
Introduction

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1 Introduction

The focus of this special issue is on experiences relating to the practical aspects of empirical research into supporting design information and knowledge management in design contexts.

The challenges of undertaking empirical research are many, and are documented in the disciplines from which general design research draws its empirical methods (Robson, 2002). However, when we consider research into supporting design information and knowledge there are a number of additional challenges. These are considerable and include:

- the distributed and often international and multicultural nature of the design process
- the range of information representations used in design, and in particular the proprietary nature of many of these
- the commercial sensitivity and in many cases confidentiality of design activities and their outcomes
- the timescales over which design projects run
- the complexity of the artefacts and the teams that work on them.

These issues make the execution of empirical work difficult. Furthermore, with multiple disciplines involved in design research, and with their varying perspectives on what is knowledge, information and design, the theoretical and empirical challenges are both multiple and additive. Whilst design is not unique in the range and complexity of the issues, the combination of the cognitive, organisational, social, technical and commercial aspects make it particularly challenging. It was these considerations that motivated a two day workshop run by the Airbus UK Knowledge Management Group and the IDMRC at the University of Bath in 2005. This Workshop provided the motivation for this special issue.

2 Overview of the papers

This special issue is composed of five papers, outlined in Table 1. All of the papers report on the application of empirical methods in studying information and knowledge in design contexts. A range of research methods are utilised, and different perspectives are taken on the important issues. As a group the papers represent a significant body of work, reflecting on the role and execution of work in design information and knowledge research and on the multiple and often competing demands and constraints on that research.

Table 1 Papers in this Special Issue

Paper 1	Empirical research on information and knowledge management in designing
Paper 2	An observational study of multi-disciplinary co-design – application to an electromechanical device
Paper 3	An empirical study of engineering knowledge dynamics in a design situation
Paper 4	Empirical research in engineering practice
Paper 5	Competencies required to undertake empirical engineering design research

The first paper, by Lauche, works well to set the scene for the remaining papers, showing the potential of theory and giving insights from research into human behaviour. Papers 2 and 3, by Marin et al. and Prudhomme et al. respectively, present two empirical studies focusing on knowledge in design and are concerned with reporting research in progress that utilises specific theories of knowledge or

collaboration (e.g. argumentation) in the context of a specific toolset. The final two papers, by Ahmed, and Aurisicchio and Wallace, respectively, provide reflections resulting from investigations into information and/or knowledge use by designers in an industrial setting. They serve to provide work that helps researchers to better understand what methods to use and when, how these methods relate to design knowledge; and what skills are needed to undertake research into knowledge and design.

Paper 1 Empirical research on information and knowledge management in designing

The issue opens with a contribution from Kristina Lauche of TU Delft with the subtitle “Where are we and where do we go from here?” Lauche’s overall concern is to lay out a route map into relevant literature, drawing on existing research and theories about how other professionals deal with complex tasks, while taking the specific context and challenges of design activities into account.

Lauche starts by reviewing the empirical and psychological basis of papers in two leading design conferences, ICED, and Design. She notes that “very little empirical research on designing draws on the findings and methodological knowledge available in the social sciences.” Lauche acknowledges that this is not the fault of designers or design researchers, noting the unfamiliarity of the territory and that most sociological or psychological research is not written up for the consumption of those outside the discipline. Empirical findings are often obtained in settings and with tasks that bear little to what designers do. She attempts to answer the question which aspects of “human behaviour such as complex problem solving, team interaction or organisational learning can be meaningfully applied to design engineering?” After reflecting on the current state of affairs in design research she proposes an outline of what kind of social science literature the design researcher might consider to inform empirical research in their domain.

Paper 2 An observational study of multi-disciplinary co-design – application to an electromechanical device

The second paper in the issue is from Philippe Marin, Laurent Gerbaud, El-Hadi Mechekour, and Cédric Masclet from the G-SCOP Laboratory of the Institut Nationale Polytechnique de Grenoble. Their paper presents an observational study of a multi-disciplinary and collaborative electromechanical design project. After presenting the context of the work the authors review approaches that may be taken to observational work in design. They then present their study which was carried out in four steps:

- 1 An observational study carried out by the researchers themselves in order to test communication and discipline specific software tools, and to define fundamental problems to observe.
- 2 A first exploratory observational study involving engineering students which enabled evaluation of the observational study procedure, roles, tools and methods.

- 3 Two controlled observational studies, to test the observational procedure and to validate data acquisition and data analysis methodologies. The collaborative protocols were checked on several projects and a complete recording of one student project (audio, video and documents) was made. An activity grid was established by the human-sciences research partners and tested on the collected data.
- 4 It was then planned to apply the know-how obtained in observation and analysis in an industrial context.

