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Generative design as a means of effective communication in multidisciplinary teams: a systematic review

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ABSTRACT: This systematic review examines how generative design enhances communication and collaboration in multidisciplinary engineering teams. Using the PRISMA framework and CASP evaluation program, we analyzed 1,105 sources to assess its role in improving workflows, facilitating collaboration, and reducing communication gaps through CAD, algorithmic modeling, and AI-driven platforms. The findings show that generative design supports teamwork, optimizes design processes, and strengthens interdisciplinary collaboration. While widely used in architecture, aerospace, and automotive industries, its adoption in product design remains limited, presenting opportunities for further research and innovation. These insights contribute to a better understanding of how generative design can bridge communication barriers in engineering projects.

KEYWORDS: generative design, computer aided design (CAD), design engineering, communication

1. Introduction

The collaboration of individuals with diverse skills and knowledge has driven the development of industrialized society. Technological advancements require interdisciplinary teams to address specific challenges by combining expertise from different fields. (Onatayo, 2024) Among the most relevant disciplines are design and engineering—two essential yet distinct areas that, despite their complementary nature, are characterized by opposing approaches and methods, often leading to communication failures. Designers typically rely on creative processes and subjective tools such as intuition. (Cross, 2021). In contrast, engineers focus on quantifying and measuring all possible aspects, prioritizing precision and objectivity. (Eddington et al., 2020) This paper presents a systematic qualitative review of the use of generative design to enhance communication within multidisciplinary teams in engineering design projects. The review was conducted using the PRISMA methodology for systematic reviews and validated through the CASP (Critical Appraisal Checklists Program) for the critical evaluation of results. Its objective is to provide a replicable, concise, and reliable analysis of existing applications related to the proposed research question while also identifying unexplored areas that could lead to the generation of new technological knowledge in the design of engineering projects. This study aims to explore whether generative design can enhance communication within multidisciplinary engineering teams by serving as a collaborative tool that bridges the gap between the creative approaches of designers and the analytical focus of engineers.

1.1. Development areas for generative design

Generative design can be defined as a combination of generative and exploratory research processes aimed at identifying design challenges through an evolutionary approach (Arzate, 2019). This approach relies on exploration and topology optimization algorithms, enabling the generation of design iterations

constrained by input limitations. The goal is to improve factors such as weight limits, material strength, production costs, and environmental impact of the designed components (Arzate, 2019).
The versatility of generative design allows it to be applied across various disciplines that require collaboration between designers and specialists from other fields. This methodology is frequently used in architecture, aerospace, and automotive industries (Ismayilov, 2024; Soori & Jough, 2024). However, areas such as product design have yet to fully develop applications for generative design, presenting research gaps that offer significant opportunities for future technological innovations and studies aimed at expanding the scope of generative design.

1.2. Generative design and interdisciplinary communication

While generative design is primarily defined as a tool for automated computer-aided design, recent research has begun to examine its impact on communication within multidisciplinary teams (Arzate, 2019; Chew et al., 2024; Klooker & Hólzle, 2024; Menold et al., 2024). The application of generative design methods not only introduces innovations in design spaces but also necessitates the evaluation of three key structures for developing collaborative innovation teams. These structures include the work environment and organizational frameworks, design approaches focused on collaboration, and the adoption of a collaborative mindset (Klooker & Hólzle, 2024). Analyzing these factors in engineering projects allows for the identification of opportunities to optimize technological innovation while addressing organizational challenges commonly encountered in multidisciplinary projects.

