

# Effects of new ways of working in product development - a systematic evaluation in an engineering simulator

Katharina Ritzer , , Rahil Mithani and Nikola Bursac 

*Hamburg University of Technology, Germany*

 [katharina.ritzer@tuhh.de](mailto:katharina.ritzer@tuhh.de)

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**ABSTRACT:** This study explores the impact of new work practices on product development in an Engineering Simulator by comparing traditional practices with new ways of working in a compressed product development process. By introducing flexibility, digital tools, and autonomy, the study highlights improvements in individual productivity and innovation. For example, teams employing new work practices developed their first prototypes 30% faster than control groups. However, challenges in communication and team dynamics emerge, underscoring the need for structured support systems. The findings further suggest that while these modern practices foster creativity and efficiency, successful implementation at the organizational level requires balancing autonomy with clear guidelines and effective management. This study provides actionable insights for adapting new work methods to engineering environments.

**KEYWORDS:** new ways of working, engineering simulator, workspaces for design, collaborative design, teamwork

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## 1. Introduction

Product development landscape has evolved significantly from its traditional roots, integrating diverse disciplines and stakeholders to meet the growing complexity of industry needs. Roozenburg and Eekels (1995) highlighted the necessity for a systematic approach in product design and development, a notion further developed by Lindemann (2016) through his discussions on concurrent and simultaneous engineering practices aimed at optimizing development activities. However, traditional product development practices are increasingly seen as inadequate due to their inability to adapt to rapid transformations in market demands and technological advancements. Early on, Anthony and McKay (1992) noted that methods struggle to keep pace with the changes in industry dynamics and customer needs. This inadequacy is compounded by evolving workforce expectations, new working patterns, and significant shifts such as the gig economy, which are reshaping the landscape of work (Francisco 2015). The COVID-19 pandemic accelerated these shifts, making the integration of digital technologies and remote work essential (Gerdeman 2021). In response to these challenges, there is a growing shift towards new ways of working that emphasize flexibility, digital integration, and innovation. These modern practices are becoming essential as industries continuously reevaluate and adapt their strategies to enhance productivity and employee well-being. This research aims to scrutinize and validate the effectiveness of these new ways of working within an Engineering Simulator (Manfred Hofelich et al. 2021) that closely mirrors real-world product development environment. By examining their impact on product development processes and comparing these to traditional practices, the study seeks to identify the key factors that facilitate or hinder the successful implementation of innovative work strategies in product development. This exploration is intended to provide empirical insights that can aid practical implementation strategies and contribute to the evolution of work practices in modern industrial settings.

