



Research methods in engineering design: a synthesis of recent studies using a systematic literature review

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Abstract

The relation between scientific research and engineering design is fraught with controversy. While the number of academic PhD programs on design grows, because the discipline is in its infancy, there is no consolidated method for systematically approaching the generation of knowledge in this domain. This paper reviews recently published papers from four top-ranked journals in engineering design to analyse the research methods that are frequently used. The research questions consider the aim and contributions of the papers, as well as which experimental design and which sources of data are being used. Frequency tables show the high variety of approaches and aims of the papers, combining both qualitative and quantitative empirical approaches and analytical methods. Most of the papers focus on methodological concerns or on delving into a particular aspect of the design process. Data collection methods are also diverse without a clear relation between the type of method and the objective or strategy of the research. This paper aims to act as a valuable resource for academics, providing definitions related to research methods and referencing examples, and for researchers, shedding light on some of the trends and challenges for current research in the domain of engineering design.

Keywords Research methodologies in engineering design · Engineering design and evaluation

1 Introduction

Doctoral studies have a long tradition in higher education systems (Bogle 2018). Doctoral studies are highly relevant because they are considered as a key for technical development and industrial excellence in developed countries. Normally, a PhD diploma is compulsory for pursuing and it is highly valued for getting involved in research projects in companies. The goal of doctoral programs is to provide postgraduates with competences for the generation of knowledge in a given domain. The means to generate knowledge depends on the area, being research methods and techniques

potentially different, and evolving in parallel with the development of the domain. In young domains such as Engineering Design, the discussion about which research procedures and paradigms should be employed is still open.

Simon (1996), in his book *The Science of Design*, defined design as a search for an optimum in a space of alternatives that take into account the specifications and restrictions of a given problem. Hatchuel (2001) highlighted limitations of Simon's position discussing that designing cannot be reduced to taking decisions among a bounded set because the number of concepts related to the problem and the possible number of decisions to be taken could be expandable and uncountable, not only due to human creativity but also to social interaction. (Subrahmanian et al. 2020) place Simon and Hatchuel's approaches in a historical timeline that describes different models of how designing is understood, evidencing the challenges for research design as a discipline that defines a common language that includes the impact of context and users in designing, in addition to the problems. Probably due to the youth of design as a research discipline, or due to its socio-technical nature, it does not yet have a consolidated research methods and techniques. Blessing and

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