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A Literature Review on the Impact of Multiskilling on Construction Project Outcomes

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Labor shortages continue to challenge the construction industry's ability to meet project demands and maintain productivity. One workforce strategy receiving increasing attention is multiskilling, which involves training and assigning workers to perform tasks across more than one trade. This paper reviews existing studies on multiskilling in construction to understand its impact on project performance and workforce outcomes. A total of 53 studies were examined, including 17 that quantitatively assessed cost, schedule, productivity, and manpower utilization. The findings suggest that multiskilling can improve efficiency and flexibility, though most studies rely on simulated data rather than real world projects. There remains a need for research grounded in field data, particularly within the United States, to better understand how multiskilling performs under actual site conditions. The review identifies gaps, including inconsistent definitions of performance metrics, limited comparisons with single-skilled labor, and lack of consideration for regulatory requirements such as prevailing wage and apprentice-to-journeyman ratios. Continued research is needed to address these gaps and build a more practical understanding of how multiskilling can be effectively applied in construction projects.

Keywords: Multiskilling, Construction workforce, Labor shortage, Workforce utilization, Project performance, U.S. construction industry

Introduction

The construction industry is a major contributor to the U.S. economy, accounting for approximately 4.4% of gross domestic product (GDP) in the second quarter of 2025 (U.S. Bureau of Economic Analysis [BEA], 2025). Beyond its economic role, the industry supports millions of jobs across public and private sectors but continues to face persistent labor shortages that threaten productivity and project delivery. According to the Associated General Contractors of America (AGC) 2025 Workforce Survey, 92% of firms hiring report difficulty finding qualified workers, 45% cite project delays caused by shortages, and 88% have open craft positions (AGC, 2025). These shortages are compounded by demographic and workforce entry challenges. Many experienced baby-boom-era craft professionals are exiting the workforce due to age, leaving a gap that younger workers are not filling in sufficient numbers (Albattah *et al*., 2015; Ostadalimakhmalbaf *et al*., 2021). As a result, the construction industry is increasingly challenged to sustain productivity and project performance amid a declining skilled workforce.

In response to these workforce constraints, multiskilling has been explored in prior research as a potential means of improving workforce adaptability and optimizing labor utilization. In general, multiskilling refers to the development and deployment of workers who possess the proficiency to perform tasks across multiple trades or specialties, allowing more flexible use of available labor resources. Within construction, this approach is discussed as a way to manage workflow variability, reduce idle time, and maintain production continuity when specific trades are unavailable (Burleson *et al.*, 1998; Haas *et al*., 2001; Nasirian *et al*., 2019b).

Although the concept of multiskilling has been examined in construction research for more than two decades, studies have varied widely in their focus and scope. Prior research has investigated multiskilling in relation to project cost, schedule performance, labor productivity, and workforce utilization (Burleson *et al*., 1998; Haas *et al.*, 2001; Lill, 2009; Pandey & Maheswari, 2015; Ahmadian Fard Fini *et al*., 2017). While these studies provide valuable insights, they differ considerably in how these outcomes are defined and measured, and much of the available evidence remains theoretical rather than based on data from actual construction projects.

This paper reviews existing research on multiskilling in construction to clarify how the concept has been examined in relation to project performance. The review analyzes how multiskilling has been evaluated across cost, schedule, productivity, and workforce utilization outcomes, as well as the data sources and study contexts that inform these assessments. Also, the paper provides a clearer understanding of how multiskilling has been studied and identifies methodological patterns that can inform future research and practice in construction workforce management.

Methodology

Relevant studies were identified through searches of major academic databases, including Scopus, Web of Science, and ScienceDirect, supplemented with targeted searches in Google Scholar to capture emerging and non-indexed research. Keywords included combinations of "multiskilling", "cross-training", cross-tasking", "multi-skilled workforce", and "construction labor flexibility". The review covered the period 1998–2025, which captured both foundational works that introduced the concept (Burleson *et al*., 1998; Haas *et al*., 2001) and recent studies employing optimization, and simulation (Nasirian *et al*., 2022; Barkokebas *et al.*, 2023; Zarei *et al*., 2024). Only publications directly relevant to construction or off-site manufacturing contexts were included.

In total, 62 studies were identified as potentially relevant, of which 53 were accessible and reviewed in full. These included 44 peer-reviewed journal articles and 9 conference papers. Although a broader range of publications referenced multiskilling or related terms, this review was deliberately narrowed to studies in which multiskilling constituted a central research focus. Publications that mentioned multiskilling only tangentially, without meaningful conceptual or analytical depth, were excluded. Each study was reviewed to identify data on reported outcomes, measurement definitions, data sources, and analytical methods.

