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RESEARCH ARTICLE

# Assessing and Improving Labor Productivity Management in Construction: A Practical Framework and Measurement Tool

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## Abstract

Despite numerous studies and resources available, the global construction sector has witnessed a decline in productivity over the past two decades, highlighting the need for practical tools and strategies to enhance labor productivity management. This study proposed a tool to support labor productivity management in construction. To achieve this, initial data were gathered through literature reviews and on-site observations, followed by interviews with 10 experienced site managers to refine a comprehensive set of productivity factors. These factors were then used to construct a system of factors before developing a quantitative management tool, inclusive of a measurement scale and an instructive guide. Finally, this tool was evaluated by 12 experts using a five-level Likert scale to ensure its practicality and accuracy. The results show that the tool offers a structured and informative approach to assessing and enhancing labor productivity in construction projects, thereby supporting managers in making informed decisions and improvements toward more successful project outcomes. The insights gained from this research contribute to the ongoing efforts to address labor productivity challenges in



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the construction industry, paving the way for future developments and enhancements in productivity management tools.

## Keywords

**Labor Productivity; Productivity Factor; Productivity System; Management Tool**

## Introduction

Labor productivity plays an important role in the success of new construction projects such as high-rise buildings, roads, and bridges as poor construction labor productivity is a major cause of delay (Abdul Kadir, et al., 2005; Assaf and Al-Hejji, 2006; Doloi, et al., 2012; Kaming, et al., 1997) and cost overrun (Abdul Kadir, et al., 2005; Soekiman, et al., 2011) of construction projects. The expense of construction labor typically makes up approximately 30% to 50% of the overall cost of a construction project in many countries; thus, the productivity of construction labor significantly influences the profitability of nearly all construction projects (El-Gohary and Aziz, 2014; Hanna, Peterson and Lee, 2002; Van Tam, et al., 2021). However, labor productivity in construction still faces significant challenges.

In the construction industry, labor productivity, commonly referred to as Construction Labor Productivity (CLP) is a technical output–input ratio that compares the proportion of labor outcomes created by workers in a given time period to the labor consumed (Lu, et al., 2021). Gouett, et al. (2011) identified several common metrics used for CLP assessment, including the productivity factor, which is the ratio of scheduled or planned to actual work hours; the unit rate, which measures the ratio of labor cost to units of output; and labor productivity itself, defined as the ratio of work hours to units of output. Thomas, et al. (1990) provided the concept of "earned hours" as a measurement of the amount of work achieved relative to the labor invested. Yi and Chan (2014) emphasized productivity as the power of being productive and the efficiency with which goods are produced.

Despite a large number of investigations, the global construction industry has shown a decline in productivity compared to other industries in the last two decades (Adebowale and Agumba, 2023; Thomas and Sudhakumar, 2013). Construction professionals spend 35% of their time on non-optimal activities, resulting in a productivity loss of more than 14 h per week per worker (PlanGrid, 2018). In a typical project, the costs associated with rework can amount up to 20% of the total contract value (CII-R252, 2011).

Considering its significance, there have been many resources, handbooks, and research studies available that provide factors (Adebowale and Agumba, 2021; Alaghbari, Al-Sakkaf and Sultan, 2019; Hamza, et al., 2022; Yates, 2014), factor relationships (Sandbhor and Botre, 2014), predicting models (Golnaraghi, et al., 2019; Mlybari, 2020; Tsehayae and Fayek, 2016), frameworks (Liao, Teo and Low, 2017), data (Chancellor, 2015; Tran and Tookey, 2011), impacts (Wandahl, et al., 2021), assessment methods (Best, 2010; Carson and Abbott, 2012), and recommendations (Gurmu, Aibinu and Toong Khuan, 2016; Hamza, et al., 2022; Pan, Chen and Zhan, 2019; Parchami Jalal and Shoar, 2019) to ensure and improve productivity in the industry. However, there is currently a lack of a comprehensive toolkit to support productivity management, which can guide, plan, evaluate, measure, and quantify for labor productivity management and improvement. Therefore, further research and development in this area are needed to develop practical tools and techniques to enhance labor productivity management.