The paper details the successive observational studies: their context, scenarios, tools, actors and recording methods, before proposing a global qualitative analysis to highlight the key parameters for the building of an industrial case observation.

Paper 3 An empirical study of engineering knowledge dynamics in a design situation

Paper three is by Guy Prudhomme and Franck Pourroy of the G-SCOP laboratory in Grenoble and Kristine Lund, from the ICAR laboratory, University of Lyon. They present work that was done within the framework of a project which focused on collaborative and synchronous design activities carried out over a network. Their objective is to understand the design processes that designers engage in so that they may propose tools that are adapted to aiding these processes. The authors distinguish between synchronous activities (e.g. meetings) and asynchronous activities (individual work by experts to develop (parts of) the solution based on disciplinary rules and individual experience). They give their perspective on data, information and knowledge in design, then explain why knowledge dynamics in collaborative activities is a matter of interest for understanding and modelling the product design process and rationale. The assumption is made that an argumentative situation – typical of product design – is a good means to study knowledge dynamics in regards to the design problem (requirements definition) and the solution. They then present the empirical study that they carried out, using as a vehicle an electromechanical design exercise carried out by a student group. The task, participants, tools and steps taken are described together with the resources used and the project deliverables. The study in particular explores the argumentation in the exchanges of the design team, which was mediated using the DREW Dialogical Reasoning Educational Web tool. The results presented identify in particular designers' knowledge objects and the personal relations they constructed in regard to these objects.

Paper 4 Empirical research in engineering practice

Saeema Ahmed of TU Denmark is known for several important studies in information and knowledge in engineering design, undertaken in partnership with industry. These build on a long tradition of empirical research in the Engineering Design Centre at the University of Cambridge. Within her paper in this special issue she takes the opportunity to step back and reflect a little on what is known about the application of empirical approaches to knowledge in design. This paper focuses on empirical research methods employed in industrial case studies in information,

knowledge and experience in engineering design, describing the methods and assessing their suitability for the particular research aims and their advantages and disadvantages. This assessment outlines five main benefits: to process, environment, product, documents and participants, and maps the research methods to these benefits to understand the limitations of the methods and to select the appropriate research method for the particular research questions. Two case studies are described in detail – the first using interviews with senior-level aerospace engineers and the second protocol analyses of experienced and novice designers. The paper draws conclusions from the studies, which focus largely on engineering knowledge management, and highlight both the benefits and the care needed in ensuring that there is a synergy between the research aims and industry aims. The research studies and examples chosen have focused upon engineering knowledge management and highlight both the benefits and the care needed in ensuring that there is a synergy between the research aims and industry aims.

Paper 5 Competencies required to undertake empirical engineering design research

The final paper, by Marco Aurisicchio and Ken Wallace of the University of Cambridge, also explores approaches to empirical work, but in this case from the perspective of identifying the competencies required of the researcher, in particular when engaged in the detailed study of design processes in engineering organisations. The authors observe that several studies have been undertaken in academic environments to study either natural or controlled design processes, and that undertaking such studies in industry is challenging and poses several research issues. They identify that researchers need credibility, knowledge and ability, and that their competencies should also include authority, pragmatism, flexibility, and sound ethics. They illustrate their observations with two case studies, the first based on a diary study and in-depth interviews, and the second on shadowing – on following the design activity of an individual for a predetermined interval of time. From the work they identify a framework which includes the researcher competencies and the characteristics (commitment and engagement) of other participants in the research, along with suggested actions to be taken to ensure that the necessary competencies and characteristics exist prior to undertaking research.

3 Conclusions

The papers in this special issue highlight a number of challenges in carrying out empirical research in design contexts. They show how different researchers can tackle issues and tensions within empiricism in different, but complementary ways. The papers also highlight routes into relevant literature, both for those undertaking empirical research into information and knowledge in design but also for those wishing to undertake more general empirical work in design.

Overall these papers should equip both novice and experienced researchers with a richer toolkit with which to undertake empiricism. We hope these papers become a well used set of papers that complement existing empirical work in design.

Whilst these papers advance our understanding of the application of empirical methods in design contexts, it is clear that this will remain an issue of importance for many years to come.

This will happen as the design research field expands to embrace more and more diverse disciplines and associated methods, and as the continued application of empirical methods to the challenges of design research produces new insights.

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Reference

Robson, C. (2002) *Real World Research*. Oxford: Blackwell.