Studies were then organized thematically to synthesize patterns across the literature. Thematic categories included implementation of multiskilling, labor optimization and planning, employee motivation, multiskilling patterns and competence development, benefits of multiskilling, and workforce development and training. These categories were informed by prior construction workforce review frameworks (Nasirian *et al*., 2019a; Costa *et al*., 2023) and refined iteratively as additional studies were reviewed. Studies were also classified by research design (empirical or simulation-based), level of analysis (crew, project, or organizational), and geographic focus (U.S., international, or comparative). Studies were also reviewed to determine whether regulatory factors affecting workforce composition or labor cost assumptions were considered. The review and thematic organization were conducted by a single author without the use of an automated tool to maintain consistent classification across studies.

Reported Performance Outcomes

Across the reviewed studies, multiskilling has been linked to improvements in project performance, particularly in cost efficiency, schedule reduction, and workforce flexibility. However, the magnitude and direction of these benefits often depend on project context, skill composition, and modeling assumptions.

Cost Impacts

Cost reduction is among the most frequently reported benefits of multiskilling in construction. Early studies established foundational evidence that multiskilling can yield meaningful labor-cost savings through improved crew utilization and reduced idle time. Burleson *et al*., (1998) analyzed a hypothetical petrochemical project using labor estimates from three independent contractors and reported potential savings of 5% to 20 % in total project labor cost, depending on the degree of skill diversification and productivity improvement factor applied.

Subsequent modeling-based studies reinforced these findings using progressively analytical techniques. Similarly, Lill (2009) simulated the economic operations of an average construction firm erecting buildings of varying structural and functional types and found that the use of multiskilled workers reduced total cost price by 3% and increased potential owner revenue by roughly 7%. Liu & Wang (2012) incorporated multiskilling into a constraint-programming optimization for a bridge project example and reported a 53% reduction in labor cost.

In examining operational performance under different workforce strategies, including no cross-training, hiring single-skilled crews, direct capacity balancing, chaining, and hiring multiskilled crews—Nasirian *et al.,* (2019b) used production data from a prefabrication facility in Australia across three case scenarios with varying levels of variability. Under no-variability conditions, multiskilled crews achieved 21% labor cost savings relative to single-skilled crews. In medium-variability conditions costs rose by 28% compared to single-skilled labor. Under high variability, labor costs increased by 9%. These results suggest that the economic advantage of multiskilling depends strongly on the degree of production variability and the flexibility of task reassignment.

More recent work by Barkokebas *et al.,* (2023) used a simulation-based digital twin to assess how multiskilling improves production in offsite construction (OSC) by automating worker reassignment. Their findings revealed a 25% reduction in production costs. Zarei *et al.,* (2024) extended this line of research through a resource-constrained scheduling framework validated on a railway bridge project comprising 34 activities. Their results indicated an approximate 24% reduction in total project cost, confirming that the integration of multiskilled labor within resource optimization models can lead to significant financial efficiencies.

Schedule Performance

The ability of multiskilling to shorten project duration has been among its most frequently cited benefits. Hegazy *et al.,* (2000) reported project duration reductions ranging from 4% to 29% when multiskilled labor was integrated into resource-constrained schedules. Lill (2009) likewise observed that engaging multiskilled workers in simulated building projects shortened construction duration by approximately 20%.

Subsequent studies reinforced these trends using optimization and simulation frameworks. Wongwai and Malaikrisanachalee (2011) found that multiskilled resource scheduling reduced project duration by 18%–22% under typical conditions and by up to 36% when heuristic algorithms were applied. Similarly, Liu and Wang (2012) demonstrated that integrating multiskilled crews in constraint-based optimization reduced project duration by 85% relative to single-skilled configurations. Pandey and Maheswari (2015) observed time savings in housing projects where combined shuttering and carpentry crews shortened cumulative employment periods by approximately 11 days while maintaining output with fewer workers.

Building on earlier research, newer studies have confirmed the schedule benefits of multiskilling in both on-site and off-site construction contexts. Nasirian *et al.,* (2019b) reported that multiskilled crew deployment reduced production makespan by 11%–19% depending on the level of variability in prefabrication tasks. Barkokebas *et al.,* (2023) showed that digital-twin–based reassignment of multiskilled workers decreased total production duration by nearly 40%, and Zarei *et al.,* (2024) observed about 14% improvement in project completion time through multiskilled resource optimization in a railway bridge project.