The primary aim of this study is to develop and validate a comprehensive management tool tailored to enhance labor productivity in new construction projects, which include diverse types such as high-rise buildings, roads, and bridges. This tool is designed to assist managers by providing a robust framework for identifying, measuring, and improving productivity factors effectively. Addressing this aim, the research is guided by the following specific questions:

- First, what are the key factors affecting labor productivity in these varied construction settings? This question seeks to identify and categorize labor productivity factors in these projects.
- Second, how can a quantitative management tool be systematically designed to assess and enhance labor productivity within these environments? This involves the creation of a tool based on identified factors and refined through expert feedback.
- Lastly, what impacts does the implementation of the proposed productivity management tool have in real-world construction projects? Evaluating the tool's effectiveness and practical applicability in actual project settings underscores its potential benefits and operational value.

The paper is structured into eight sections. The first section serves as the introduction, presenting a summarized general background and introducing the research topic. The second section provides a comprehensive literature review. The third section outlines the research methodology employed in the study. In the fourth section, a system of factors affecting labor productivity in construction is presented. The fifth section introduces an assessment tool designed to support labor productivity management. The sixth section involves an evaluation of this tool, assessing its effectiveness and applicability. The implications of the tool are discussed in the seventh section. Finally, the eighth section offers concluding remarks, summarizing the key findings and implications of the study.

## Literature review

Over the years, many studies have been conducted to investigate the factors that impact labor productivity growth in construction projects. The summary of the critical factors impacting labor productivity in the literature review is systematically presented in Table 1, while Table 2 outlines the various system dynamics and predictive modeling studies relevant to this research.

In developing countries, studies such as those by Thomas and Sudhakumar (2013), Hiyassat, Hiyari and Sweis (2016), and Agrawal and Halder (2020) have thoroughly examined the obstacles to productivity growth in construction. Meanwhile, in developed nations, Durdyev and Mbachu (2011), Karimi, Taylor and Goodrum (2017), and Moselhi and Khan (2012) have undertaken similar investigations with the aim of understanding and addressing these challenges. The critical factors impacting labor productivity identified in different countries can be different. In Jordan, Hiyassat, Hiyari and Sweis (2016) conducted a study that identified factors impacting construction labor productivity. Their research identified a total of 23 factors and highlighted the significance of work experience, feeling of achievement, efficient scheduling, the utilization of foreign workers, and the use of machinery as key determinants of labor productivity in the Jordanian construction industry.

Dixit, et al. (2017) indicated 24 factors impacting labor productivity in India and underscored the significance of decision-making, availability of labor, logistics, planning, and budget as fundamental factors of productivity. Ohueri, et al. (2018) identified 14 factors and found that effective management practices, training and development opportunities, a safe and welcoming working environment, financial incentives, and career progression contributed significantly to labor productivity in Malaysia. Meanwhile, in Cambodia, Durdyev and Mbachu (2018) identified poor leadership, inadequate construction methods, poor labor supervision, planning inefficiencies, and communication gaps as top factors among 36 identified factors. Alaghbari, Al-Sakkaf and Sultan (2019) in Yemen indicated 52 factors and emphasized the significance of labor experience and skill levels, material availability both on-site and in the market, effective leadership and management efficiency, and the impact of political and security situations. Palikhe, Kim and Kim (2019) in Nepal stressed the unavailability of tools and materials arriving on time at worksites, delay in procurement and material payment, and lack of monetary incentives as the important factors among 30 identified factors.

Notably, some studies have taken a step further by employing system dynamics in the form of qualitative models, to analyze the connections of these factors (El-Batreek, Ezeldin and Elbarkouky, 2013; Mawdesley and Al-Jibouri, 2009; Nasirzadeh and Nojedehi, 2013; Palikhe, Kim and Kim, 2019; Parchami Jalal and Shoar, 2019). System dynamics is a methodology for understanding the behavior of complex systems over time. This method uses feedback loops and time delays to simulate the interactions and impacts of various factors within a system. Mawdesley and Al-Jibouri (2009) and El-Batreek, Ezeldin and Elbarkouky (2013) introduced a system-dynamics-based method for modeling productivity. Nasirzadeh and Nojedehi (2013) proposed a system-dynamics-based approach for studying and modeling the interactions among factors influencing labor productivity. Parchami Jalal and Shoar (2019) introduced a system-dynamics-based method capable of revealing the interconnected relationships between the causes and effects of construction labor productivity.