## 2. State of the art

### 2.1. New ways of working in engineering

New ways of working have become increasingly relevant in modern engineering contexts, driven by the transformational shifts brought about by the industrial revolution and digitization. These changes have reshaped operational needs and expectations across both individual and organizational levels, challenging traditional workplace management practices and necessitating the exploration of more effective work methodologies. Originating in the 1970s, the term “New Work” was coined to address the changing nature of work in a rapidly evolving society, aiming to create a more human-centered approach to employment. As described by Hofmann et al. (2019), and further elaborated by Schnell and Schnell (2021), the idea emerged from the visionary insights of Austro-American social philosopher Frithjof Bergmann. Confronted with the automation-driven job losses in industries like General Motors, Bergmann proposed a revolutionary model where employees would retain their jobs but work only six months per year (Schnell and Schnell 2021). His vision expanded to suggest that individuals split their work into three parts: traditional employment, work they are genuinely passionate about, and high-tech self-production. This framework not only promoted self-determination, freedom, and community participation but also aimed to make work not just a means to an end but a fulfilling aspect of life that caters to individual needs and desires. Devivere (2018) highlights that new ways of working address the several challenges, including the integration and management of innovative technologies, transformation in goods production, and establishing new work modalities that fulfill individual preferences and facilitate coordination within communal frameworks. The evolution of these practices also coincides with the rise of digital and technological advancements, as noted by Jurian. During the same period that Bergmann developed his ideas, other visionaries like Nilles, Drucker, and Toffler were conceptualizing mobile offices and flexible workspaces, largely in response to shifting workforce demands such as the desire for part-time work and flexible working hours (van Meel 2011). These adaptations aim to harness digital tools to achieve greater work flexibility, altering leadership principles to accommodate a more fluid, value-based approach to work. Today, new ways of working are often embraced by dynamic, less structured organizations and pose questions about their applicability in traditional, larger firms. The dual approach of New Work-enhancing productivity through technological empowerment and focusing on personal and professional development, champions a culture that values both efficiency and individual well-being. As these practices continue to evolve, they unite various initiatives aiming to prepare work environments for future challenges, making the continuous exploration and adaptation of these practices a pertinent area of research (Teichert et al. 2023). Recent research further explores these challenges in the context of hybrid work and digital collaboration tools. Studies on hybrid work models indicate that flexible work arrangements enhance job execution, teamwork, and employee satisfaction when supported by effective communication strategies (Santillan et al. 2023). Additionally, digital collaboration tools and AI-driven assistance are reshaping teamwork dynamics by improving efficiency, automating repetitive tasks, and influencing decision-making processes (Ulfsnes et al. 2024). However, these technologies also introduce new complexities, such as the need for structured knowledge-sharing frameworks to prevent fragmented communication and information silos (Jackson et al. 2022). Moreover, AI-assisted teamwork in engineering environments presents both opportunities and challenges. AI tools have been shown to enhance team productivity and problem-solving capabilities, but their impact on human collaboration and trust varies depending on implementation strategies (Xu et al. 2023). In summary, new ways of working not only reflect a shift towards more adaptive, fulfilling, and technologically integrated work environments but also embody a broader movement towards redefining the role of work (Kingma 2019) in society, with ongoing implications for both policy and practice in the face of future industrial transformations.

New ways of working are increasingly being recognized for their potential to enhance productivity across various industries. For instance, BorgWarner Ludwigsburg GmbH implemented digital personnel deployment planning, which significantly improved the efficiency of shift scheduling and provided greater flexibility for employees, leading to higher overall productivity (Hofmann et al. 2019). Similarly, an experiment conducted by the BMW group introduced job rotation, resulting in employees gaining a deeper understanding of company processes and continuous growth in their skill sets (Julich 2000). This strategic approach not only enhanced organizational flexibility but also improved the quality of work and productivity at BMW. Further examples of companies adopting new work practices include the introduction of co-working areas at Deutsche Bahn, life situation-based flexible working at AOK

Baden-Württemberg, trust-based working hours at Kärcher SE and Co. KG, consistent process organization at Roto, and cross-functional project initiatives at DKB Berlin (Helmold 2021; Hofmann et al. 2019). These initiatives highlight the broad applicability and effectiveness of new work practices in enhancing operational efficiencies and fostering a more adaptable and skilled workforce.

As organizations continue to explore new work methodologies, integrating insights from both historical theories and modern empirical research will be crucial in designing work environments that balance flexibility, productivity, and innovation.

## 2.2. Engineering Simulator

The Engineering Simulator bridges the gap between theoretical research and their practical realization. Building on the concept of live labs (Albers et al. 2018) it enables iterative testing of design processes to refine and implement innovative solutions. By offering a controlled yet realistic environment, studies have shown that such an approach allows for the observation of ideation, collaboration, creativity, and team-based problem-solving (Walter et al. 2016). The Engineering Simulator serves as an efficient platform for design support validation (Manfred Hofelich et al. 2021), by simulating real world product development scenarios and constraints in a controlled research environment, e.g. shown in the study by Duehr et al. (2023). Drawing from the Engineering Simulator developed for sheet metal design validation developed by Maass et al. (2023), our Engineering Simulator compresses a typical product development cycle into an eight-hour session. The primary purpose of the Engineering Simulator in this research is to assess the impact of new ways of working on the product development process, enabling the controlled evaluation of these methodologies by replicating dynamic conditions typical of a product development cycle but within a compressed timeframe. The Engineering Simulator is divided into distinct phases, each reflecting critical stages of a product development lifecycle, designed to elicit specific behaviors and outcomes relevant to both traditional and new working practices (cf. Figure 1).

