A dynamic approach to real-time performance measurement in design projects

Recent developments in engineering design management point to the need for more dynamic, fine-grain measurement approaches able to deal with multi-dimensional, cross-level process performance in product design. Thus, this paper proposes a new approach to the measurement and management of individual and teamwork performance in engineering design projects. This integrates multiple, previously disparate, aspects of design management and performance measurement theory in a single framework. Further, a fully realised performance measurement approach is developed, which complements existing management strategies. This framework is synthesised from an extensive review and illustrated via an in-depth case study. As such, this work contributes to performance measurement theory in engineering design and has significant implications for both engineering design research and industry.
Nudge, persuasion, and the influencing of human behaviour through design are increasingly important topics in design research and in the wider public consciousness. However, current theoretical approaches to behaviour change have yet to be operationalized this in design process support. Specifically, there are few empirically grounded processes supporting designers in realising behaviour change projects. In response to this, 20 design projects from a case company are analysed in order to distil a core process for behavioural design. Results show a number of process stages and activities associated with project success, pointing to a new perspective on the traditional design process, and allowing designers to integrate key insights from behaviour change theory. Using this foundation we propose the Behavioural Design process.
Designer's identity: Development of personal attributes and design skills over education

Designers' professional identity (DPI) is a social- and self-perceptive construct through which designers are able to identify themselves. To understand the development of DPI, not just as a profession but also as an educational process, there is a need to consider the designer as both individual and trained professional. These interactions become also a necessary foundation for professionalism that is especially important for design activity. For this study, a psychometric survey was developed by taking in consideration both aspects of DPI, making use of a set of elements distilled from literature as conceptual parameters for Personal Attributes and Design Skills. The survey evaluated professional self-awareness of design students at bachelor and master level; also providing a first profile model of the two groups. The dynamics of the relations between the DPI elements changes and develops very slowly due to the process of identity consolidation over the educational period. Further, DPI consolidates through a lifelong learning process. These results provide an initial insight into the development of DPI and the challenges of measuring this subjective aspect over education.
Exploring Uncertainty Perception as a Driver of Design Activity

This paper investigates uncertainty perception as a general driver of individual design activity. An observation based protocol study is used to explore the interaction between uncertainty perception and three core actions connected in design activity: information action, knowledge sharing action, and representation action. We bring together prior works on uncertainty perception in the design and management literatures to derive three contributions. First, we describe how uncertainty perception is associated with activity progression, linking all three core actions. Second, we identify characteristic patterns of interaction between uncertainty perception and activity. Third, we decompose uncertainty perception to further explain its role in driving design activity. This extends prior research on design activity, and supports a number of theoretical and empirical implications.
Information-triggered Co-evolution: A Combined Process Perspective

Core elements of design work include the development of problem/solution understanding, as well as information and knowledge sharing activities. However, their interrelationships have been little explored. As such, this work aims to take the first steps towards a more integrated evaluation and description of the interaction between understanding and activity, based around co-evolutionary transition events; and start to answer the question: How can the link between co-evolution and activity be systematically characterized as a foundation for a more fundamental description of design activity? A protocol analysis is used to provide the basis for characterization of different types of coevolutionary transition event. A number of distinct event types are described and significant differences in information use and team engagement are identified across transition events. Bringing these findings together, we propose a unitary model of the interaction between activity and understanding around co-evolutionary transition events. This has a number of implications for future theory building and testing in both design activity and wider design research.

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management, Delft University of Technology
Authors: Cash, P. (Intern), Gonçalves, M. (Ekstern)
Pages: 501-520
Publication date: 2017

Host publication information
Title of host publication: Analysing Design Thinking: Studies of Cross-Cultural Co-Creation
Publisher: CRC Press
ISBN (Electronic): 9781138748446
Main Research Area: Technical/natural sciences

Supporting the development of shared understanding in distributed design teams
Distributed teams are an increasingly common feature of engineering design work. One key factor in the success of these teams is the development of short- and longer-term shared understanding. A lack of shared understanding has been recognized as a significant challenge, particularly in the context of globally distributed engineering activities. A major
antecedent for shared understanding is question asking and feedback. Building on question-asking theory, this work uses a quasi-experimental study to test the impact of questioningsupport on homogeneous and heterogeneous teams. The results show significant improvement in shared understanding for both team types (27% improvement for heterogeneous and 16% for homogeneous), as well as substantial differences in how this improvement is perceived. This extends theoretical insight on the development of shared understanding and contributes one of few empirical studies directly comparing homogeneous and heterogeneous teams in the engineering design context. This has implications for how distributed teams can be more effectively supported in practice, as well as how shared understanding can be facilitated in engineering design.
The role of logbooks as mediators of engineering design work

Information transformation is key to engineering design work. However, research on how information management tools, and logbooks in particular, mediate this, is fragmented. We explore this via two studies (from which we confirm the central role of logbooks) and propose three modes of mediation: facilitating cognition and creation, gathering and collation of information, and staging and transformation of information. The findings explain the widespread use of logbooks through their support of these three modes. Consequently, we contend that multi-modal mediation is one of the main reasons why logbooks are such a central and enduring medium. This synthesises and extends theory on mediation and information use in engineering design. Further, practical insights are derived for the development new information management tools.