2. Methods

This study is a qualitative systematic review that utilizes a dataset of 1,105 literary sources collected with the Publish or Perish tool—a software designed for bibliometric citation analysis. Records were gathered from Google Scholar, CrossRef, and Semantic Scholar due to their broad accessibility and capability to perform keyword searches based on natural language queries and Boolean operations. These features facilitated the development of relevant, carefully proofread keywords derived from a preliminary analysis of the research question. The systematic review was conducted by the lead researcher and subsequently cross-validated by three secondary reviewers using CASP guidelines. The search results were recorded, discussed, and analyzed using the HubMeta platform, which provided tools to identify patterns, correlations, and the most relevant sources. This comprehensive process, coupled with rigorous cross-validation, ensures both the thoroughness and validity of the findings. The results are presented in a PRISMA flow diagram for systematic reviews and in a qualitative table (Table 2) detailing the eligibility criteria used for the final screening.

2.1. Search terms

The search and eligibility criteria were defined using the PICOSt framework (Participants, Interventions, Comparators, Outcomes, and Settings) to derive the research question that served as the basis for the selected keywords. This approach allowed for the clear definition of keywords and selection boundaries necessary to construct a robust database. Moreover, using this model ensured transparency and coherence in the methodological process, thereby facilitating replicability. The criteria were designed to be inclusive, ensuring that all relevant sources were considered. A set of keywords—including "generative design," "interdisciplinary communication," and "multidisciplinary engineering teams"—was employed to construct code-based queries in Publish or Perish. These keywords were adapted to the specific search criteria of each database using artificial intelligence, thereby ensuring the accuracy and relevance of the results obtained (Table 2).

Table 1. PICOSt model criteria

PICOSt Model elegibility criteria	
Population	Multidisciplinary teams involved in engineering design projects. Projects unrelated to engineering and non-generative design approaches were excluded.
Intervention	Interventions utilizing generative design tools and methods to facilitate processes and cross-disciplinary communication in multidisciplinary teams were included. Interventions involving non-communicative design processes were cluded.

Table 1. Continued.

PICOSt Model elegibility criteria	
Comparators	Studies that included facilitation methods for design, such as generative design, algorithmic design, topological optimization, and AI-based design. Traditional design approaches were excluded.
Results	Primary outcomes included improved communication, optimized collaboration, and increased project efficiency, particularly within multidisciplinary teams. Results unrelated to engineering projects, absence of generative design methods, biased communication, and teams without a cross-disciplinary focus were excluded.
Context	Open-access studies conducted in interdisciplinary engineering project environments were included.

Table 2. Search prompts for different databases

Google Scholar	("generative design" OR "CAD design automation" OR "algorithmic design") AND ("effective communication" OR collaboration OR "team communication") AND ("multidisciplinary teams" OR "interdisciplinary teams" OR "cross-functional teams" AND "engineering")
CrossRef	title: "generative design" OR title: "CAD design automation" "abstract: "effective communication" OR abstract: "technical collaboration" ("multidisciplinary engineering teams" OR "cross-functional engineering teams") from-pub-date:2019 to-pub-date:2024
Semantic Scholar	("generative design" OR "CAD design automation" OR "algorithmic design") AND ("effective communication" OR collaboration OR "team communication") AND ("multidisciplinary teams" OR "interdisciplinary teams" OR "cross-functional teams") AND "engineering"

2.2. Screening

Once the maximum number of sources allowed by Publish or Perish was collected for each registry (CrossRef: 1,000; Google Scholar: 100; Semantic Scholar: 5), citations from Semantic Scholar were excluded due to their lack of relevance. Meanwhile, citations from CrossRef and Google Scholar were exported in Bib format and integrated into a HubMeta project for further analysis.

The evaluation process consisted of three stages. First, the lead researcher reviewed titles, abstracts, and availability, with verification by the secondary reviewers. Next, a full-text analysis was conducted on articles that met the PICOSt criteria, excluding those that did not meet the requirements for open access, the use of generative design, or the presence of multidisciplinary teams in engineering projects. Conference articles were also excluded, as they typically undergo limited peer review due to time constraints before submission deadlines (Scherer & Saldanha, 2019).