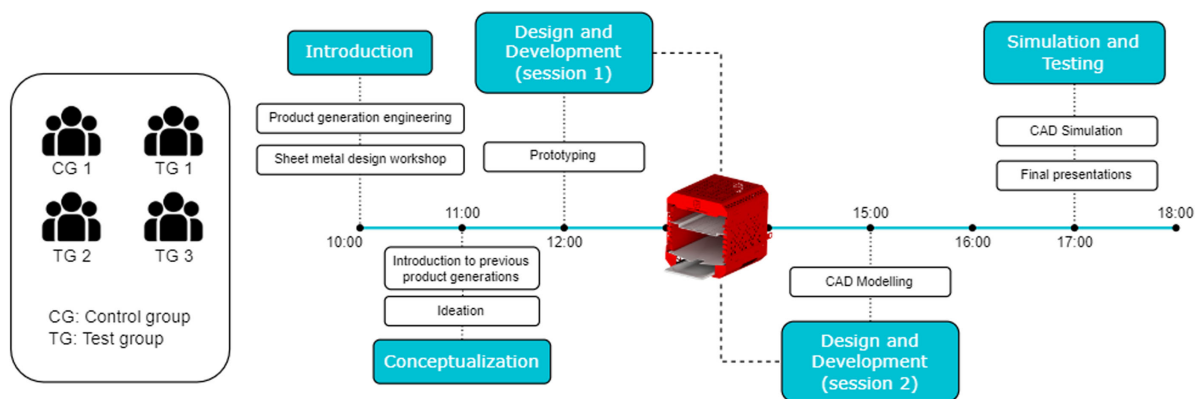


Figure 1. Engineering Simulator timeline based on Maass et al. (2023)

- **Problem definition:** This introductory phase sets the stage for the product development activities by providing a comprehensive briefing on the project scope and objectives, focusing on the task of iterating on an existing product, which in this instance is a barbecue tray in a portable grill machine. The briefing underscores the PGE - Product Generation Engineering concept (Albers et al. 2017), emphasizing iterative design and enhancement based on prior product generations.
- **Conceptualization:** In this phase, participants are tasked with generating and refining innovative design solutions that prioritize usability, and manufacturability of the grill trays. The methodology here facilitates a divergence from standard ideation processes by allowing participants in experimental groups to autonomously structure their ideation activities and therefore encouraging self-directed project management and creative independence, in contrast to structured and inflexible nature of traditional product development practices.
- **Prototyping:** Following ideation, participants are challenged with developing low-fidelity prototypes using materials and tools that simulate actual conditions of sheet metal fabrication and considering design constraints which play an important role in manufacturing using sheet metal. These prototypes not only test design manufacturability but also serve as reference models for creating 3D models of the newly iterated trays.

- Digital modeling: Participants use 3D modeling software to translate their physical prototypes into digital formats. The emphasis here is on refining prototypes into workable digital models that can be tested in subsequent simulation activities.
- Simulation testing and final evaluation: The final phase involves simulating the solutions using a virtual bending machine simulator, allowing participants to observe how well their designs translate into physical products and thus, providing valuable insights into the effectiveness and practicality of the proposed solutions.

