ongoing collaborative meaning making process was beneficial. It enabled participants to continue to provide useful insights during a co-design process over time, including greater levels of detailed, diverse, and rich feedback;[77] generated better knowledge of and improved the match between user needs and provision, consistent with the findings of Marc Steen and his colleagues;[78] and helped participants to articulate their tacit knowledge and reveal their latent needs, the "experiential knowledge that is difficult to express, and the hidden needs that they were "not yet aware of."[79] For all these reasons, this study contributes to answering well-established calls for more concrete evidence[80] of the impact of co-design.

A Unique Methodological Approach

A key element within this study was our use of a contextually relevant attribute quality theoretical framework. The framework performed two roles during the process: it benchmarked the quality of the reports and thus enabled commentary on the collaborative meaning making process used to develop the design outcomes. When appropriately grounded, this form of assessment can help researchers identify where meaning is and is not created, and whether meaning(s) can lead to changes in the quality of the design outcomes. More generally, an appropriate framework (based on the attributes of the design outcome being developed) can support an understanding of the effectiveness of the design process undertaken. The information science framework and the coding differentiations we used did enable relatively detailed insights to be extracted from the study data, to the extent that some of the findings were initially counterintuitive – for example, perceived Clarity and Summary, Interpretation, and Explanation actually decreased over time. These findings helped us uncover the underlying and evolving needs of the increasingly inquisitive users, such as their need to provide additional supporting information to counter the increased information density. Capturing detailed insights from study data in a rigorous manner, and doing so using an established theoretical framework, contributes to calls in the literature for improved metrics and more concrete evidence of co-design benefits.[81]

73 Tefko Saracevic, "Relevance: A Review of the Literature and a Framework for Thinking on the Notion in Information Science. Part III: Behavior and Effects of Relevance," *Journal of the American Society for Information Science and Technology* 58, no. 13 (2007): 2126–44, DOI: https://doi.org/10.1002/asi.20681.

74 Kolko, "Sensemaking and Framing."

75 Akama and Prendiville, "Embodying, Enacting, and Entangling," 37.

76 Visser and Visser, "Re-using Users," 151.

77 Ibid., 151.

78 Steen et al., "Benefits of Co-design in Service Design Projects," 58.

79 Visser et al., "Contextmapping," 122.

80 Szebeko and Tan, "Co-designing for Society," 584; Hoyer et al., "Consumer Cocreation in New Product Development," 293; Steen et al., "Benefits of Co-design in Service Design Projects," 59.

81 Szebeko and Tan, "Co-designing for Society," 584; Hoyer et al., "Consumer Cocreation in New Product Development," 293; Steen et al., "Benefits of Co-design in Service Design Projects," 59.

The study was designed to incorporate a "think aloud" approach, not only to enable the householders to set the agenda and steer the discussions, but also to provide a design context within which they could focus on the quality attributes most salient to them.[82] Thanks to this approach, we had more confidence that any design changes made were the most important to the householders. The think aloud approach also made the co-design process adaptive and reflexive. This, coupled with the application of a theoretical framework for data analysis, struck a balance between constraining external validity at the risk of affecting internal validity voiced in the literature.[83] Future practitioners could employ similar approaches to evidence the benefits of applying co-design whilst not constraining its collaborative, free-flowing nature.

82 Saracevic, "Relevance," 2130.

83 Kristensson and Magnusson, "Tuning Users' Innovativeness," 155; Mitchell et al., "Empirical Investigation," 216–17.

84 Visser et al., "Contextmapping."

Discerning Implicit and Explicit References

As described previously, we coded the householder participants' statements in relation to specific attributes (see Figure 4) as either explicit or implicit. Many of the insights were implicit in nature (71% of all coded comments). An example of an implicit negative comment was this: "I don't actually know whether … the actual PlayStation turned off, whether that means there's electric[ity] – like it's on standby, and it's still using electricity and whether I have to turn it off at the wall." The comment, and the context around it – a discussion of the newly-introduced, disaggregated appliance energy data on the revised energy report – imply that the report's ability to address specific individual needs could have been increased by providing information to clarify this point (Specificity attribute). We used the implicit/explicit coding approach to capture and evidence the nuanced affects elicited via interaction with the energy advice reports, as we felt the implicit statements especially would be good indicators of the participant householders' tacit knowledge and latent needs.[84]

Although including implicit references increases a researcher's ability to extract meaning from the study data, it clearly introduces greater subjectivity during analysis. The attention given to implicit references is an important consideration, as it can change the key messages derived – for example with Clarity, including the more nuanced references demonstrated that clarity of the reports' information delivery actually decreased during the co-design process – which might be explained by the reports' increasing complexity – whereas the opposite would have been the case if we had only taken explicit statements into account. The findings suggest that it is important for researchers to "dive into the data" and "read between the lines" to extract actionable meaning from participants' input whenever a research methodology calls for interpreting participants' responses, as our think aloud approach did.