Productivity and Workforce Utilization

Beyond cost and schedule improvements, multiskilling contributes significantly to workforce efficiency and productivity. Burleson *et al.*, (1998) found that dual-skill and four-skill strategies reduced the number of required workers by 18% to 35%, while increasing employment durations by 18% to 47%, resulting in a leaner and more continuously employed workforce. Likewise, Pandey & Maheswari (2015) observed that when a multiskilled crew performed both shuttering and carpentry tasks in a housing project, total labor time decreased and the average number of workers required declined by 40%, from 36.6 to 22, without loss of output.

Ahmadian Fard Fini *et al.,* (2017) quantified the productivity impact of multiskilling using a mathematical model that accounted for the visual, auditory, cognitive, and psychomotor demands of construction tasks. Their analysis revealed a 28.3% increase in daily throughput during concrete operations in a multi-story residential project. Sarihi *et al.,* (2020) also examined multiskilling as a workforce management approach for multi-project environments and found that integrating multiskilled labor reduced total workforce requirements by up to 40% in their simulation-based mode.

The resilience advantages of multiskilling have also been examined under workforce shortage conditions. Araya (2022) employed agent-based modeling to evaluate the impact of multiskilled labor during COVID-19–related disruptions, showing that integrating multiskilled workers reduced overall labor deficits from 33.4% to 16.7%. Barkokebas *et al.,* (2023) extended these findings using digital-twin simulation and found that automated reassignment of multiskilled workers reduced average waiting times by 62%, demonstrating improved operational flow and resource utilization.

Workforce Motivation and Organizational Outcomes

The ongoing labor shortage in construction has necessitated the importance for strategies that retain a skilled and motivated workforce. As project demand grows, maintaining existing workers has become a practical means of sustaining workforce capacity, particularly since multiskilling can reduce overall labor requirements while increasing workforce stability (Haas *et al.,* 2001). Previous studies indicate that multiskilling enhances job satisfaction and engagement, factors closely linked to reduced turnover and stronger retention (Andersen & Ankerstjerne, 2010; Morrison & Savery, 1996; Wang *et al.*, 2020).

Multiskilling influences motivation through both financial and psychological mechanisms. Financially, workers proficient in multiple trades tend to earn higher wages, enjoy more continuous employment, and experience greater job security (Akinola, 2019; Burleson *et al*., 1998; Stanley, 1997). Carley *et al*., (2003), in a study of more than 700 U.S. craft workers, reported that individuals pursued additional skills primarily for higher pay, sustained employment, and deeper engagement in their trade, benefits that translated into tangible gains such as increased hourly wages and steadier employment continuity.

From the employer's perspective, multiskilling reduces the costs associated with recruitment, retraining, and onboarding, while promoting workforce flexibility and stability under fluctuating labor conditions (Albalawi *et al.*, 2024; Gomar *et al*., 2002; Lill, 2009). Beyond economic benefits, multiskilling contributes to more meaningful work experiences. According to Hsu & Liao (2016), higher skill variety, task identity, and task significance enrich job content, fostering stronger intrinsic motivation and organizational commitment.

The growing adoption of multiskilling reflects not only employer demand but also changing worker preferences. The Construction Industry Institute (2021) reported consistent growth in multiskilling adoption over the past 15 years, with continued expansion projected through 2030. This trend aligns with evolving workforce priorities such as geographic stability and dual-income household arrangements, both of which favor long-term employment with a single firm. Earlier findings by Glover (1975) similarly revealed that multiskilled workers are less susceptible to unemployment, enjoy higher annual earnings, and have greater opportunities for advancement into supervisory roles.

Methodological Trends and Data Characteristics

Among the 53 studies identified in this review, 17 assessed how multiskilling influences project performance metrics. These studies aimed to quantify the extent to which multiskilled deployment affects project cost, schedule, productivity, and workforce utilization as shown in Appendix A. Despite their contributions, considerable variation exists in outcome definitions, data sources, and analytical methods, which complicates cross-study comparison and reduces the comparability of results across different research contexts.