Furthermore, some studies have been conducted to construct predicting models for labor productivity in the construction industry (Dissanayake, et al., 2005; Golnaraghi, et al., 2019; Jang, et al., 2011; Mlybari, 2020; Tsehayae and Fayek, 2016). For instance, Golnaraghi, et al. (2019) and Dissanayake, et al. (2005) have investigated the utilization of artificial intelligence and computational intelligence models to enhance predictive accuracy in labor productivity. Mlybari (2020) has adopted advanced computing techniques for predicting labor productivity. Meanwhile, Tsehayae and Fayek (2016) have emphasized the significance of work sampling proportions in construction labor productivity modeling and developed a system modeling approach to supporting users and researchers in analyzing factors impacting productivity, in conjunction with work sampling proportions.

While many studies have been conducted to investigate labor productivity from various angles, such as identifying critical factors, exploring correlations among these factors, and establishing predicting models, a notable gap exists in the form of a comprehensive tool that can quantitatively provide managers with insights into the situation of labor productivity management. Therefore, there is a pressing need for further research and development in this domain to create a practical tool that can significantly enhance labor productivity management.

Table 1. Critical factors impacting labor productivity in construction.

| Country | Researchers | Year | Critical factors |
|---|---|---|---|
| Jordan | Hiyassat, et al. | 2016 | Work experience, feeling of achievement efficient scheduling, foreign workers, and machinery use |
| India | Dixit, et al. | 2017 | Decision-making, labor availability, logistics, planning, and budget |
| Malaysia | Ohueri, et al. | 2018 | Management practices, training, work environment, financial incentives, and career progression |
| Cambodia | Durdyev and Mbachu | 2018 | Leadership, construction methods, labor supervision, planning, and communication |
| Yemen | Alaghbari, et al. | 2019 | Labor experience, material availability, leadership, management efficiency, and political/security situations |
| Nepal | Palikhe, et al. | 2019 | Tool/material availability, procurement delays, and lack of monetary incentives |

Table 2. System dynamics and predictive models for construction labor productivity.

| Researchers | Year | Focus of study | Methodology |
|---|---|---|---|
| Dissanayake, et al. | 2005 | Predictive modeling for labor productivity | Predictive modeling |
| Mawdesley and Al-Jibouri | 2009 | Modeling productivity using system dynamics | System dynamics |
| Jang, et al. | 2011 | Accessing the significance of labor productivity factors using modeling | Predictive modeling |
| El-Batreek, et al. | 2013 | Modeling productivity using system dynamics | System dynamics |
| Nasirzadeh and Nojedehi | 2013 | Studying interactions among factors influencing labor productivity | System dynamics |
| Tsehayae and Fayek | 2016 | Analyzing factors impacting productivity with work sampling proportions | System modeling |
| Parchami Jalal and Shoar | 2019 | Revealing interconnected relationships between causes and effects of productivity | System dynamics |
| Golnaraghi, et al. | 2019 | Enhancing predictive accuracy in labor productivity using artificial intelligence | Predictive modeling |
| Mlybari | 2020 | Predicting labor productivity using advanced computing techniques | Predictive modeling |

## Research methodology

The research methodology employs a mixed-methods research (MMR) approach, which combines both quantitative and qualitative methods. To better understand the process, Figure 1 is provided to visually represent the research methodology. This study employs various evidence sources, such as literature reviews, on-site observations, interviews, and document analysis, to enhance validation. Also, interviewees were asked to review the interview transcripts to confirm that their views were accurately documented.

Initially, factors were collected through literature reviews, including books and scientific papers, and on-site observations of construction projects. In conducting the literature review, a systematic approach was employed to identify, select, and analyze relevant studies on factors influencing labor productivity in construction. The search was performed across databases such as ASCE, Emerald, Scopus, Science Direct, and Web of Science using key terms such as "construction productivity", "labor productivity factors", and "construction efficiency", filtered for articles published from 2000 onward. Additionally, resources such as Google Scholar and general internet search engines were also employed to conduct a more exhaustive search, uncovering valuable insights and practical information. Studies focusing specifically on productivity in the construction industry and labor performance were included, while those unrelated were excluded. An initial screening of titles and abstracts was conducted to assess relevance, followed by a detailed review of full texts to apply the inclusion and exclusion criteria. Data from the selected articles, including publication year, geographic region, methodology, and productivity factors, were then extracted and categorized. Subsequently, interviews collecting opinions toward these factors were conducted with 10 construction experts in Vietnam, who are site managers with a minimum of 5 years of experience, shown in Table 3. The group of 10 experts come from a diverse mix of companies with their size ranging from small to