Formative vs. Summative Design Input

We sub-divided coding for ten of the attributes shown in Figure 4, to differentiate between general comments on the reports and more specific comments about a particular feature or aspect. For example, "Yeah, when you compare the two … yeah, that's easier to look at isn't it?" represented the information as a whole being perceived as accessible, while, "So the fact that the scales are different … makes it quite hard to do a direct comparison," represented a reference to a specific design feature. The general comments and (most of) the comments on specific design features were summative evaluations of the energy advice report, and as such, were less effective at enabling more specific design improvements, but still useful in some cases for validating the overall approach taken. Although the comments on specific features – such as the scales used on the energy bar graphs – were also (mostly) summative, they were more useful in terms of pinpointing specific issues

with particular content or format details. And even though the think aloud approach afforded the householders an opportunity to emphasize their most salient issues (general or specific), it was less effective at identifying how improvements might be made, for example, how the clarity of the reports might be improved or what types of supporting information might be needed. This highlights a tension between (1) allowing user insights and needs to emerge at a personal and contextual level – in other words, not artificially constraining the collaborative design process;[85] and (2) designing the co-design process to be more explicitly formative with more structured interjection from those facilitating – which may affect internal validity.

Limitations

There were a number of limitations to this research. As with many studies that recruit members of the public, it is difficult to eliminate the self-selection bias resulting from only those participants being interested in the topic being motivated to take part in the study. The "energy" aspect was initially disguised, but despite recruitment efforts, by the commencement of the study there was a bias towards energy-aware participants. Although this potentially limits the topic specific generalizability of the results, it does not impact on the overall message being conveyed by this paper.

A second limitation related to the extent to which dynamic personal energy usage data could be incorporated into the trial. Because the resources required to collect and process these data were considerable, we only included one sample of data in the study (Visit 2). Visit 3 focused on increasing the detail of those same data (from additional data sources) based on a better understanding of the householders' needs. The reduction in the currency assessment reflects this, and also to some extent validates the capacity of the method to detect changes in information perceptions. Clarity may have also diminished due to the degradation of recall that takes place over time – non-exceptional events, such as energy usage, are gradually forgotten over time. However, an analysis of the householders' comments showed that the majority of negative comments relating to clarity were related to increasing granularity in the data and the lack of supporting explanations for this, rather than the householders' forgetting what they were doing, or why, at an earlier point in time.

Conclusions

This article has attempted to contribute to the well-established calls in the literature for improved evaluation metrics and more concrete evidence of the impact of co-design,[86] and offer some guidelines for procuring that evidence. Our study demonstrates that co-design – in our case, a collaborative process based around understanding and meaning making – enabled tacit knowledge and latent and evolving user needs to be discovered and addressed. Co-design enabled us to make a better match between the design outcomes and user needs while at the same time to uncover and at times address evolving user needs. The co-design process was effective at uncovering rich levels of feedback and suggested on-going iteration was required to reach more meaningful outcomes for the householders.

From a methodological perspective, the coding process and framework provided *one* particular approach for evidencing *how* co-design can successfully inform the development of aspects of an (information-intensive) service. The theoretical framework enabled a fine-grained and relatively nuanced analysis of our design approach and worked well because it was tailored very specifically to desirable

85 Kristensson and Magnusson, "Tuning Users' Innovativeness," 147–59; Mitchell et al., "Empirical Investigation," 216–17.

86 Szebeko and Tan, "Co-designing for Society," 584; Hoyer et al., "Consumer Cocreation in New Product Development," 293; Steen et al., "Benefits of Co-design in Service Design Projects," 59.

attributes of the design outcomes. The coding approach also proved viable; it showed that by incorporating implicit references to the framework, more detailed insights are available and a more nuanced approach to interpreting participants' comments is possible—a key requirement for extracting tacit knowledge and latent needs from future end users.