Finally, a qualitative assessment was conducted on the sources that met all inclusion criteria. This analysis, structured using the CASP (Critical Appraisal Checklists Program) framework, is presented in a comparative table (Table 3). The CASP framework ensured a rigorous evaluation of source quality. The table summarizes the authors, methodologies, applications of generative design, relevant fields of study, years of publication, and the primary communication medium or tool associated with each source.

3. Results

The search conducted for this review identified 32 information sources detailing various engineering projects employing generative design as a tool. These sources meet the criteria for validity, accessibility, use, and reference to generative design tools and methods, as well as effective interdisciplinary collaboration, as outlined in the corresponding PICOSt model (Table 1).

While the PICOSt model serves as a guide to establish the search criteria used in this study, the collected information encompasses a wide range of methods, communication approaches, and applications of generative design. For this reason, the results are presented in a descriptive table tailored to the review's objectives, based on the risk of bias assessment questionnaires for systematic reviews and qualitative studies from the CASP (Critical Appraisal Checklists Program).
The table lists the authors, year of publication, methods, specific uses of generative design, the field of knowledge to which each source belongs, and the primary communication medium or tool employed in each project. This structure provides a comprehensive perspective on the role of generative design in contemporary engineering design, identifying recurring application areas and revealing research gaps that could present opportunities for innovation. Based on the reviewed studies, these findings can be grouped into three primary themes: technological tools for collaboration, methodological approaches for design iteration, and strategies for optimizing interdisciplinary workflows.

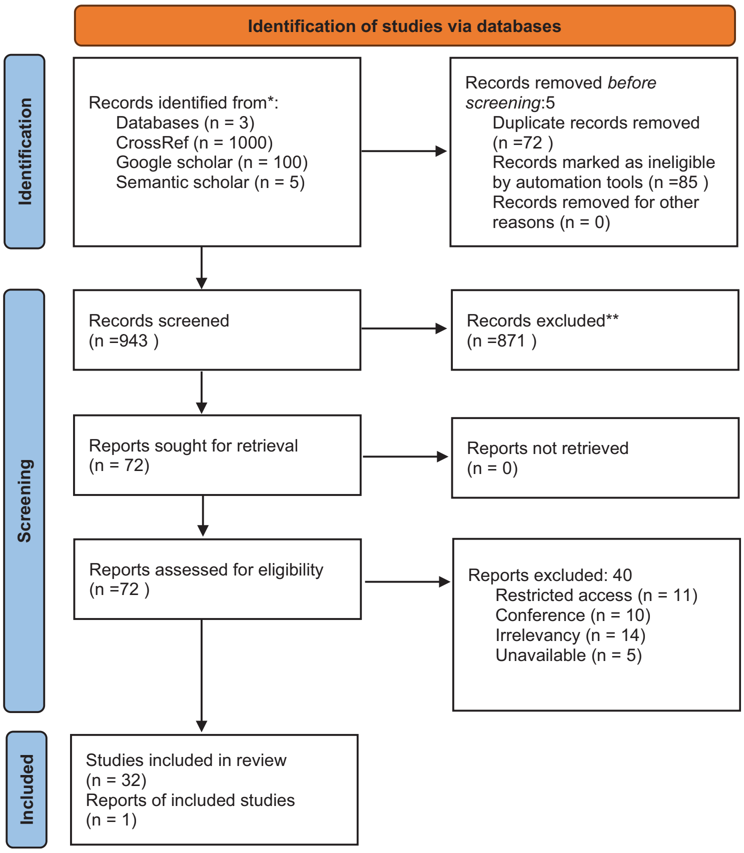

Figure 1. PRISMA flow diagram for the use of generative design as a means of communication in multidisciplinary engineering projects

Table 3. Areas of application for generative design across the papers included in the review

The reviewed studies can be categorized into three main themes: collaborative technological tools, design iteration methodological approaches, and strategies for enhancing interdisciplinary workflows.

