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Project scale and the wicked problem in Fourth Order design

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Abstract: User-centred design evolved in the context of product design – projects with client-defined goals and comparatively short lead-times (Sanders and Stappers, 2008; Herriott, 2014). These conditions are not standard in product design. Yet the need remains to involve users appropriately and effectively (to do with matters of equity) in larger scale projects such as transport and architecture. To explore the effect of scale and duration on user-centred design, this paper compares cases of hospital design and public transport design. This paper has synthesised empirical studies of user involvement in public transport and hospital design. The paper draws comparisons between large design projects and case of “wicked problems”. Using this link, the paper argues for the reasons outlined in Rittel and Webber (1973) that large systems projects are not readily amenable to tackling using standard design processes. The paper then tries to show that the success of design approaches in the first three orders of design (Buchanan, 2001) are not automatically transferrable to what Buchanan terms Fourth Order design.

Keywords: Accessibility, Design Process, User-Centred Design, Public Transport, Architecture

1. Introduction

User-centred design and co-design have a long history in design research, with work going back to the 1990s. For this paper, it is assumed that the reader is familiar with the main concepts of accessibility, user-participation and co-design methods. However, for a handy overview of user-centred design and its related approaches readers can review Nilsson et al (2010), Erikkson et al (2014) and Kelly and Matthews (2014) Sanders and Stappers (2008).

Broadly speaking, work on various forms of co-design has its origins in the development of products and has been extended to larger projects such as architecture and public transport (Nilssen et al. 2010). This paper synthesises investigations on the design processes in public transport (Herriot and Cook, 2014) and a recent study of hospital design (Herriott, 2017) in Denmark with a view towards comparing how they incorporate the needs of the user. It also builds on Ph.D. work regarding the delimitation of Inclusive Design (Herriott, 2014), which can be taken as a specific type of co-design, sharing many of its main features, primarily user-investigation methodology and ethical
characteristics with co-design but directed towards specific goals (design for older and disabled users).

The public transport projects in (Herriott and Cook, 20014) related to the design of light and heavy rail carriages for use in Denmark, France and Germany. The hospitals studied in Herriott (2017) were constructed in Denmark, being either new buildings or extensions. What the architecture and rail carriages have in common is the large scale and long-term nature of the projects and that they were conducted by and for public sector. This contrasts with the typical products of industrial design with their relatively short lead times and their clear commercial nature. As well as this consideration of design process and scale, there is another direction to consider the matter from. The oft-cited work of Buchanan (2001) discusses Fourth Order Design, focused on environments and systems (ibid. p. 9).

A quarter of a century later, it is still not apparent that this evolution in design has taken place and the question arises as to why this is the case. By this it is meant that though environments and systems are designed, they are not apparently designed using the range of tools and approaches of industrial design.

This paper is structured as follows. First there is a review of the work on public transport and hospitals. Next, there is a comparison of these. The results are then discussed in the light of relevant literature. The material is then reviewed in the light of Buchanan’s (2001) paper.

The practical consequence of this is to make explicit the nature of “traditional” design (orders One to Three, after Buchanan) which may otherwise have remained tacit.

Following Love’s (2000) meta-theoretical structure of design theory, this work deals with design as information processing (ibid. p16). Using Love’s numbering system (1-10), this the study addresses mechanisms of choice (4), design methods (5) and general design theories (8).

2. Public Transport and Hospital Design

The following two sections review the research on public transport and hospital design. First, public transport.

2.1 Design for public transport

Herriott and Cook (2014) investigated methods used in the rail sector to achieve the goals of accessibility in the design of carriages. The research question was how much the methods used for rail differed from those prescribed for commercial, industrial product design. “Semi-structured interviews were conducted with nine rolling stock producers, operators and design consultancies. The purpose was to determine if ID design methods are used explicitly and the extent to which the processes used conformed to ID, if at all” (ibid, p. 1).