### 3. Research objective and methodology

#### 3.1. Research objective and research question

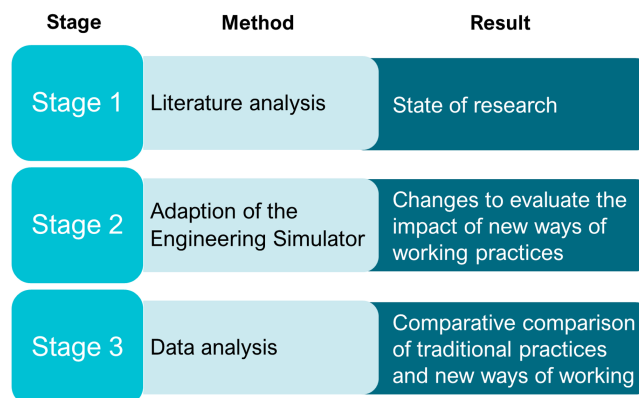
The overarching goal of this research is to conduct a systematic validation of new ways of working within the context of product development. This study aims to distinguish these modern practices from traditional ones by demonstrating their core components and establishing a clear understanding of their credibility and adaptability in enhancing product development processes. By investigating both the theoretical underpinnings and practical realization of these practices, this research seeks to illuminate the distinctions between contemporary and conventional work approaches, focusing on their impact on employee motivation, technical affinity, productivity, and other key performance indicators within an Engineering Simulator environment. This leads to the following research question:

How do specific new ways of working affect individual and organizational performance in product development, compared to structured, predefined workflows in a simulated product development environment?

In this study, new ways of working refer to the implementation of five key dimensions: flexibility and autonomy, activity-based workspaces, resource allocation with employee involvement, digital dexterity, and job purposing. These are contrasted with ‘traditional practices,’ which involve structured, predefined workflows with limited flexibility in tool selection, decision-making, and collaboration.

#### 3.2. Research methodology

This research is structured in three main stages (cf. Figure 2).



**Figure 2. Structure of the research based on three stages**

The first stage entailed defining the research context by gaining a broad understanding of the study's focus, accomplished through a comprehensive literature review that sharpens the study's objectives. In the second stage, we collected and analyzed existing data on new ways of working, setting a theoretical foundation that guides the practical work on adapting the Engineering Simulator in a way that a comparison between traditional practices and new ways of working was possible. These adaptations were realized by implementing different new ways of working strategies within a controlled experimental setting, the Engineering Simulator, to observe and record their effects in a real-time, dynamic environment. In the third and final stage, we carried out the experiment and analyzed the data obtained to evaluate the effectiveness of new work practices, synthesizing the findings into actionable insights and recommendations for future application in industry practices.

## 4. Investigating new ways of working in an Engineering Simulator - study design

To effectively evaluate the impact of new ways of working on product development, specific changes were made to the Engineering Simulator (ES) to more accurately reflect the dynamics of new ways of working. Changes were aimed at enhancing the simulator's ability to capture complex human interactions and process efficiencies that these new ways of working might influence. The simulator's focus was narrowed to activities that are most likely to be impacted by new ways of working, particularly those involving collaborative efforts, creativity, and flexible workflow management. The selection of these practices was informed by a need to understand how greater autonomy, flexibility in work arrangement, and digital integration could improve both the process and outcomes of product development. Regular surveys were conducted alongside real time observations by a moderator to capture feedback from participants in both test and control groups. These surveys gathered data on participant satisfaction with the work environment, the effectiveness of new work practices, and the perceived impact of autonomy and tool selection on their overall performance. The validation of new work practices within the ES used a combination of human-related and process-related metrics

- Human-Related Factors: Engagement, motivation, collaboration dynamics, and skill application were tracked through surveys, direct observations, and peer feedback, providing a triangulated view of the interpersonal effects of new work practices.
- Process-Related Factors: Operational aspects such as the efficiency of workflows, milestone achievements, and the quality of deliverables were assessed, offering insights into the practical benefits of the implemented practices.