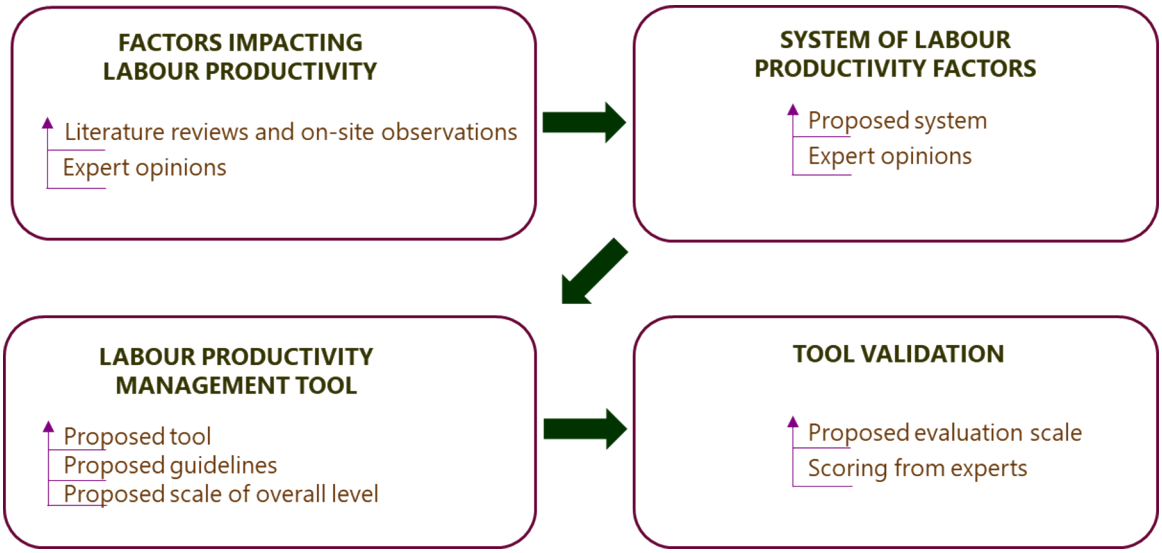


Figure 1. Research process.

large. Among them, some are responsible for managing high-rise commercial projects, with a focus on sustainability and modern urban infrastructure. Others specialize in suburban residential developments and housing complexes, having a background in affordable housing or renovating existing commercial properties. Two site managers focus on the industrial sector, overseeing the construction of large-scale manufacturing facilities, while one of the site managers has built a career in infrastructure projects such as roads and bridges.

From the selected factors, a comprehensive system of labor productivity factors was proposed before being carefully revised based on expert opinions, ensuring its accuracy and relevance. The next step focuses on analyzing collected qualitative data to construct a quantitative tool. Based on the synthesis of gathered information from knowledge, experience, observation, and literature, with recommendations about the process of developing tools from the 10 experts, a quantitative labor productivity management tool with a user guide is developed. The final step involves the development of assessment criteria to evaluate the tool using a five-level Likert scale (Likert, 1932) and conducting testing the tool with the assessment from 10 mentioned experts, plus 2 additional experts in Vietnam: a project manager (8 years of experience) and a foreman (6 years of experience). The information of experts and project types used for validation process is shown in Table 3. The tool was developed and tested in the summer of 2022. Each expert received both a digital version, accessible via computers or tablets, and a printed paper version of the assessment tool. They were instructed to use each format independently to evaluate how the tool performed in real-world scenarios. The feedback gathered from these sessions highlighted the tool's strengths and areas for improvement, guiding further refinements.

## System of factors impacting labor productivity

A system of factors that affect construction labor productivity will be presented in this section. The system was built with four main categories, which include eight subcategories representing a total of 49 component factors. These categories were inspired by the productivity management framework from the study of Yates (2014). This served as the starting reference. Subsequently, the categories were developed based on personal experience before being refined and validated through consultations with the 10 site-manager experts. A visual representation of the system's structure and components is shown in Figure 2. The four main categories are resource utilization, management methods, project characteristics and features, and internal

Table 3. Expert information.