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management, University of Bristol
Authors: McAlpine, H. (Ekstern), Cash, P. (Intern), Hicks, B. (Ekstern)
Pages: 1-29
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Design Studies
Volume: 48
ISSN (Print): 0142-694X
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.3 SJR 1.229 SNIP 2.638
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.115 SNIP 3.216 CiteScore 2.74
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.283 SNIP 2.752 CiteScore 2.78
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.36 SNIP 2.39 CiteScore 2.89
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.489 SNIP 2.607 CiteScore 2.41
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.997 SNIP 2.628 CiteScore 2.45
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.825 SNIP 2.432
This paper contributes to design for behaviour change by testing the potential of priming via everyday products as a means of influencing users and dissolving conflicting individual and collective concerns. Self-construal is introduced as a core explanatory concept with respect to behaviours that unite individual and collective concerns. Two studies are reported. In the first, abstract representations of the target behaviour are elicited and incorporated into subconscious priming stimuli for each of the major senses: sight, hearing, touch, and smell. These primes are then evaluated in a controlled experiment. From these studies implications for both researchers and practitioners are identified. In particular, priming showed a significant effect across all senses.

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management, Technical University of Denmark
Authors: Cash, P. (Intern), Holm-Hansen, C. (Ekstern), Olsen, S. B. (Ekstern), Christensen, M. L. (Ekstern), Thi Trinh, Y. M. (Ekstern)
Pages: 32-65
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Design Studies
Volume: 49
ISSN (Print): 0142-694X
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.3 SJR 1.229 SNIP 2.638
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.115 SNIP 3.216 CiteScore 2.74
Web of Science (2015): Indexed yes
A model of designing as the intersection between uncertainty perception, information processing, and coevolution

A number of fundamental perspectives on designing have been described in the literature, in particular problem/solution coevolution and information use. However, these different perspectives have to-date been modelled separately, making holistic description of design activity difficult. This paper takes the first steps towards linking these disparate perspectives in a model of designing that synthesises coevolution and information processing. How designers act has been shown to play an important role in the process of New Product Development (NPD) (See e.g. Badke-Schaub and Frankenberger, 2012). Modelling design activity in NPD is typically done in one of three ways; object-, subject- or process oriented. First, it can be modelled by focusing on the object of design: the product. Second, it can be modelled by describing the social interaction and knowledge exchange between actors. Third, design activity can be modelled by describing the steps and phases that entails a specific design activity (Bedny & Harris, 2005). In all aspects and stages of the NPD process, uncertainty plays a key role both within the project itself as well as in relation to the project environment (Huang, Liu & Ho, 2015). In order to resolve uncertainty, both individuals and teams need to engage in decision making. In the case of decision making in a team, there is also greater scope for uncertainty, since personality and cognitive style influence decision making (Dewberry, Juanchich & Narendran, 2013) and every person has a different perception of uncertainty. This difference can for example lead to a lack of agreement on the best solution. In NPD projects information is used to minimize the uncertainties inherent to innovation (Stockstrom & Herstatt, 2008; Huang, Liu & Ho, 2015), however, it is important to accept that there are uncertainties that can not be minimized and are inherent to the project itself (Ullman
Thus, in NPD, the designer's activity is impacted by a wide range of variables. First, uncertainty is significant both inside and outside the project (as in the market for example), and is perceived and acted upon by the designer. Uncertainty perception can be connected to personal characteristics and cultural background, as well as experience and domain specific knowledge. The designer may perceive uncertainty arising from the design of the artefact, from the market, from consumer use, from prototyping, and others. Second, the designer's perceived uncertainty is the motivation to start a process of collecting, exchanging, and integrating knowledge. This has been formalised in Information-Processing Theory and more generally described by authors such as Aurisicchio et al. (2013) who describe design as an information transformation process. Here the aim of the activity is to reduce the perceived uncertainty through identifying and integrating external information and knowledge within the design team. For example, when perceiving uncertainty the designer might seek new information online, process this information, and share with their team in order to assess e.g. opinion, after that they process this knowledge together with their interpretation, giving a context to it and finally analysing if the new knowledge is helpful. Third, the designer's perceived uncertainty might also be the motivation to start a process of synthesizing information and ideas into new design propositions through the process of simulation. That is, design work is characterised by an iterative process between problem and solution space, also termed design coevolution (Poon and Maher, 1997; Dorst and Cross, 2001). This describes how problem and solution coevolve over time and have a mutual effect on one another, helping the designer to resolve high levels of uncertainty (Christensen & Ball, 2013). Thus in resolving NPD projects two fundamental processes are the manipulation and evolution of the problem and solution spaces (Christensen & Ball, 2013), and the transformation of information (Aurisicchio et al., 2013). However, prior research has traditionally modelled these perspectives separately; making holistic description of designer activity difficult. Thus, the aim of this paper is to propose a model that links design coevolution and information processing via uncertainty perception. This brings us to the following question: How are coevolution, information processing, and perception of uncertainty connected? The paper is structured in the following way. First, it presents the definitions and literature review of Uncertainty Perception, Information Processing, and Coevolution highlighting connections between them. The proposed model is then presented and explained. The paper closes with conclusions, limitations, and suggestions for further studies, including testing of the model itself.