The study involved N = 13 (male, aged between 23 and 28) participants, all enrolled in M. Sc mechanical engineering and management program to ensure a comparable technical knowledge base. The participants were selected based on their understanding of design methodologies, prototyping, and engineering simulation tools. To maintain experimental control, participants were randomly assigned to one control group (n = 3) and three test groups (n = 3/4 each). Each test group operated under different New Work conditions, while the control group followed a structured, predefined workflow to provide a benchmark for comparison. Randomization aimed to reduce bias and ensure that individual skill variations did not disproportionately affect group performance. All participants had prior exposure to engineering simulations, though none had previously worked within the specific Engineering Simulator setup used in this study. This ensured that the study captured the effects of the new ways of working rather than familiarity with the simulator itself.

The Engineering Simulator was specifically set up to validate a selection of new work practices within a conventional product development cycle, considering limitations like session duration and participant numbers. The ES environment was meticulously crafted to differentiate the experiences of the test groups from the control groups by implementing various new ways of working, enabling precise evaluation under controlled conditions. The Engineering Simulator explores the efficacy of new ways of working including flexibility and autonomy, activity-based workspaces, resource allocation, digital dexterity, and job purposing, each tailored to match the simulator's constraints.

- Flexibility and Autonomy  
Participants in the test groups were offered a choice in their workflow and selection of 3D modeling software, in contrast to the control group, which adhered to a predefined workflow and software. This setup allowed for a direct assessment of how autonomy in workflow and tool selection impacts productivity and satisfaction.
- Activity-Based Workspaces  
In the ES, all tools and resources were organized and made easily accessible to test groups, aiming to minimize downtime and maximize efficiency. This setup was compared to a less structured environment provided to the control group, thus measuring the impact of workspace organization on operational efficiency.
- Resource Allocation with Employee Involvement  
Test group participants managed their own scheduling for the use of shared resources like prototyping desks. This participatory approach was designed to observe changes in resource

utilization and operational efficiency compared to the control group, which did not participate in resource planning.

- Digital Dexterity

Access to digital tools and the internet was granted to the test groups, enabling them to utilize AI and online resources to enhance their design processes. The impact of this access was measured against the control group's performance, which lacked such resources.

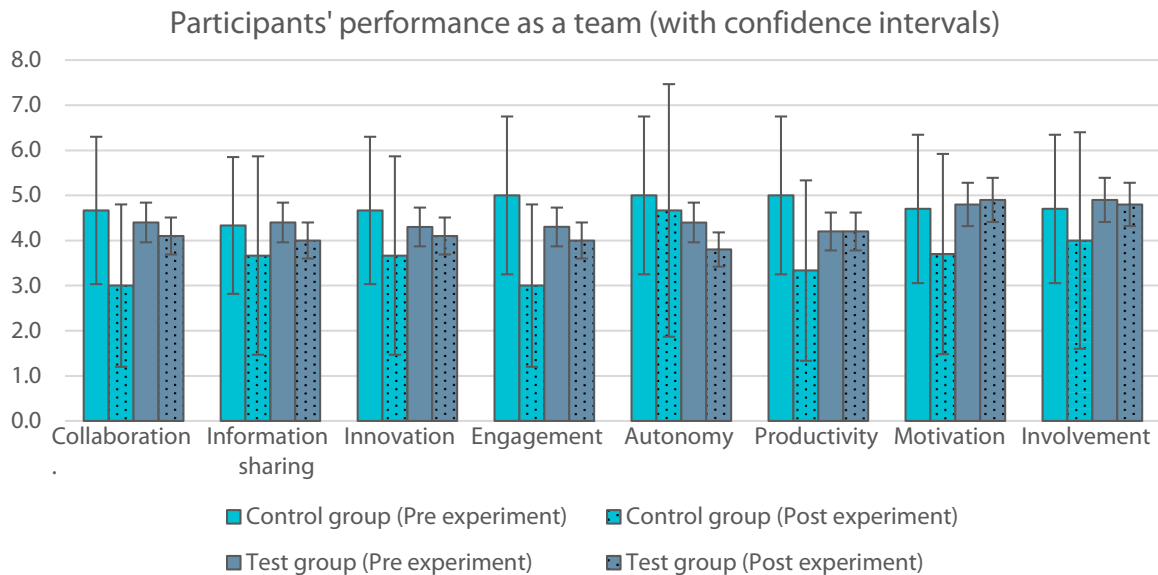
- Job Purposing

The test groups were informed about the broader implications of their work, particularly emphasizing the sustainability and usability of the final product. This strategy was employed to evaluate whether understanding the larger impact of their work could boost motivation and engagement compared to the control group, which did not receive this contextual information.