Author	Year of publication	Method	Application of GD	Main themes	Cross-communication means
Farrugia et al.	2023	Thematic analysis and literature review	Decision-making regarding materials, design concepts, optimization of functional and simulation aspects	Strategies for Enhancing Interdisciplinary Workflow	Inductive coding
Lu et al.	2024	Generative AI-based optimization of design processes	Automation of specific design tasks in automotive design	Collaborative Technological Tools	Generative AI platforms

Table 3. Continued.

Author	Year of publication	Method	Application of GD	Main themes	Cross-communication means
Klooker et al.	2024	Longitudinal and retrospective data collection	Development of a dynamic generative design model for collaborative innovation spaces	Strategies for Enhancing Interdisciplinary Workflow	Generative design methods
Ogundipe et al.	2024	Use of natural language models and generative design in product design	Automation of design iterations	Design Iteration Methodological Approaches	AI-driven market and design optimization
Ghorbani	2023	Qualitative research	Creation of design iterations	Collaborative Technological Tools	AI resources
Gulanova Et al.	2021	Generative design methods	Generative design applied to surface-based components	Design Iteration Methodological Approaches	Generative design methods
Ismayilov	2024	Qualitative research	Generation of design iterations	Collaborative Technological Tools	AI resources
Soori Et al.	2024	Systematic review	Generation of steel moment frame structures	Design Iteration Methodological Approaches	generative design, topology optimization, and AI
Ploennigs et al.	2024	Idealized integrated workflow	Comparison with image-based diffusion models	Strategies for Enhancing Interdisciplinary Workflow	Generative AI
Spicek et al.	2023	Case study evaluation	Structure optimization for additive manufacturing	Design Iteration Methodological Approaches	Comprehensive interview
O'Hara	2021	Concurrent engineering	Design space exploration	Strategies for Enhancing Interdisciplinary Workflow	Concurrent Generative Engineering Tooling (COGENT)
Song et al.	2022	Human subject experiment	Drone design iterations	Design Iteration Methodological Approaches	Text-only channels
Miao et al.	2024	Diamond of thought	Combination with Large Language Models for wearable design iterations	Design Iteration Methodological Approaches	Large Language Models
Moshood et al.	2024	Qualitative review	Architectural exploration	Metaverse in architecture	Real-time stakeholders
Coutts et al.	2024	Design methods	Realization and acceleration of the design process	Strategies for Enhancing Interdisciplinary Workflow	Social media
Onatayo et al.	2024	BIM implementation	Facilitation of data-driven design	Collaborative Technological Tools	GPT-4
Jianjun et al.	2024	Generative material design method	Material discovery	Design Iteration Methodological Approaches	Simulation codes
Ghobakhloo et al.	2024	Interpretive structural Modelling (ISM)	Cost reduction	Collaborative Technological Tools	Generative AI systems
Chew et al.	2024	Generative design methods	Enhancement of design quality and workflows	Design Iteration Methodological Approaches	Generative design methods
Kumar et al.	2024	Case study	Progressive die design	Design Iteration Methodological Approaches	Generative design
Khan et al.	2019	Generative design methods	Building of efficient parametric structures	Design Iteration Methodological Approaches	Teaching-Learning-Based Optimization
Rane et al.	2023	Systematic review	Broadening design spaces	Collaborative Technological Tools	ChatGPT
Liu et al.	2024	DIKW (Data, Information, Knowledge, Wisdom) pyramid	Design Customization	Collaborative Technological Tools	Data Science
Bender	2020	Non-linear and non-positivistic approach	Building performance	Collaborative Technological Tools	Dual communication flow

The reviewed studies can be categorized into three main themes: collaborative technological tools, design iteration methodological approaches, and strategies for enhancing interdisciplinary workflows.

Table 3. Continued.