Outcome Measurement Approaches

Across the 17 quantitative studies, schedule performance was the most frequently evaluated outcome, analyzed in 12 studies. Cost was examined in 8 studies, while productivity and manpower utilization were considered in 4 and 3 studies, respectively. Measurement definitions and levels of analysis varied considerably. Schedule performance was measured both at the task or crew level, as in studies assessing makespan reductions in prefabrication, concreting operations (Pandey and Maheswari, 2015; Nasirian *et al*., 2019b), and at the project level, such as total completion time or duration savings (Hegazy *et al*., 2000; Lill, 2009). Cost impacts were alternately defined as labor-only costs (Burleson *et al.*, 1998; Liu and Wang, 2012) or total project costs, incorporating indirect and overhead factors (Lill, 2009; Zarei *et al*., 2024). Productivity was measured less consistently. Ahmadian Fard Fini et al. (2017) directly assessed productivity using daily throughput and task performance data, while Arashpour *et al.,* (2015) and Barkokebas *et al.,* (2023) used process efficiency and waiting-time metrics as proxies. Manpower utilization was primarily captured through changes in required crew size or reductions in labor deficits (Pandey and Maheswari, 2015; Sarihi *et al*., 2020; Araya, 2022).

Although these studies quantified performance improvements under multiskilled deployment relative to single-skilled or baseline configurations. Reported benefits ranged widely from 4% to 85%

reductions in project duration, 3% to 54% labor-cost savings, and 18% to 50% reductions in workforce size. These discrepancies reflect differences in project context, data fidelity, and modeling assumptions.

Overview of Data and Research Methods

A review of the 17 quantitative studies reveals a strong reliance on modeled and simulated datasets, with comparatively few studies grounded in empirical observations from real construction projects. Only three incorporated some form of field-based data, and none were conducted on U.S. jobsites. Most of the field-based examples originated in Asia and Australia, where differing labor markets and regulatory environments may limit the transferability of findings to the U.S. context.

Early investigations, including those by Burleson *et al.,* (1998), Hegazy *et al.,* (2000), Lill (2009), and Zarei *et al.,* (2024), typically employed hypothetical project data or modeled inputs derived from contractor estimates and prior research. While these approaches allow for controlled exploration of workforce scenarios, they offer limited representation of the operational variability and coordination demands that characterize active construction projects.

A smaller group of studies analyzed factory or off-site production data, where workflows and cycle times can be observed under more stable conditions. For instance, Nasirian *et al.,* (2019b) and Barkokebas *et al.*, (2023) examined prefabrication and modular construction settings in Australia and Canada, respectively, using production data to evaluate how multiskilled labor mitigated bottlenecks and enhanced throughput. These studies contribute valuable insights into repetitive and standardized environments but provide only partial understanding of multiskilling's effectiveness in traditional on-site construction. Even in studies that incorporated contractor collaboration, data were most often used to parameterize simulation models rather than to validate empirical outcomes. As a result, the evidence base for multiskilling remains largely theoretical, offering limited verification under real project conditions.

Collectively, these trends underscore the field's dependence on simulated or semi-empirical data and highlight a persistent lack of field validation, particularly within the U.S. construction industry. Addressing this gap will require context-specific, project-level studies capable of capturing the complexities of on-site coordination, labor constraints, and regulatory considerations such as wage determinations, apprenticeship ratios, and project labor agreements.

Conclusion and Future Research Directions

This review examined fifty-three studies on multiskilling in construction, including seventeen that quantitatively examined its influence on cost, schedule, productivity, and manpower. The literature suggests that multiskilling can improve workforce flexibility, improve productivity, and, under certain conditions, reduce costs and project duration. However, these benefits are highly context-dependent, varying with project type, crew composition, and labor market conditions.

Despite progress in understanding multiskilling's potential, most existing studies rely on simulation or optimization approaches rather than data from active projects, limiting their relevance to real construction environments. Research has also tended to treat the workforce as a single entity, offering limited insight into the performance of specific trades or skill combinations. Expanding future studies to include diverse trades and field-based data would provide a more practical understanding of where and how multiskilling is most effective. Few studies have conducted direct head-to-head comparisons between multiskilled and single-skilled workforce strategies, leaving uncertainty about their relative efficiency, cost, and schedule reliability. Future research should apply consistent performance metrics to both strategies under comparable conditions to generate more robust evidence.

Another important direction involves examining regulatory factors that influence the implementation of multiskilling in the U.S. construction industry. None of the reviewed studies accounted for federal or state-level requirements that shape workforce composition and labor costs. Regulations governing apprentice-to-journeyman ratios can constrain the allowable mix of skilled and semi-skilled workers on projects, while Davis–Bacon prevailing wage laws affect cost assessments by setting minimum pay rates on federally funded work. Similarly, Project Labor Agreements (PLAs) which have become more prevalent under federal initiatives such as the Inflation Reduction Act, introduce jurisdictional constraints that can limit the cross-trade flexibility central to multiskilling. Addressing these regulatory dimensions is essential for translating theoretical models into practices that align with U.S. labor and market realities.