Interviews (nine in all) were conducted with five design consultancies, a light rail operator, a heavy rail operator, and two firms charged with both the design and construction of carriages. The expert interview method (Bogner et al. 2009) was used. The authors interviewed subjects about the user-investigation methods involved and whether these were direct or indirect. The assumption was that the greater application of direct user-investigation methods was preferable to a reliance on indirect data (such as that provided by the clients). It was found that
“direct and indirect user-involvement serve different ends. Standards offer consistency; specialist advisors offer support to the client’s unique design needs, for example. Ideally, standards form a minimum level of user input but can’t provide the rich information that direct involvement can.” (ibid, p. 8).

Table 1 (below) indicates the level of user-involvement of the firms interviewed by Herriott and Cook (2014). Direct user-involvement refers to user-participation and direct communication with the firm during the design process (e.g. user-trials, interviews, focus groups). User-data provided by the clients and reference to legislation and standards was considered indirect user-involvement.

Table 1. User involvement in light rail design process. The figures represent the number of design methods used.

<table>
<thead>
<tr>
<th>Name</th>
<th>Direct involvement</th>
<th>Indirect involvement</th>
<th>User testing</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Rail Operator</td>
<td>5</td>
<td>1</td>
<td>1:1 model</td>
<td>5</td>
</tr>
<tr>
<td>Heavy Rail Operator</td>
<td>5</td>
<td>n/a</td>
<td>1:1 model</td>
<td>3</td>
</tr>
<tr>
<td>Builder A</td>
<td>2</td>
<td>6</td>
<td>CAD, detail</td>
<td>3</td>
</tr>
<tr>
<td>Builder B</td>
<td>0</td>
<td>2</td>
<td>No data</td>
<td>1</td>
</tr>
<tr>
<td>Consultancy X</td>
<td>2</td>
<td>3</td>
<td>1:1 model</td>
<td>2</td>
</tr>
<tr>
<td>Consultancy Y</td>
<td>2</td>
<td>2</td>
<td>No data</td>
<td>3</td>
</tr>
<tr>
<td>Consultancy Z</td>
<td>2</td>
<td>8</td>
<td>1:1 model</td>
<td>5</td>
</tr>
<tr>
<td>Consultancy C</td>
<td>8</td>
<td>9</td>
<td>1:1 model</td>
<td>2</td>
</tr>
<tr>
<td>Consultancy D</td>
<td>2</td>
<td>2</td>
<td>1:1 model</td>
<td>4</td>
</tr>
</tbody>
</table>

The table is the product of an analysis of answers to questions about user-involvement in the design process: what methods were used. The list of methods is not exhaustive but included, interviews, focus groups, ethnography, public consultation and ergonomic trials. The repeated use of a method counted as a separate instance e.g. builder B cited two points in the product development where there was indirect involvement. That counted as two instances of that method. The instances were counted and tabulated. It was assumed that there was some correlation between the amount of direct user-involvement and the quality of the design outcome. The constructors who designed in-house reported low scores for direct involvement but with such a small sample, it is hard to see the data as being any more than indicative. Provisionally though, it would be not unreasonable to conclude that the full suite of industrial design methods (and specifically Inclusive Design) were not being exploited. A more nuanced reading of some of the interviews shows that while “hiring expert consultant” (Consultant X) merely counts as one instance, it refers to the systematic use of expertise related to accessibility and to user-requirements. Perhaps the consultant carried out user-involvement activities that, if discussed and then counted separately, would increase the rating for this firm. They could be given the benefit of the doubt. In contrast, the rhetoric of Consultant Y
clearly showed a gap between the stated claim and the actuality: “...inclusivity is such an important motivation behind what we do it isn’t differentiated, it’s part of the whole technics of the whole process...”. The rating for this subject’s firm lay at the low end of the scale, that is to say there were only two instances of direct user-involvement. Their rhetoric suggested a lack of user-investigation was being glossed over and that the importance of the motivation was not that high.

The study determined that all the firms relied primarily on reference to and compliance with industry standards. The design consultancies showed a slight but noticeable willingness to make use of more user-centred design. However, this was in response to the clients’ request rather than being self-motivated. Where the operators of the carriages took more control of the design process, accessibility was handled in a more thorough-going manner. The study came to the conclusion that it became harder to integrate users into the design process the more it was spread over geographic space (client and designer in different countries) and the more actors were involved (designers, manufacturers, client). The worst-case scenario was for a client to hire a designer, a separate manufacturer and for the production and design to be carried out somewhere other than the county in which the equipment was to be deployed. Of the projects described, only one featured the use of systematic documentation to record and track the meeting of user requirements, Operator B, a light rail system in Denmark.