| No. | Company size | Title | Working project | Background | Project used for validation process | Experience (years) |
|---|---|---|---|---|---|---|
| 1 | Large | Site manager | High-rise commercial project | Modern urban infrastructure | High-rise commercial project | 12 |
| 2 | Small | Site manager | Suburban residential development | Affordable housing | Suburban residential development | 5 |
| 3 | Large | Site manager | High-rise commercial project | Green buildings | High-rise commercial project | 15 |
| 4 | Medium | Site manager | Housing complex | Affordable housing | Urban residential project | 6 |
| 5 | Medium | Site manager | Suburban residential development | Affordable housing | Suburban residential development | 10 |
| 6 | Large | Site manager | High-rise commercial project | Commercial buildings | High-rise commercial project | 11 |
| 7 | Large | Site manager | Industrial sector | Large-scale manufacturing facilities | Large-scale manufacturing facility | 14 |
| 8 | Medium | Site manager | Suburban residential development | Affordable housing | Suburban residential development | 9 |
| 9 | Small | Site manager | Suburban residential development | Renovating existing properties | Brownfield redevelopment | 7 |
| 10 | Large | Site manager | Infrastructure project | Roads and bridges | Large-scale infrastructure project | 13 |
| 11 | Large | Project manager | High-rise commercial project | Commercial buildings | Mid-rise building projects | 8 |
| 12 | Medium | Foreman | High-rise commercial project | Commercial buildings | Mid-rise building projects | 6 |

and external factors. The first category, resource utilization, encompasses the use of materials and equipment, and labor resources. The second category is management methods, which includes construction and project management, and level of competency and skill among team members. The third category, project characteristics and attributes, includes specific project characteristics and working conditions. Finally, the fourth category is internal and external factors, which includes safety and environmental considerations, and economic and social factors.

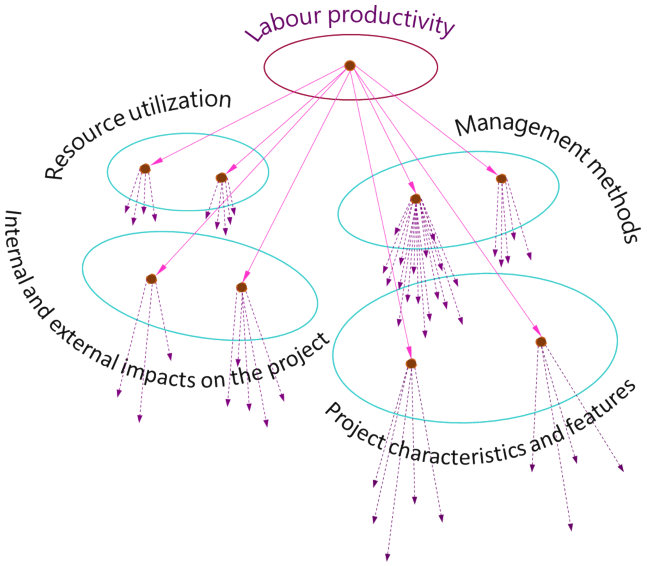


Figure 2. System of factors impacting labor productivity.

## CATEGORY 1: RESOURCE UTILIZATION

### Sub-category 1.1: Materials and equipment

There are four factors in the materials and equipment group, which are availability of construction materials on the job site; availability of tools, equipment, and construction machinery; maintenance of machinery and equipment; and use of new materials. The availability of construction materials on the job site is a vital factor in labor productivity. Timely and sufficient availability of materials ensures smooth progress and minimizes downtime. Delays in delivery of construction materials can lead to rework (Arashpour, et al., 2014), which decreases efficiency and reduces productivity. The availability and quality of tools, machinery, and equipment significantly impact labor productivity. Having the necessary tools and equipment readily available on the job site enables workers to perform their tasks efficiently. Limited access to tools and equipment can cause delays (Toor and Ogunlana, 2008), inefficiencies, and increased labor effort.

Regular maintenance on equipment are also crucial to maintaining optimal labor productivity. Machines that are diligently and regularly maintained not only retain their ability to adhere to precise specifications and tolerances but also play a crucial role in minimizing the need for rework (Lee, 1995), hence improving overall productivity. Additionally, the utilization of new materials in construction projects can have implications for labor productivity. New materials can offer improved characteristics, such as enhanced durability, ease of installation, or reduced weight (Karbhari and Seible, 2000), which can enhance construction processes and increase productivity. Proper planning, training programs, and effective implementation strategies can harness the benefits of utilizing new materials while minimizing disruptions to labor productivity.