An Introduction to Experimental Design Research

Design research brings together influences from the whole gamut of social, psychological, and more technical sciences to create a tradition of empirical study stretching back over 50 years (Horvath 2004; Cross 2007). A growing part of this empirical tradition is experimental, which has gained in importance as the field has matured. As in other evolving disciplines, e.g. behavioural psychology, this maturation brings with it ever-greater scientific and methodological demands (Reiser 1939; Dorst 2008). In particular, the experimental paradigm holds distinct and significant challenges for the modern design researcher. Thus, this book brings together leading researchers from across design research in order to provide the reader with a foundation in experimental design research; an appreciation of possible experimental perspectives; and insight into how experiments can be used to build robust and significant scientific knowledge. This chapter sets the stage for these discussions by introducing experimental design research, outlining the various types of experimental approach, and explaining the role of this book in the wider methodological context.
Designer’s Identity: Personal Attributes and Design Skills

A designer’s professional identity (DPI) develops through both education and professional experience, building on core personality traits and innate skills. In this paper a systematic literature review and a secondary narrative review were developed in order to map personal attributes and design skills that comprise the DPI. Just a few works in literature dealt with these two elements holistically. Thus, in order to address this gap a holistic understanding of these elements, in context, is proposed as a cohesive framework where a DPI can be described as it evolves over time.

Experimental Design Research: Approaches, Perspectives, Applications

This book presents a new, multidisciplinary perspective on and paradigm for integrative experimental design research. It addresses various perspectives on methods, analysis and overall research approach, and how they can be synthesized to advance understanding of design. It explores the foundations of experimental approaches and their utility in this domain, and brings together analytical approaches to promote an integrated understanding. The book also investigates where these approaches lead to and how they link design research more fully with other disciplines (e.g. psychology, cognition, sociology, computer science, management). Above all, the book emphasizes the integrative nature of design research in terms of the methods, theories, and units of study—from the individual to the organizational level. Although this approach offers many advantages, it has inherently led to a situation in current research practice where methods are diverging and integration between individual, team and organizational understanding is becoming increasingly tenuous, calling for a multidisciplinary and transdisciplinary perspective. Experimental design research thus offers a powerful tool and platform for resolving these challenges. Providing an invaluable resource for the design research community, this book paves the way for the next generation of researchers in the field by bridging methods and methodology. As such, it will especially benefit postgraduate students and researchers in design research, as well as engineering designers.
Prototyping with your hands: the many roles of gesture in the communication of design concepts

There is an on-going focus exploring the use of gesture in design situations; however, there are still significant questions as to how this is related to the understanding and communication of design concepts. This work explores the use of gesture through observing and video-coding four teams of engineering graduates during an ideation session. This was used to detail the relationship between the function behaviour structure elements and individual gestures as well as to identify archetypal gesture sequences – compound reflective, compound directed one-way, mirroring, and modification. Gesture sequences occurred at critical periods during the design session, such as idea evolution and developing shared understanding. They are used to act out design concepts, repeat and learn from sequences, and establish shared understanding. Finally, a number of implications are identified for both researchers and those seeking to support practice.

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management, Engineering Systems
Authors: Cash, P. (Intern), Maier, A. (Intern)
Pages: 118–145
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Engineering Design
Volume: 27
Issue number: 1-3
ISSN (Print): 0954-4828
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.19 SJR 0.64 SNIP 1.491
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.792 SNIP 1.607 CiteScore 2.12
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.172 SNIP 1.254 CiteScore 1.74
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.089 SNIP 1.64 CiteScore 2.06
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.082 SNIP 2.059 CiteScore 1.54
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.528 SNIP 1.341 CiteScore 1.14
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.548 SNIP 1.022
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.687 SNIP 1.221
Activity Theory as a means for multi-scale analysis of the engineering design process: A protocol study of design in practice

This paper contributes to improving our understanding of design activity. Specifically, the paper uses Activity Theory to enable a multi-scale analysis of the activity of three engineering designers over a period of one month. Correspondingly, this paper represents the first work that explicitly investigates design activity across different scales, referred to as macro-, meso- and microscales. In addition to establishing the range of activities and tasks that occur at, and constitute, each scale the underlying relationships between the scales of activity are discussed. Further, the paper elucidates the wider implications of the proposed framework and its findings for both design research and practice. Central to these implications is the articulation of design as a complex fabric of interwoven processes. © 2015 Elsevier Ltd. All rights reserved.
A foundational observation method for studying design situations

Observational studies of designers play an important role in engineering design research, yet there is currently no accepted standard approach for comparing, combining, or contrasting studies. Consequentially, reuse, reanalysis, replication, and aggregation of data are limited and the potential impact of individual studies is severely constrained. This paper begins to address this issue by introducing and developing a foundational method for observational design research to improve replicability, reuse, and overall comparability of empirical studies. A three-step foundational method is proposed that covers capture, coding, and analysis. The capture step defines overall and situational context as well as multiple capture streams, generating a broad data-set that can be examined from multiple perspectives. The coding step employs a multi-level approach that seeks to minimise workload while describing both detailed and high-level information. The analysis step builds on the multi-level approach to provide for a flexible yet standardised examination of the data-set. The overall approach is introduced theoretically and illustrated using a comparison of an industrial study and an experimental study. Finally, it is argued that the proposed method promotes rigour, reliability, and standardisation; and could provide one means for improving comparison and aggregation, ultimately increasing impact in academia and practice.
Building a Cohesive Body of Design Knowledge: Developments from a Design Science Research Perspective

Design is an extremely diverse field where there has been widespread debate on how to build a cohesive body of scientific knowledge. To date, no satisfactory proposition has been adopted across the field – hampering scientific development. Without this basis for bringing research together design researchers have identified difficulties in building on past works, and combining insights from across the field. This work starts to dissolve some of these issues by drawing on Design Science Research to propose an integrated approach for the development of design research knowledge, coupled with pragmatic advice for design researchers. This delivers a number of implications for researchers as well as for the field as a whole.