2.2 User involvement in hospital design

Herriott (2017) presented a literature review of work related to hospital design and non-hospital co-design building projects. During this review no literature was discovered which fell into both categories, that is work of an architectural nature involving co-design and hospitals. The study then described and analysed the content of three semi-structured interviews carried out with senior managers working at large architecture consultancies in Denmark. The consultancies had recently completed hospital design projects.

Uniformity characterised the design processes of the hospital design cases. The process all featured a health authority as the commissioning agency. These authorities retained consultancies to define the initial brief. However, during the course of the interviews the subjects generally did not make further reference to the brief in relation to either patients’ needs or the design process. There was one exception: the subject reported that the health authority expressed the wish to place the medical staff uppermost in the design priorities. The overall finding of the investigation was that patients and relatives’ interests are implicitly but not explicitly addressed during design.

On the subject of which methods were used to discover the needs of patients and families the following observations were made: interviews and workshops were used but there was no data on when in the process this took place; staff were shown “virtual” models of proposals; full-size mock-ups of selected details were shown to employees; the terms “focus groups”, “forum” and “workshop” were used interchangeably; there were no details on how presentations to staff were structured; some specialists assisted in one projects and suppliers were consulted so as to hear “different views... (to) see what different possibilities are on the market” (Herriott 2017, p.9.)

The interviews required the subjects to describe the relative importance of patients during design. The subjects generally did not name patients unambiguously or name patients first. In one case, only residents in the area of the project were further down the list of stakeholders in terms of priority. Further, despite the focus of the interviews on patients and relatives, the subjects frequently adopted the term “user”, both implicitly and explicitly meaning the medical and ancillary staff.
Another finding of the investigation was that where patients or patient representatives were consulted, this was carried out by the contractor. In the Danish hospital design processes, the contractor is involved once the competition phase has been complete and major design work finished. One firm described experience from previous projects as counting towards patient involvement in a project without any express user (meaning staff) involvement. The exact phrase used was “general awareness of users” which could be interpreted as a means to obscure the otherwise very plain lack of user or patient involvement in the design process. A further example of weak involvement was it being described as “the opportunity to ask questions” during public consultation.

Table 2 shows a summation of the number of direct and indirect means to gauge patient/relatives’ insights during the design process. It is only indicative and the section “methods” is left blank deliberately. It was not possible to accurately determine how many methods were used since the terms, “forum”, “consultation” and “focus groups”, for example were used indiscriminately by the subjects.

<table>
<thead>
<tr>
<th>Name</th>
<th>Direct</th>
<th>Indirect</th>
<th>User-testing</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat</td>
<td>1</td>
<td>2</td>
<td>Mock-up</td>
<td>-</td>
</tr>
<tr>
<td>Sky</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Steel</td>
<td>2</td>
<td>2</td>
<td>Mock-up</td>
<td>-</td>
</tr>
</tbody>
</table>

Reich et al (1996) “present a discussion of the problems of participation in product design”. Their main finding is of direct relevance to projects such as hospitals. They describe the problem of information asymmetry between parties (ibid. p.179) echoing Fouqué and Lammineur (1995). The procedures for recording information and checking it is acted upon are a source of difficulty with large scale projects. But, as the Danish light rail case discussed above, it shows that the most important factors in ensuring participation are related to the recording system that preserves data on “design decisions, projects’ progress and outcomes” (ibid).

2.3 Comparison of the two processes

Tables 1 and 2 show how uses are involved in the design process of light and heavy rail carriage design and in the design process of hospitals respectively. While recognising the small sample from the case of hospital design, one can infer that the consultancies do not make extensive use of methods to determine the requirements of patients/relatives and that the scores are similar to the lowest ranking cases examined in public transport. Further, full-size mock-ups were referred to as the means of user-testing. CAD models were not explicitly discussed or discussed in detail. The public transport designers were clearer on which methods they used to determine user needs. In the case of the hospital designers, it is not possible to be confident about the methodology other than a variety of similar methods may have been used. In determining user needs the method of inquiry determines the kind of information gathered. It is possible that the hospital designers do not have a clear definition of what they wish to find out in terms of quality or quantity of information. The
summary of the hospital design case shows reliance on indirect means of handling the needs of users in that they referred to building standards and information gathered by the health authority itself or its proxy.