The reviewed studies can be categorized into three main themes: collaborative technological tools, design iteration methodological approaches, and strategies for enhancing interdisciplinary workflows.					
Author	**Year of publication**	**Method**	**Application of GD**	**Main themes**	**Cross-communication means**
Kun-Ying et al.	2024	Automated CAD modelling	Generate CAD designs without the need to define design parameters or constraints.	Design Iteration Methodological Approaches	Generative pre-trained transformer
Pestana	2024	Generative design and building information modeling methods	Optimizing early Mechanical, Electrical, and Plumbing in residential actual state	Strategies for Enhancing Interdisciplinary Workflow	Interviews with experts
Marrone	2023	Mixed methods	Broadening of machine learning methods and simulations	Collaborative Technological Tools	AI systems
Bucher et al.	2023	Generative design methods	Broaden the range of design representations used in engineering	Design Iteration Methodological Approaches	Generative design
Cascini et al.	2022	Structure–Behavior–Function (SBF) modeling	Design criteria processing	Strategies for Enhancing Interdisciplinary Workflow	Cross-pollination
Chung	2023	generative design praxis matrix	Design leverage for designers and non-designers	Strategies for Enhancing Interdisciplinary Workflow	Presentation software
Arzate	2019	3D printed design and co-design workshop	Collective creation process	Strategies for Enhancing Interdisciplinary Workflow	Co-design
Menold et al.	2024	Mixed-methods	Effective collaboration through virtual technologies	Collaborative Technological Tools	Collaborative design platforms

4. Discussion

4.1. Review findings

The studies reviewed in this paper were categorized into three key areas based on their contributions to the application of generative design in multidisciplinary teams. The first category, "Collaborative Technological Tools," was the focus of 10 papers, accounting for 30.3% of the studies reviewed. The second category, "Design Iteration Methodological Approaches," received the most attention, with 12 papers (36.4%) addressing various methods for iterative design in generative design processes. Lastly, the third category, "Strategies for Enhancing Interdisciplinary Workflow," represented 11 papers, or 33.3%, and highlighted approaches aimed at improving collaboration within multidisciplinary teams.

The reviewed studies also spanned a variety of fields, with 3 papers (9.1%) focused on product design, 6 (18.2%) addressing architecture, and 4 (12.1%) dedicated to manufacturing. This classification helps synthesize the literature by identifying overarching themes, offering valuable insight into current trends and research gaps in generative design applications.

4.2. Review limitations

Based on the categorization of the reviewed studies and the research findings, this systematic review was conducted with a systems-oriented approach focusing on collaborative technological tools, design iteration methodologies, and strategies for enhancing interdisciplinary workflows. The aim was to minimize potential biases stemming from personal interpretation while analyzing the application of generative design in multidisciplinary teams. However, certain limitations are acknowledged, such as the time-consuming nature of the review process, the restriction to freely accessible sources, and the exclusion of conference papers, which may have led to the omission of some relevant information. Additionally, there is limited research on generative design as a tool specifically aimed at improving communication within multidisciplinary teams, which represents an important area for further exploration. Moreover, the novelty of applying generative design to product design remains an emerging field with significant potential for innovation. To improve the comprehensiveness of future research, it is recommended that these filters be broadened. Expanding the scope of sources could further reduce biases and enhance the overall integrity and applicability of the results. Further studies should also explore how generative design can serve as an effective communication tool in engineering and other sectors, particularly in areas where its application has not yet been fully developed, such as product design.

5. Conclusion

In conclusion, this systematic review highlights the potential of generative design as a tool for optimizing engineering design and improving communication within multidisciplinary teams. By processing requirements through optimization algorithms, generative design may help bridge communication gaps between designers and engineers, reducing biases and conflicts. However, the findings also underscore the need for further research to explore these preliminary observations and their impact on communication between disciplines.

The revisions made throughout this paper have strengthened the connection between generative design and enhanced communication. These modifications emphasize generative design's role in supporting collaboration, iteration methods, and optimizing interdisciplinary workflows. While its application has been well-explored in fields such as architecture, aerospace, and manufacturing, its use in product design remains underdeveloped, presenting significant opportunities for future research. Expanding its application in these areas could improve organizational conditions and lead to more efficient and innovative project development.

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