Future research should integrate field data from active construction projects to capture real working conditions and assess how multiskilled deployment influences on-site coordination, training requirements, and regulatory compliance. For practitioners and policymakers, the review highlights multiskilling as an area where further evaluation and data collection may be needed, rather than as a proven response to current workforce shortages. Expanding this evidence base will clarify where multiskilling provides the most value and guide its application to strengthen workforce capacity and project performance.

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Appendix A. Summary of Studies Quantifying the Impact of Multiskilling on Project Performance Metric

Study	**Data Source**	**Method/Approach**	**Performance Focus**	**Performance Metric**	**Reported Outcome**
Burleson et al. (1998)	Simulated petrochemical project (U.S.)	Labor modeling (CII Model Plant)	Cost, Manpower	Labor cost, workforce size, employment duration	5%–20% labor cost savings; 18%–35% fewer workers; 18%–47% longer employment duration.
Hegazy et al. (2000)	Case study project with 20 activities	Heuristic procedure for resource scheduling	Schedule	Project duration (days)	Up to 29% shorter duration with

	from a prior study				multiskilled crews
Tam et al. (2001)	Simulated – generic construction project	Genetic algorithm optimization for labor allocation	Cost	Labor cost	3.7% labor cost increase under skill substitution shortage scenario
Lill (2009)	Simulated – multi-project firm model	Economic modeling	Cost, schedule, revenue	Cost price, duration, owner's revenue	3% lower cost; 20% shorter duration; 7% increase in revenue
Wongwai and Malaikrisanachalee (2011)	Simulated – case data from construction projects	Augmented heuristic algorithm for resource substitution	Schedule	Project duration	16%–25% reduction
Liu and Wang (2012)	Simulated – bridge project from prior study	Constraint programming for repetitive activity optimization	Cost, schedule	Total cost, total duration	54% lower cost; 85% faster completion using multiskilled crews
Pandey and Maheswari (2015)	50-unit housing project (India)	Line-of-Balance with work-shifting, multi-, and dynamic scheduling	Schedule, Worforce	Duration of employment, number of workers	11 days faster (1% improvement); 15 fewer workers (40% less workforce)
Ahmadian Fard Fini et al. (2016)	Residential building project (Australia)	Crew-composition optimization model	Schedule	Project duration	27% shorter project duration
Ahmadian Fard Fini et al. (2017)	Residential building project (Australia)	Mathematical modeling that accounted for psychomotor and cognitive workloads	Productivity	Daily throughput	28% improvement in daily productivity
Nasirian et al. (2018)	Modular Prefabrication factory (Australia)	Mathematical framework	Cost, Schedule	Labor cost, makespan	41% labor cost savings; 17% makespan reduction

Nasirian et al. (2019b)	Modular Prefabrication factory (Australia)	Quadratic resource model	Cost, Schedule	Labor cost, makespan	21% labor cost savings under no-variability; 9–28% higher costs under variable conditions; 11%–19% makespan reduction
Korb et al. (2019)	Simulated-residential constructions	Agent-based simulation using LeapconX	Schedule	Average length of simulated project	38.7% shorter duration
Sarihi et al. (2020)	Simulated – organization-wide project data	Constraint programming for cross-project workforce assignment	Cost, manpower utilization	Cost, number of workers	9% lower cost; up to 40% reduction in required workers
Araya (2022)	Simulated – workforce disruption due to COVID-19	Agent-based modeling	Workforce utilization	Labor deficit	Workforce deficit reduced from 33.4% to 16.7%.
Barkokebas et al. (2023)	Offsite construction factory	Simulation-based digital twin for worker reassignment	Cost, schedule	Production cost, production duration, average waiting time	25% cost reduction; 40% faster production; 62% less idle time.
Zarei et al. (2024)	Railway bridge with 34 activities	Fuzzy multi-objective optimization	Cost, schedule	Total project cost, Project completion time,	24% lower cost; 14% shorter duration.
Mozhdehi et al. (2024)	Simulated multi-project scheduling	Biogeography-based optimization (MBBO)	Schedule	Project completion time (days)	18% improvement due to dexterity enhancement.