3. Design Processes as Information Flows

Diagrams 1, 2 and 3 represent an attempt to approximate the flow of information in the design of product, public transport (trains) and hospitals. The flow diagram for product design is based on the “standard models” (Dong, 2003) which is described as:

- Step one: briefing (designers get the brief from the client).
- Step two: finalising the brief (designers interpret the brief and finalise the brief with the client).
- Step three: developing concept (designers develop concepts and present them to the client).
- Step four: selecting the concept (the client selects the concepts from the designers’ proposals).
- Step five: implementing the design (designers implement the final design with the client).

In terms of information flow this can be represented as follows, where the designer is part of the same organisation as will manufacture the product. As with all three schematic diagrams in this paper, the arrow shows the direction of information flow. For example, in Figure 1 information flows from the user to the designer in the sense that the designer uses various methods to find out about the user. The designer sends information to the production facility in the form of CAD files that described the geometry of the product and, perhaps, information on the expected production rate. Production sends information back to the designer in the form of a finished prototype and written and oral data on problems encountered in producing the required object. The time element of the relation is not captured in the diagrams.

Figure 1. The structure of information flow in “standard” product design.
The diagram in Figure 1 serves as a general indication of the relation of the user and designer for a simple product. See Discussion section 4 for further comment on the diagram. Generally speaking, the information flow from user to designer and production is short spatially and temporally.

The following diagram shows the information flow in relation to the design of public transport (specifically the carriages):

![Diagram of information flow in design for public transport]

**Figure 2. The structure of information flow in design for public transport.**

In Figure 2 the user is one element among a much larger array of actors. Two elements are problematic in terms of information flow. One, design standards, is the result of inputs from industry groups (Herriott and Cook, 2014) and is slow and difficult to change as it required consensus among those groups. Two, the “market”. It is in inverted commas because it is not a market such as the market for many similar discretionary products such as vacuum cleaners or toothbrushes. The feedback signal is weak and open to interpretation. A case could be made that there is no true market signal from users of a particular design. In a variant of this schema, the designer may be the constructor’s in-house office. There may also be an office responsible for design at the owner-operator.

The following diagram shows the information flow in relation to the design of a hospital (based on the Danish case described above:}
Like Figure 2, Figure 3 shows the user (patient/relatives) as one stakeholders among many more. Based on the findings of Herriott (2017) there is consultation of the users carried out by the construction firm after the desk-design has been approved. Regulations also affect design choices and are difficult to change. Additionally, legislation affects the scope of the project and is unidirectional. The legislation relates to the budget available and possibly the location of the project.

What distinguishes Diagram 1 from 2 and 3 is that it is, in simple terms, a circular flow of information and is a closed loop. Diagrams 2 and 3 are effectively open and non-circular. Both 2 and 3 have internal circuits which have one-way flows. Adding complication are the spatial and temporal relationships between the elements. If a key aspect of design is problem definition whereby initial research leads to redefinition of the problem, then the information flow required is unavoidably complex. Further, the signal from product to user/patient in cases 2 and 3 is indirect and hard to define. Public transport and patients users have little or no choice about the product; further, the recipients of the signal are very likely to be a different group of actors whereas with product design Company X is able to quantify and qualify market data within time periods of months. Even with a moderate level of turnover, those who designed product X are likely to be the same pool of professional as will design Product X’s successor.

The diagram in Figure 1 shows a generalised design process model. The diagrams in Figures 2 and 3 generalise the empirical findings of Sections 2.1 and 2.2. The model from industrial design of iterative design process works because the cycle time is short and the paths of information flow simple. For public transport and hospitals, the complex paths of information flow make iteration difficult with the potential loss of information along the way or militate against iteration at all but the most basic level. In the case of hospital design, a likely scenario is that a large-scale requirement defined by legislation and regulation may result in a small-scale but non-trivial detail problem that cannot be rectified by a further iteration. An example might be the definition of a standard room size that cannot accommodate patients’ different needs or might not have room for storage of personal belongings.
4. Discussion

This article takes empirical data showing the ways in which design for public transport of hospital design accommodate the needs of users. Public transport design is in some ways closer to product design in that user needs are accounted for to an appreciable extent by the use of 1:1 models and user-investigations during several stages of the projects. One gets the sense from architecture that user investigations have a much smaller role in the design process and are not central. The most important information-flow relationship is that between the health authority, architect and construction firm. The user-to-architect flow is a kind of by-way or annexe to the primary flow.

