An Exploration of Prototyping Strategies and Frameworks through a Systematic Literature Review

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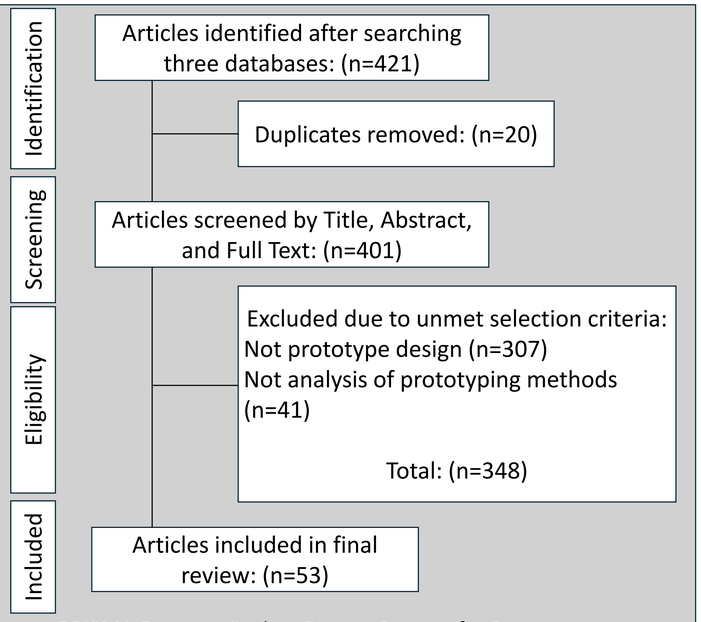
Abstract

Prototyping is an integral component of the engineering design process, serving as a bridge between conceptualization and realization. This systematic literature review examines existing published literature to understand how the broader engineering design community approaches the prototyping process through defined and formalized strategies and frameworks. To achieve this, we conducted a comprehensive search, identifying 402 unique papers across 11 esteemed journals using crafted search strings. Applying inclusion criteria, we refined the selection to 53 papers that demonstrated relevancy to prototyping strategies and practices. Currently, we are analyzing the selected literature, focusing on identifying connections and overarching themes and topics that emerge across the studies. The anticipated outcome is the development of a taxonomy that not only assists designers during the embodiment stage of design but also integrates a systematic evaluation of critical factors. This taxonomy aims to guide designers in selecting the most effective prototyping strategies tailored to specific project contexts. The scarcity of aggregated research on prototyping and its approaches highlights a significant gap in the literature. Our research seeks to fill this gap of knowledge in this domain, thereby providing a valuable framework that synthesizes and clarifies prototyping strategies, contributing to both academic scholarship and practical application in the field of engineering design.

PRISMA Diagram



PRISMA Diagram Outline Review Process for Papers

Methodology

This research employs a structured process for literature review to discover, evaluate, and examine pertinent studies. Opting for a systematized review allows for a comprehensive survey of diverse viewpoints. The endeavor gathered 421 articles from three distinct databases, out of which 53 were chosen for an in-depth full-text analysis.

To gather the 421 articles from three distinct databases a search string was identified. The initial string is derived from the authors' understanding of the research question and was adjusted as the search progressed. Note that the search string slightly differs from engine to engine for search syntax.

AB(prototyp* AND (iterative OR parallel OR "one-shot" OR "high-fidelity" OR "low-fidelity" OR physical OR incremental OR hybrid OR framework OR approach* OR structure OR organization OR categorization))

Database	Journals	# of Papers
ProQuest	Design Science Journal of Engineering Design Journal of Engineering Education Research in Engineering Design	98
EagleSearch	Design Studies Artificial Intelligence for Engineering Design Analysis & Manufacturing Journal of Computer and Information Science in Engineering International Journal of Design Creativity and Innovation Journal of Mechanical Design CoDesign	301
IJEE	International Journal of Engineering Education	21

Selection Criteria	Justification
Peer-Reviewed Articles and Academic Theses/Dissertations	Ensures academic integrity by focusing on rigorously reviewed research, providing in-depth insights into prototyping methods.
Focus on Prototyping in Engineering Design	Directly relevant to our study, concentrating on specific prototyping techniques within engineering.
Comparative Analysis of Prototyping Methods	Emphasizes studies comparing prototyping strategies, offering valuable perspectives on their effectiveness in engineering design.
The paper is published in English	Simplifies review process by eliminating language barriers, ensuring consistency in literature analysis.

The screening process is shown in the PRISMA diagram. After searching the databases, a total of 421 papers were collected from the three databases. After removing 20 duplicates, there were a total of 401 unique papers. Following the review for exclusion criteria, 53 papers were selected for analysis.

Next Steps

The next steps for this systematic literature review on prototyping strategies and frameworks are the following:

- **Taxonomy Development:** Develop the taxonomy of prototyping strategies through analysis and validation.
- **Future Research and Practical Guidelines:** Outline future research opportunities based on identified gaps and develop a framework to assist practitioners in selecting and applying effective prototyping strategies.