The study specifically employed a data-driven approach, rather than a top-down data collection structure. This had high ecological validity—it enabled aspects relevant to individual householders to become the focus of analysis. Equality and shared ownership of the co-design process are key to a successful collaboration. A drawback is that "letting participants drive the process" limits the extent to which specific design recommendations can be obtained. A balance can clearly be struck in this respect: the users of the design outcome can take the design process in a direction that addresses *their* current and evolving needs, while still allowing facilitators to focus closely on exploring more detailed, conceptual design options if they wish.

Acknowledgments

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Appendix A: Details of the ten households recruited to the study

House No.	*House Type*	*No. of Bedrooms*	*Construction Age*	*Household Composition*	*Floor Area*	*Technological Expertise*	*Microgeneration Installed*
H01	Detached	4	1975–1980	2 Adults (EN*)	103	Experienced	Solar PV
H06	Detached	4	2005	2 Adults (EN)	193	Experienced	Solar PV
H07	Semi-detached	3	1965–1974	2 Adults, 2 Children (<5**)	98	Experienced	Solar PV
H09	Detached	4	1919–1944	2 Adults (EN)	143	Inexperienced	None
H10	Detached	4	1919–1944	2 Adults, 2 Children (<5)	109	Experienced	None
H12	Detached	3	1991–1995	2 Adults, 1 Child (>10)	78	Inexperienced	None
H13	Detached	4	Post 2002	2 Adults, 2 Children (<5)	208	Experienced	None
H15	Semi-detached	3	1965–1974	1 Adult	78	Inexperienced	None
H16	Detached	5	1981–1990	2 Adults, 4 Children (>10)	182	Experienced	Solar Thermal
H18	Detached	4	1965–1982	2 Adults (EN)	116	Experienced	None

* "EN" stands for empty nesters.

** The number in parenthesis refers to the age range of the child.

Appendix B: Information quality attributes in Carol Barry and Linda Schamber's information relevance framework*

Quality Attribute	*Description*
Accessibility	The extent to which householders would have to expend some effort or cost to obtain or extract information or meaning from their reports e.g. could they easily assimilate what was contained, or did they deliberate or ask for support?
Accuracy, Validity	The extent to which householders judged the information contained in their energy reports to be accurate, correct or valid e.g. did they judge annual consumption costs to be correct?
Affectiveness	The extent to which the information contained in the energy reports provoked an emotional response from the householders such as pleasure or enjoyment, or did it raise concerns over their energy usage?
Availability of Information	The extent to which the information contained in the energy reports were perceived to be available from elsewhere or were already in the householders' possession e.g. did they already have the information on their current energy bills?
Clarity	The extent to which the householders judged the information to be clearly presented in a well-organized manner, and could therefore easily understand what was contained e.g. did they easily come to conclusions about their energy use or did it take time and require support from the facilitators or a fellow householder?
Currency	The extent to which the householders judged the information contained on their energy reports to be current, recent, timely or up-to-date at the time they were presented with it.
Detail, Depth	The extent to which the householders judged the information contained on their energy reports to be of sufficient detail and depth e.g. were standard energy consumption bar charts detailed enough or did they express a requirement for more detail?
External Verification	The extent to which the information was judged by the householders to be either consistent with or supported by other information within the field e.g. was it in line with their current energy bills or their own energy readings?
Quality of Sources	The extent to which the householders assumed general standards of quality or specific qualities of their energy advice reports based on the source providing the information; did they believe the source as reputable, trusted or expert and therefore that the information was trustworthy?
Scope	The extent to which the householders judged the information contained in their energy advice reports to be of a sufficient level of variety e.g. did they wish to see anything different to that presented?
Specificity (to Users' Needs)	The extent to which the householders judged the information contained on their energy reports as being specific to their individual needs e.g. was something included/ not included that they had wished to see?
Summary, Interpretation & Explanation	The extent to which the householders believed there to be a sufficient summary, interpretation or explanation provided to support their understanding of their energy data e.g. were consumption figures calculations explained, or source of measurements taken explained?
Tangibility	The extent to which the information contained on the energy reports was judged by the householders to relate to real, tangible issues, to be definite and proven, and that hard data or actual numbers were provided e.g. did the householders believe the energy data contained represented reality or made their energy use "more real?"
Volume	The extent to which the householders judged their energy reports to contain a sufficient volume of information e.g. was there "enough," "too much," or "not enough?"

* Barry and Schamber, "Users' Criteria for Relevance Evaluation."

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