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management
Authors: Cash, P. (Intern), Piirainen, K. A. (Intern)
Number of pages: 10
Publication date: 2015

Host publication information
Title of host publication: Proceedings of the 20th International Conference on Engineering Design (ICED15)
Publisher: Design Society

Series: ICED
Number: 15
ISSN: 2220-4334
Main Research Area: Technical/natural sciences
Electronic versions:
Building_a_Cohesive_Body_of_Design_Knowledge.pdf
Source: PublicationPreSubmission
Source-ID: 113905947
Publication: Research - peer-review › Article in proceedings – Annual report year: 2015
Multifaceted Assessment of Ideation: Using Networks to Link Ideation and Design Activity

Ideation is core to the innovation process, and has been the subject of study across a range of fields, from psychology to engineering. However, despite substantial progress in outcome-based descriptions of idea generation, research has often resulted in more questions than answers. For example, open questions remain with respect to the differences in behaviour related to ideation between novices and experts, the change in rates of ideation over time in different design teams, and the changing role of ideation from conceptual to detailed design. In each of these cases, robust explanation has proved elusive due to difficulties in characterising the ideation process itself. This paper discusses a major new approach for elucidating ideation and its related design processes through direct observation. A novel network visualisation approach is demonstrated in practice for the first time. This uses network analysis to link ideas dynamically to both the engineering context and the wider design process. This linking analysis gives a substantial new insight into what drives ideation and how previously inscrutable results can potentially be explained by linking ideation into other design processes.
Questioning in Distributed Product Development Teams: Supporting Shared Understanding

Distributed teams are an increasingly common feature of New Product Development (NPD). Key to the success of these teams is the development of both short and longer term shared understanding. Lack of shared understanding has been recognized as a significant challenge, particularly in the context globally distributed NPD activities. Poor shared understanding can ultimately result in delays and rework. One major antecedent of shared understanding development is question asking. This work uses a quasi-experimental study to test the impact of questioning support on different types of distributed teams, both homogeneous and heterogeneous. This extends theoretical insight into the development of shared understanding and contributes one of few empirical studies directly comparing the response characteristics of different team types. From a managerial perspective this work has implications for how distributed NPD teams can be more effectively supported, as well as how shared understanding development can be facilitated in the NPD process.
Information processing theory in the early design stages

Developing appropriate theory is one of the main challenges facing engineering design (Cross, 2007). Theory helps to both explain design activity but also support greater research impact in the domain. It is useful for gaining a more comprehensive understanding of design activity and developing suggestions for improvements and support. One theory that may be particularly applicable to the early design stages is Information Processing Theory (IPT) as it is linked to the design process with regard to the key concepts considered. IPT states that designers search for information if they perceive uncertainty with regard to the knowledge necessary to solve a design challenge. They then process this information and compare if the new knowledge they have gained covers the previous knowledge gap. In engineering design, uncertainty plays a key role, particularly in the early design stages which has been highlighted as the fuzzy front end. To solve this uncertainty, designers collect and exploit information to mitigate uncertainty in design decisions (Love and Roper, 2009). This is then turned into knowledge in order to make it applicable to the designer’s and business’ needs (Cousins et al., 2011). Finally, the new knowledge is shared between the design team to reduce ambiguity with regards to its meaning and to build a shared understanding – reducing perceived uncertainty. Thus, we propose that Information-Processing Theory is suitable to describe designer activity in the early design stages and a potentially useful theory to adopt in engineering design. The aim of this paper is to explore whether the predictions of IPT apply to empirical designer activity in the early design stages. Based on the literature on IPT, a mental framework is presented that depicts the theoretical predictions. This is applied to an experimental study with student engineers solving a product design task. The results show that IPT is indeed a useful theory and we discuss the implications for the field.
Investigating design: A comparison of manifest and latent approaches
This paper contributes to the on-going focus on improving design research methods, by exploring and synthesising two key interrelated research approaches e manifest and latent. These approaches are widely used individually in design research, however, this paper represents the first work bringing them together and explicitly investigating their complementarity in the design domain. This is realised using an example artificial observation study. In addition to discussing underlying relationships between the approaches, this paper identifies key opportunities for improving design research methods by more explicitly combining both manifest and latent elements. Finally, a number of combinatory approaches are proposed based on a conceptual framework. © 2014 Elsevier Ltd. All rights reserved.

General information
State: Published
Organisations: Technology and Innovation Management, Department of Management Engineering, University of Bath
Authors: Cash, P. (Intern), Snider, C. (Ekstern)
Pages: 441-472
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: Design Studies
Volume: 35
ISSN (Print): 0142-694X
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.3 SJR 1.229 SNIP 2.638
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.115 SNIP 3.216 CiteScore 2.74
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.283 SNIP 2.752 CiteScore 2.78
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.36 SNIP 2.39 CiteScore 2.89
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.489 SNIP 2.607 CiteScore 2.41
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.997 SNIP 2.628 CiteScore 2.45
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.825 SNIP 2.432
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.754 SNIP 1.769
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.692 SNIP 1.818
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.163 SNIP 2.175
Scopus rating (2006): SJR 0.703 SNIP 2.58
Using visual information analysis to explore complex patterns in the activity of designers

The analysis of complex interlinked datasets poses a significant problem for design researchers. This is addressed by proposing an information visualisation method for analysing patterns of design activity, qualitatively and quantitatively, with respect to time. This method visualises the temporality of interrelations between interlinked variables and, as such, can be applied to a range of datasets. By providing a statistical analysis of the networks’ growth the proposed method allows for the modelling of complex patterns of activity. Throughout, the method is demonstrated with respect to a fully realised example of information seeking activity. The core contribution of the proposed method is in supporting the analysis of activity with respect to both macro and micro level temporal interactions between variables.