To return to Figure 1, a case could be made that the information-flow relationship is more complex than that shown. If, for example, one disaggregates the “designer” into several units to show that design is a team activity, the diagram becomes more complex. One can also disaggregate “management” into sub-sections. This, however, does not undermine the argument for the same disaggregation is possible for Figure 2 and Figure 3, resulting in yet more complex flow paths for data and decisions.

Richard Buchanan’s Fourth Order of Design was cited in the introduction. The first is graphic design (symbols). The second is industrial design (objects) and the third interaction design (actions). The fourth is “environmental design” and comes under the rubric of “thought”. The Fourth Order deals with systems, of which public transport and architectural projects are surely examples. It is not apparent from the empirical work discussed above that recognisably iterative and responsive design process are being deployed at the large scale. The question arises as to why this is the case. In Rittel and Webber (1973) the wicked problem concept is introduced and discussed. Much of the focus in subsequent discussions of the paper are on the matter of problem definition: “the formulation of the wicked problem is the problem!” (ibid, p.161). Rittel and Webber present the example of the poverty problem. One way to map the relations of the elements in this case is as shown in Figure 4.

![Figure 4. Possible elements of the poverty problem.](image)

In this instance the elements are not mapped as information flows but as the possible linkage of cause/effects. If we compare this with diagram 2 and diagram 3, we can see a similar number of elements, meaning “signals” which might be decisions or information pass through different nodes at different times and they are not clear market signals (more or fewer sales), for example, but complex
judgements based on diverse sources of opinion. Rittel and Webber (ibid. p156) write: “There seems to be a growing realisation that a weak strut in the professional’s support system lies at the juncture where goal-formulation, problem-definition and equity issues meet.” As noted, the usual interest in the wicked problem concept is in the problem-definition. This applies to some extent to public transport and hospital design. However, the empirical data described above (showing the difficulty of incorporating users’ needs into a complex process) shows the nature of the matter of equity. The goal of a user-centred design process is to place the user at the centre of the project. The less the user in involved the less equitable the process will tend to be. In that sense, these cases are like wicked problems. To connect that to Buchanan’s belief design can deal with systems-level cases, one sees that this belief runs up against fundamental problems outlined by Rittel and Webber. This then is a suggested answer as to why, so many years after Buchanan called for Forth Order design to be implemented, the user/patient is only a weak force and minor element of the systems supposedly designed for their benefit. Broadly speaking, industrial design deals with particular cases and does so experimentally. Large scale projects tend to be dealt with on a legislative basis which means they are supposed to be universal and also, to use Rittel and Webber’s (1973) terms, “one-shot” solutions (ibid, p. 163).

Finally, as stated in section 1, practical consequence of this is to make paper explicit the nature of “traditional” design (orders One to Three, after Buchanan) which may otherwise have remained tacit. What the standard design process (see figure 1) depends on is a close spatial and temporal interlinkage of the main stakeholders in the design process. Further, it depends ultimately on a market signal which the problems and processes in Diagram 2 and 3 lack.

To summarise, this paper has synthesised empirical studies of user involvement in public transport and hospital design. It has found the user has weak or minor role in the design process. The paper draws comparisons between large design projects and case of “wicked problems”. Using this link, the paper argued for the reasons outlined in Rittel and Webber (1973) large systems projects are not readily amenable to tackling using standard design processes. The paper thus shows that the success of design approaches in the first three orders of design (Buchanan, 2001) are not automatically transferrable to what Buchanan terms Fourth Order design.

References
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Richard Herriott is associate professor of industrial design at the Design School Kolding. His main interests are co-design, Inclusive Design, aesthetics, design methodology and research design in design research.