- Through these differentiated setups, the ES provided a structured and empirical basis to assess how various new work practices could potentially reshape engineering environments, offering significant insights into their practical applications.

## 5. Comparative analysis of traditional practices and new ways of working

The comparative analysis between traditional practices and new ways of working followed the mentioned study design. To give a detailed example of the comparison, an analysis based on the survey data and the real-time observations made by the moderator is now presented focusing on the overall performance as a team (cf. Figure 3). The evaluation criteria presented below were specifically developed for this study, considering the defined scope of research and the selected data collection methods. These criteria were designed to systematically assess team performance, engagement, and workflow efficiency within the Engineering Simulator environment. Given the controlled nature of the study, the evaluation framework was tailored to ensure compatibility with the available observational and survey-based data, allowing for a structured comparison between traditional and New Work practices.



**Figure 3. Participants' performance as a team (with confidence intervals)**

At the beginning of the experiment, both the control and test groups started with high motivation and involvement. As the experiment progressed, the distinct work environments influenced these levels differently. The control group, operating under traditional work structures, saw a decline in motivation from 4.7 to 3.7 and involvement from 4.7 to 4.0, likely due to rigid structures limiting autonomy, decision-making, and time management. The test groups, however, exhibited different trends. One maintained relatively stable motivation (4.8 to 4.9) and involvement (4.9 to 4.8), potentially benefiting from autonomy and flexibility. However, the other two test groups showed slight declines in motivation and involvement, averaging final scores of 4.6 and 4.7, respectively. This suggests that while autonomy

in work practices can foster engagement, its effectiveness varied across teams, and some struggled with coordination, leading to differences in engagement levels.

Despite challenges, the test groups exhibited greater resilience than the control group. However, fragmented communication and self-organization led to varying success across the test groups. Some groups were able to leverage flexibility effectively, while others faced difficulties in maintaining workflow synchronization and team cohesion. Autonomy levels, however, decreased across the board, more so in the test groups, reflecting the complexities introduced by greater flexibility which sometimes reduced individuals' control over their work. However, the structured support within new work practices helped mitigate some negative impacts, suggesting that with appropriate management, the benefits of new work practices can be better realized, potentially enhancing productivity and innovation even amid transitional challenges. Additionally, 90% of test group participants reported in a survey that understanding the broader purpose of their contributions positively influenced their motivation. This was reflected in the frequency of team interactions, where one test group recorded 650 interactions, while the other two groups averaged 590 interactions, compared to 460 in the control group. The higher number of interactions in test groups suggests that a broader understanding of purpose may have encouraged more frequent knowledge exchange, collaborative problem-solving, and iterative refinement of ideas, ultimately facilitating more dynamic team engagement.

Similarly, the speed of prototyping differed among the test groups. One test group developed the first prototype 35% faster (85 min vs. 130 min), while the other two test groups achieved a 28% and 30% faster completion time, respectively. This suggests that New Work practices, though beneficial, showed varying degrees of efficiency depending on the group's ability to adapt to a flexible environment. These variations underline the importance of team structure and self-management skills in optimizing New Work practices.

## 6. Discussion and outlook

This study highlights that new ways of working enhance individual productivity and creativity by providing autonomy in decision-making. However, their impact on team dynamics varies. While flexibility allows individuals to align tasks with their strengths, the lack of standardized workflows led to misalignment and communication challenges. These findings suggest that while new work practices offer benefits, their effectiveness at the team and organizational levels depends on structured communication frameworks and adaptive management strategies. Successful adoption requires balancing autonomy with mechanisms that support collaboration and coordination.