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management, Swiss Federal Institute of Technology, University of Zagreb
Authors: Cash, P. (Intern), Stanković, T. (Ekstern), Štorga, M. (Ekstern)
Pages: 1-28
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: Design Studies
Volume: 35
Issue number: 1
ISSN (Print): 0142-694X
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.3 SJR 1.229 SNIP 2.638
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.115 SNIP 3.216 CiteScore 2.74
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.283 SNIP 2.752 CiteScore 2.78
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.36 SNIP 2.39 CiteScore 2.89
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
A bibliometric analysis of the DESIGN 2012 conference

Bibliometric analyses play an important role in reflecting on a research field and identifying areas of strength and weakness. This paper builds on recent reflective efforts within the community by presenting a bibliometric analysis of the DESIGN 2012 conference. Over 2700 citations were identified, classified, and grouped in order to describe citation trends by field, type of work and distribution. Based on this multifaceted analysis three key conclusions are drawn. First, the uptake and impact of work from fields other than design is unexpectedly low given the research themes within the design research community. Second, where other fields are cited there is little focus, suggesting that citation and uptake of key principals is generally ineffective and is not then subsequently incorporated into the design research corpus. Finally, we conclude that it is critical that a concerted effort be made by the community as well as individual authors to consider the wider scope of work from related fields, and that this learning is incorporated into the design research corpus in a coherent and focused manner.

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management, University of Zagreb
Authors: Cash, P. (Intern), Skec, S. (Ekstern), Storga, M. (Ekstern)
Pages: 043-052
Publication date: 2013

Host publication information
Title of host publication: Proceedings of the 19th International Conference on Engineering Design (ICED13) : Design For Harmonies
Volume: 2
A comparison of designer activity using core design situations in the laboratory and practice

In 2011 one quarter of all articles published in Design Studies and the Journal of Engineering Design used experimental studies. However, there is little work exploring the relationship between laboratory and practice. This paper addresses this by detailing an analysis of designer activity in three situations commonly studied by design researchers: information seeking, ideation and design review. This comparison is instantiated through three complementary studies: an observational study of practice and two experimental studies. These reveal a range of similarities and differences that are described using a mixed methods approach. Based on this it is concluded that laboratory studies are important research tools and that clear and definable relationships do exist between design activity in practice and the laboratory. © 2013 Elsevier Ltd. All rights reserved.
An analysis of engineers information seeking activity

Information seeking is an important part of the engineering design process. In this context the Internet has become a significant source of information, shaping the way engineers work and interact. Current work has focused on characterizing this activity in terms of total time allocated to different information sources or overall tasks, such as evaluating. However, these approaches do not give an understanding of how engineers information seeking affects their problem solving activity and ultimately their performance in the context of the design process. As such, a new approach is needed to decompose the complexity of information seeking activity in order to more effectively support the evolving needs of engineering designers and design researchers. This paper addresses these issues by using an experimental study and network visualization technique to analyze Internet based information seeking activity and its affect on engineers overall performance during the information seeking/feasibility stage of the design process. The study uses both final year trainee engineers and practicing engineers in order to more fully explore the different modes of information seeking activity. With the study complete, the visual network analysis is used to explore patterns of information seeking and other design activity. Based on the results, three clearly differentiated types of information seeking activity are identified and discussed.

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management, Swiss Federal Institute of Technology, University of Zagreb
Authors: Cash, P. (Intern), Stanković, T. (Ekstern), Štorga, M. (Ekstern)
Number of pages: 10
Pages: DETC2013-12054
Publication date: 2013

Host publication information
Publisher: American Society of Mechanical Engineers
Main Research Area: Technical/natural sciences

Bibliographical note
Information included in the article
Source: dtu
Visually Augmented Analysis of Socio-Technical Networks in Engineering Systems Design Research
In characterizing systems behaviour, complex-systems scientists use tools from a variety of disciplines, including nonlinear
dynamics, information theory, computation theory, evolutionary biology and social network analysis, among others. All of
these topics have been studied for some time, but only fairly recently has the study of networks in general become a major
topic of research in complex engineering systems. The research reported in this paper is discussing how the visually
augmented analysis of complex socio-networks (networks of people and technology engaged in a product/service-system
(PSS) life cycle) may be applied in engineering design research. Network thinking of the kind described in this paper could
be fundamental for developing new and effective techniques for solving the problems in the engineering design research
related to the interpretation of the huge amount of data captured during experiments and observations that are more and
more used as a main research method. Case studies that are presented illustrate also the significance of the network
based research approach in providing insight into ways of improving the design process for complex engineering systems.

