

Mini summary of the PhD thesis

What Leonardo could mean to us now.

Systematic variation 21st century style, applied to large-scale societal issues

The problem: Design challenges are becoming increasingly complex, amongst others because real life is getting more complex. Society is more interconnected than before and most problems occur in a variety of -quickly changing- shapes and forms, i.e. in different contexts. These contexts pose different requirements and often have interdependencies as well. How can design engineers respond to this rise in diversity of requirements and the likely interdependencies?

To reduce the complexity and increased diversity the common response is simplification, e.g., choosing one context as scope of the design task. In a highly interconnected society this no longer suffices. The initially optimal solution creates a path dependency and lock-in that delays or hinders achieving impact on a large scale beyond the initial context.

Research focus: The thesis focuses on the question what evolution in design engineering might be possible to address this problem. As a starting point, the oldest design characteristic, i.e. systematic variation, as pioneered by Leonardo da Vinci, is given a contemporary twist. It is suggested to be used before the design task is set in order to ensure *multi-contextual perspectives* of a large-scale issue. To provide further focus for this research, it revolves around an actual approach that does just that, called Context Variation by Design (CVD), and is mostly applied to basic quality-of-life issues. The research primarily has a design engineering angle, and additionally includes considerations and consequences for management and education. Evolution of design engineering alone, even with management considerations, cannot address the entire problem but might offer a contribution.

Research approach: This thesis represents exploratory, therefore inductive, research. The extensive literature research resulted in ten theoretically backed *propositions* as key component of the thesis. Out of 23 available real-life situations to choose from, mostly MSc-level graduation, course and group assignments, seven were selected based on direct access to rich, high quality information. These cases were analysed and the main results were expressed as *empirical findings*, in relation to the ten propositions, 41 in total. Furthermore, three key defined constructs had been identified to explore more in depth: context, richness in the design space and adaptive architectures.

Main results and conclusions: The analysis of the patterns of the empirical research reveals various signs that a *design engineering approach* that uses *systematic variation before the design task is set*, can deliver high quality, potentially superior results when dealing with large-scale (quality-of-life) issues. This was true in particular for cases where students executed full assignments, as opposed to short ones. Because the design result, i.e. an *informed* adaptive architecture, incorporated requirements from a variety of contexts, the additional effort to scale to these contexts is much smaller from a design engineering perspective. Such signs cannot be considered as (conclusive) evidence, and it was not the intention of this inductive thesis to deliver such results. More light has been shed on particular framings that might be conducive, and the specific interpretation of the key constructs, all resulting in a version 2.0 of CVD. The results can be elaborated upon in next steps.

Next steps: The main suggested next steps including 'bite size' titles: "*Revelling in richness*" (further explore richness as a defined construct in the design space), "*Going for Gold*" (engage in long term commitments and broader partnerships to investigate actual multi-contextual implementation), "*C'est le ton qui fait la musique*" (explicitly verify framings that resonate with managers and others) and "*Leave no Leonardo behind*" (explore how using a multi-contextual approach can be used in education to boost the aptitude of design engineers-to-be).