### 6.1. Applicability and limitations of the Engineering Simulator

The Engineering Simulator (ES) provided a controlled environment to study workflow flexibility, collaboration, and decision-making in product development. However, its applicability has limitations:

- **Domain-specific scope:** Designed for mechanical engineering, findings may not directly translate to software, electrical, or civil engineering, where work methodologies and constraints differ.
- **Participant demographics:** The study was conducted with M.Sc. mechanical engineering and management students, making the results most applicable to early-career engineers. While these groups have comparable technical backgrounds, the extent to which the results are transferable to experienced industry professionals remains unclear.
- **Small sample size and team composition:** The study was conducted with teams consisting of only three participants per group. In contrast, real-world engineering teams often involve larger and more diverse groups, including specialists from multiple disciplines. So certain complexities of real-world team dynamics were not fully captured in this study.
- **Time constraints:** The Engineering Simulator compresses a product development cycle into an 8-hour session, meaning it does not capture long-term adaptation or sustainability of new ways of working over extended project timelines.
- **Organizational and cultural context:** Unlike corporate settings, the ES does not reflect hierarchical decision-making, regulatory influences, or external stakeholder interactions, all of which shape the success of new work practices.

While the ES provides valuable insights into team behavior and workflow adaptability, future research should validate findings in longitudinal industry studies to assess effectiveness across diverse engineering and business environments.

## 6.2. Future research directions

This research has systematically explored the impact of New Work practices within an Engineering To strengthen the applicability of these findings and address the study's limitations, future research should explore the following areas:

- Longitudinal studies: Future studies should extend beyond short-term experimental settings to assess how new ways of working influence teams over months or years, particularly in relation to long-term efficiency, adaptation, and organizational culture shifts.
- Industry validation across sectors: The findings should be validated in real-world engineering environments, with diverse participant groups, including experienced professionals and interdisciplinary teams from diverse industries such as automotive, aerospace, software development, and manufacturing etc..
- Cross-disciplinary comparisons: Research should explore how new ways of working compare across different engineering domains, particularly in fields that rely on rigid regulatory constraints (e.g., civil engineering, aviation etc.) versus those that encourage agile methodologies (e.g., software development).
- Integration of organizational factors: Future research should consider how corporate structures, leadership styles, and workplace hierarchies influence the success or failure of new ways of working when implemented at large-scale industrial levels.
- Impact of multiple factors: The simultaneous implementation of multiple new work practices in the test groups reflects a realistic approach but complicates the isolation of individual effects. Future research will isolate individual effects using a Design of Experiments (DoE) approach.
- Digital tools and AI integration: Future research will explore how real-time collaboration platforms, AI-driven project management tools, and augmented reality workspaces impact team dynamics, communication efficiency, and resource management.
- Robust data collection method: The current study relied on surveys and direct observations, which may introduce observer bias. Future studies should explore automated tracking systems, AI-driven analytics, and multi-source data validation to improve the reliability and depth of empirical findings.

By addressing these research gaps, future studies can enhance the generalizability and real-world applicability of new ways of working, ensuring that organizations are equipped to navigate the evolving landscape of engineering work environments.

## 6.3. Practical implications for organizations

As Organizations implementing new work methodologies must address cultural resistance and adapt management structures to foster flexibility while maintaining team cohesion. Shifting to these models may require rethinking project management strategies, redefining collaboration, and integrating digital tools to enhance efficiency. While new work practices offer significant benefits, their success depends on strategic implementation tailored to industry-specific needs. Longitudinal studies, industry collaborations, and adaptive leadership approaches will be crucial in ensuring that organizations not only transition effectively but thrive in an increasingly digital and autonomous work environment.

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