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management, Department of
Mechanical Engineering, Engineering Design and Product Development, University of Zagreb, Swiss Federal Institute of
Technology
Authors: Štorga, M. (Ekstern), Stanković, T. (Ekstern), Cash, P. (Intern), McAloone, T. C. (Intern)
Number of pages: 10
Publication date: 2013

Host publication information
Title of host publication: Proceedings of TFTD13
Main Research Area: Technical/natural sciences
Conference: The Future of Transdisciplinary Design (TFTD13), Luxembourg City, Luxembourg, 24/06/2013 - 24/06/2013
Socio-technical networks, Visualisation, OrganicViz, Traceability, Engineering design research, PSS, Innovation, PD
methods

Bibliographical note
Authors: Štorga M., Stanković T., Cash P., McAloone T. C.
Conference: The Future of Transdisciplinary Design (TFTD13)
June 24-25, 2013, Luxembourg city, Luxembourg
Source: dtu
Source-ID: u::7789
Publication: Research - peer-review › Article in proceedings – Annual report year: 2013

Characterising the relationship between practice and laboratory-based studies of designers for critical design situations

General information
State: Published
Organisations: Technical University of Denmark, University of Bath
Authors: Cash, P. (Intern), Culley, S. (Ekstern), Hicks, B. (Ekstern)
Number of pages: 342
Publication date: Jun 2012

Publication information
Publisher: University of Bath
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Cash_PhD_Thesis_2012_.pdf
Source: dtu
Source-ID: u::4962
Publication: Research › Ph.D. thesis – Annual report year: 2012

A comparison of the behaviour of student engineers and professional engineers when designing

General information
State: Published
Organisations: Technical University of Denmark
Authors: Cash, P. (Intern), Hicks, B. (Ekstern), Culley, S. (Ekstern)
A review of state of the art and emerging interaction technologies and their impact on design and designing in the future

Engineering design generates a large quantity of digital and physical information in a wide variety of formats, which can be challenging to manage effectively. With designers increasingly having to consider a product’s entire lifecycle and potentially coordinate the activities of an internationally distributed supply and manufacturing network this is only becoming more difficult. Issues with fragmented information, integrating physical and digital information and productivity all contribute to these difficulties.

Digital information has several distinct management advantages over physical information (such as paper documents) including indexing, searching, editing and replicating. Whilst certain design activities and their associated information can be readily digitised the process of doing so often leads to a loss in the intrinsic value of the original format. Furthermore, performing the same task on a computer can hinder the activity, such as sketching and making personal notes (McAlpine 2010). This suggests that the process of interacting with the information is a key issue that needs to be addressed to help bridge the physical-digital divide.

Interaction technologies have developed substantially over recent years including gesture control with the Kinect and multi-touch screens, driven by increased focus placed on usability by consumer electronics companies. These emerging and state of the art interaction technologies offer the potential to improve the way designers interact with digital information in a number of ways; existing digital interactions can be improved by replacing ill-suited modalities (interaction communication paths: vision, sensory and auditory (Karray et al. 2008)) with more natural and intuitive interfaces; physical interactions can be digitised; information from capturing interaction can be used to generate knowledge about how designers work, for example the divide between digital and physical information can be reduced through for example AR; introduce new ways of working. This paper reviews these technologies giving examples of how they are currently used and how they could be introduced into the design process. The review is not intended to be exhaustive but provides suggestions for further research as to how the interaction technologies could be used to support design in the future.

Comments will be made on the quality of existing interaction modalities and how the “designer-computer interface” is moving towards a bi-directional modality future where users input and output information from computers simultaneously in multiple ways.
Methodological insights from a rigorous small scale design experiment

This paper discusses the methods used to conduct high quality small-scale design experiments. It aims to provide a demonstrator promoting the uptake of more rigorous methods in design research and based on this it aims to specify a body of further work for linking study types and contexts. A small-scale experiment was conducted using methods specifically developed to mitigate four core problem areas identified from review: context, system understanding, methods and controls. The techniques were then critiqued in detail and used to draw several insights for design researchers including the value of control techniques and triangulation of metrics. Finally, the critique is used to specify further research aimed at linking design experimentation and design practice more effectively for design research.
Pragmatic risk assessment approach for product development

The paper proposes a practical assessment approach to estimate duration of the product development process incorporating risk management principles. Risk assessment, as a crucial part of risk management process, is a systematic process for estimating the risk level of previously identified and recognized risks. Currently, the best-known relationship in risk assessment is that risk level equals the product of two factors – likelihood and impact. The proposed approach treats these factors as random variables with triangular probability distributions in order to mitigate biases due to subjective risk estimation. Based on a literature review, the approach considers probability functions assigned to estimated values which together with Monte Carlo simulation avoid fixed single-point estimations and deterministic simulation issues. Relating this kind of assessment with previously established risk mapping on the product development process broadens insight about the influence of risk on the process metrics. Since, risk assessment is still mostly approached in terms of individual reasoning, intuition or previous experience, providing a practical method for assessing risks can enhance and facilitate the usability of risk management principles in product development companies.

The proposed approach is illustrated using an example, which involves an automated car washing facility product development process.

General information
State: Published
Organisations: University of Zagreb, Technical University of Denmark
Authors: Skec, S. (Ekstern), Stankovic, T. (Ekstern), Cash, P. (Intern), Rohde, D. (Ekstern), Marjanovic, D. (Ekstern)
Number of pages: 10
Publication date: 2012

Host publication information
Title of host publication: 9th International workshop on Integrated Product Development
Main Research Area: Technical/natural sciences
Conference: 9th International Conference on Integrated Product Development, Magdeburg, Germany, 05/09/2012 - 05/09/2012
Electronic versions:
IPD2012_paper.docx
Source: dtu
Source-ID: u::4929
Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

The placebo and design research

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management
Authors: Cash, P. (Intern)
Pages: 7-8
Publication date: 2012

Publication information
Pages (from-to): 7-8
Newspaper: The Design Society Newsletter
**Variation in creative behaviour during the later stages of the design process**

This paper presents results from an experiment studying the creative behaviour of 14 engineering designers during a later stage engineering design activity; with the aim of identifying important considerations that must be made when supporting designers in later stage design situations. Data gathered demonstrates the variation in designer behaviour that occurs even when completing identical activities; and differing creative approaches that designers may follow within the later stages of the design process. By understanding the individual behaviour of designers, it will be possible to better inform the use of methods for creative support within the later stage engineering design process.

**General information**

State: Published
Organisations: University of Bath, Technical University of Denmark
Authors: Snider, C. (Ekstern), Cash, P. (Intern), Dekoninck, E. (Ekstern), Culley, S. (Ekstern)
Number of pages: 8
Publication date: 2012

**Host publication information**

Title of host publication: The 2nd International Conference on Design Creativity (ICDC2012)
Main Research Area: Technical/natural sciences
Conference: 2nd International Conference on Design Creativity, Glasgow, United Kingdom, 18/09/2012 - 18/09/2012
Electronic versions:
Variation_in_creative_behaviour.pdf
Source: dtu
Source-ID: u::4927
Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

**A technology selection process for the optimal capture of design information**

There is currently a lack of good practice guidance and commonly accepted standards for empirical design researchers in terms of a) the amount of information to capture and b) the appropriateness (what is captured, and in what form). For example, it is common for researchers to default to video capture. This is often costly to implement and generates large datasets that are difficult and time consuming to analyse. This paper thus attempts to provide practical guidance to the researcher on what technologies are optimal for capturing various common design situations.

**General information**

State: Published
Organisations: University of Bath, Technical University of Denmark
Authors: McAlpine, H. (Ekstern), Cash, P. (Intern), Storton, A. (Ekstern), Culley, S. (Ekstern)
Number of pages: 11
Publication date: 2011

**Host publication information**

Title of host publication: ICoRD'11 - International Conference on Research into Design
Main Research Area: Technical/natural sciences
Conference: 3rd International Conference on Research into Design, Bangalore, Anguilla, 10/01/2011 - 10/01/2011
Electronic versions:
A_Technology_Selection_Process.pdf
Source: dtu
Source-ID: u::4924
Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

**Designer behaviour and activity: An industrial observation method**

**ABSTRACT**

The relationship between laboratory based study and the actual practice of engineering design is very important. For research activity, laboratory based studies have an important role. The problem is the difficulty of relating laboratory study to practice, it is thus important to fully understand this relationship. To address this, an observational method is proposed that focuses on characterizing the
activities and behaviors of designers in practice. The method has been developed to provide rich context, whilst avoiding information overload. The proposed method is then critically discussed with respect to the issues particularly affecting empirical design research, such as contextualization, validity and repeatability. Finally, the paper highlights the potential importance and impact of the method for developing the relationship between practice and laboratory based experiments.

General information
State: Published
Organisations: Technical University of Denmark, Ryerson University, University of Bath
Authors: Cash, P. (Intern), Hicks, B. (Ekstern), Culley, S. (Ekstern), Salustri, F. (Ekstern)
Number of pages: 12
Publication date: 2011

Host publication information
Title of host publication: International Conference on Engineering Design
Main Research Area: Technical/natural sciences
Electronic versions:
Designer_behaviour.pdf
Source: dtu
Source-ID: u::4922
Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

An information requirement strategy for capturing and analysing design activity and behaviour
This paper forms part of the wider ongoing discussion on the issues and possible mitigating techniques present in empirical design research today. Indeed it is widely acknowledged that there are many diverse methods available to the empirical researcher. There are also a number of ways in which these can be compared or controlled. Ultimately, however, all of these techniques aim to develop some form of rigour, validity, replicability and understanding in the wider design research community. This paper brings these discussions together acknowledging their differences but also drawing out a number of fundamental similarities in order to identify and address the key barriers to success. Further it goes on to argue that these fall into an overarching theoretical frame from which common factors and issues can be identified and recognised. This is then used to structure the argument for a broader understanding and reporting of contextual and social factors while also offering a more focused discussion of empirical information gathering and experimental planning. This discussion is intended to act as an overview of the issues an empirical researcher must be aware of and to offer some guidance of how they can start to address these data collection and validity issues as part of their experimental design. The paper is also aimed at bringing together and moving forward the discussion on what constitutes good empirical research, what its influences are and how design research as a community can set about mitigating them. The paper focuses on the research and methodological aspects of design research. In this way design in industry is affected indirectly through improvements in design research quality.

General information
State: Published
Organisations: Technical University of Denmark
Authors: Cash, P. (Intern), Hicks, B. (Ekstern), Culley, S. (Ekstern)
Number of pages: 10
Publication date: 2010

Host publication information
Title of host publication: Design 2010 - International Design Conference
Main Research Area: Technical/natural sciences
Conference: 11th International Design Conference, Cavtat-Dubrovnik, Croatia, 17/05/2010 - 17/05/2010
Electronic versions:
Design_2010_Cash_Hicks_Culley.pdf
Source: dtu
Source-ID: u::4919
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Key themes in design information management
A product development process of some sort can be found in virtually every engineering design organisation. Delivering this process are a number of different organisational functions and stakeholders, including engineers, knowledge and information managers, all of whom provide inputs to – or support for – the process of design itself. This process is usually also supported by an Information Management (IM) system such as Product Lifecycle Management (PLM) or Product Data Management (PDM). In practice, such systems often comprise a collection of information, document management systems and associated procedures. However, IM systems have commonly been developed for one particular purpose, or
to support the needs of a particular stakeholder. Whilst more recent efforts have been directed toward supporting the whole design process from the perspective of multiple stakeholders through, for example, customisable user interfaces, the more fundamental issue of what requirements these various stakeholders have is not well understood. Drawing principally on work conducted in the Innovative Design and Manufacturing Research Centre (IdMRC) at the University of Bath, this paper aims to explore the viewpoints of these stakeholders. The viewpoints are then synthesised to identify five key themes, that together form a set of requirements for an IM system that can support the product development process in an integrated manner. Potentially conflicting aspects of the five themes are highlighted and areas for further work identified.

General information
State: Published
Organisations: University of Bath, Technical University of Denmark
Authors: McAlpine, H. (Ekstern), Cash, P. (Intern), Howard, T. (Ekstern), Arikoglu, E. (Ekstern), Loftus, C. (Ekstern), O’Hare, J. (Ekstern)
Number of pages: 10
Publication date: 2010

Host publication information
Title of host publication: Design 2010 - International Design Conference
Main Research Area: Technical/natural sciences
Conference: 11th International Design Conference, Cavtat-Dubrivnik, Croatia, 17/05/2010 - 17/05/2010
Electronic versions:
McAlpine_et_al_Key_Themes_in_Design.Information_Management.pdf
Source: dtu
Source-ID: u::4920
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

The challenges facing ethnographic design research: A proposed methodological solution
Central to improving and maintaining high levels of performance in emerging ethnographic design research is a fundamental requirement to address some of the problems associated with the subject. In particular seven core issues are identified and include the complexity of test development, variability of methods, resource intensiveness, subjectivity, comparability, common metrics and industrial acceptance. To address these problems this paper describes a structured methodological approach in which three main areas are proposed, the modularisation of the research process, the standardisation of the dataset and the stratification of the research context. The paper then examines the fundamental requirements of this scheme and how these relate to a Design Observatory approach. Following this, the proposed solution is related back to the initial problem set and potential issues are discussed. Finally the paper concludes with a possible scheme for the implementation process required for such a solution and the roles to be played by a Design Observatory approach.

General information
State: Published
Organisations: Department of Management Engineering, Technology and Innovation Management, University of Bath
Authors: Cash, P. (Intern), Hicks, B. (Ekstern), Culley, S. (Ekstern)
Number of pages: 12
Publication date: 2009

Host publication information
Title of host publication: Proceedings of International Conference on Engineering Design, ICED’09
Main Research Area: Technical/natural sciences
Electronic versions:
The_challenges_facing.pdf
Source: dtu
Source-ID: u::4918
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Projects:

From analysis to intervention to real world impact in behaviour design
Department of Management Engineering
Period: 01/11/2017 → 31/10/2020
Number of participants: 3
Phd Student:
Nielsen, Camilla Kirstine Elisabeth (Intern)
Supervisor: Daalhuizen, Jaap (Ekstern)
Main Supervisor: Cash, Philip (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Creativity workshop facilitation in the business context
Department of Management Engineering
Period: 15/09/2016 → 14/09/2019
Number of participants: 3
Phd Student: Wróbel, Agata Ewa (Intern)
Supervisor: Lomberg, Carina (Intern)
Main Supervisor: Cash, Philip (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Uncertainty Perception in Product Innovation Projects
Department of Management Engineering
Period: 15/10/2015 → 14/10/2018
Number of participants: 2
Phd Student: Lasso, Sarah Venturim (Intern)
Main Supervisor: Cash, Philip (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Science Without Borders, Brasi
Project: PhD

Analysis of the role of designers self-identity and behavior on design teams for performance improvement
Department of Management Engineering
Period: 01/02/2015 → 31/01/2018
Number of participants: 3
Phd Student: Kunrath, Kamila (Intern)
Supervisor: Li-Ying, Jason (Intern)
Main Supervisor: Cash, Philip (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Science Without Borders, Brasi
Project: PhD
Tools for global innovation and product development
A four year project to develop tools to support: performance measurements in global product development and support decision making, and model for join innovation.

Department of Management Engineering
Technology and Innovation Management

Production and Service Management
Period: 01/10/2012 → 30/04/2017
Number of participants: 5
Product development, Performance indicators, Decision making, Joint Innovation
Number of related Ph.D. students: 2
Project participant:
Jensen, Ole Kjeldal (Intern)
Cash, Philip (Intern)
Maier, Anja (Intern)
Phd Student:
Taylor, Thomas Paul (Intern)
Project Manager, academic:
Ahmed-Kristensen, Saeema (Intern)

Financing sources
Source: Public research programme (public)
Name of research programme: Industriens fond
Amount: 6,000,000.00 Danish Kroner
Year of approval: 2012

Relations
Related projects:
Global Product Development
Activities:
Global Product Development Industry Workshop
Project