### Sub-category 1.2: Labor resources

The labor resources group consists of five factors, namely workforce experience, labor discipline, cultural knowledge, relationship between construction workers, and pay structure and amount. The level of experience of the workforce is the first factor that can significantly impact labor productivity. A lack of experienced workers is one of the causes of rework (Yap, Low and Wang, 2017) that not only disrupts the construction timeline but also leads to unnecessary waste of materials (Mahamid, 2022). This issue can also lead to delays (Ogunlana, Promkuntong and Jearkjirm, 1996; Sambasivan and Soon, 2007), errors (Karimi, et al., 2016), and the need for additional supervision and training, ultimately reducing labor productivity. Labor discipline also plays a vital role in labor productivity. Lack of discipline can result in absenteeism (Salehi Sichani, Lee and Robinson Fayek, 2011), low motivation, and reduced productivity. Establishing clear expectations, encouraging a culture of accountability, and providing ongoing supervision can enhance labor discipline and productivity.

The cultural knowledge of the workforce also impacts labor productivity. Workers with higher levels of cultural knowledge possess better problem-solving skills, adaptability, and a broader understanding of construction processes (Manoharan, et al., 2024). Inter-worker relationships significantly influence labor productivity. Positive and collaborative relationships among workers enhance effective communication, teamwork, and coordination, leading to improved productivity (Fulford and Standing, 2014). Conversely, conflicts, lack of communication, or poor teamwork can cause disruptions, misunderstandings, and decreased efficiency. The structure and extent of wages can also impact labor productivity. Fair and competitive wages motivate workers to perform their work well, enhancing commitment and productivity. In contrast, wage disparities can diminish group cohesion, which is crucial for enhancing productivity, especially in tasks requiring employee cooperation (Leete, 2000; Levine, 1991).

## CATEGORY 2: MANAGEMENT METHODS

### Sub-category 2.1: Construction and management

Construction and management factors can be categorized into three main groups. The first group is design and planning-related factors, which include adjustments needed due to the differences between reality and design, changes in technical or architectural requirements, availability of construction drawings, unclear construction drawings, rationality of planning and scheduling, arrangement and layout of the construction site, and the plan for supplying and transporting construction materials and equipment. The second group is information and communication-related factors, including ineffective information management and communication systems, lack of standardized measurement and forecasting systems for labor productivity, coordination among stakeholders, and subcontractor management. The third group is construction-related factors, which include ineffective construction techniques, adopting new construction technology and methods, plan for using and maintaining machinery and equipment, arrangement of personnel and supervision, mistakes during the construction process, incentive mechanisms, and training and development programs for workers. Addressing these factors is crucial to ensure effective labor productivity in construction projects.

Regarding the first group, which includes design and planning-related factors, discrepancies between the design and the reality on the construction site often emerge as a primary issue. These differences can arise from errors or omissions in the design documentation or unforeseen site conditions (Naoum, 2016). Such variations significantly impact labor productivity by subjecting workers to unexpected obstacles or necessitating additional resources to align the project with the intended design. Changes in technical or architectural requirements also have a substantial influence on labor productivity management (Moselhi, Leonard and Fazio, 1991). As projects progress, modifications may become necessary to meet evolving

needs or comply with updated regulations. These alterations disrupt workflow and productivity (Ibbs, 2005) as workers must adapt to new instructions, acquire additional skills, or adjust their work processes. The availability of construction drawings plays a crucial role in labor productivity management (Dai, Goodrum and Maloney, 2007). Insufficient or incomplete drawings can cause misunderstandings among the workforce. This can create confusion and disagreement, resulting in numerous errors in the workplace, ultimately impacting labor productivity. Unclear construction drawings can also lead to rework, delays (Assaf and Al-Hejji, 2006; Noulmanee, et al., 1999), and inefficiencies as workers seek clarification, make assumptions, or engage in trial and error.

The rationality of planning and scheduling is another critical factor affecting labor productivity. Poorly organized or unrealistic schedules strain the workforce, resulting in rushed work, inadequate resource allocation, delays (Khoshgoftar, Bakar and Osman, 2010; Ogunlana, Promkuntong and Jearkjirm, 1996), or a lack of coordination. Conversely, with a clear and well-planned schedule, when workers stick to their assigned tasks and timelines, the work progresses smoothly, leading to optimal performance and results (Ballard and Howell, 1995). The arrangement and layout of the construction site significantly impact labor productivity. A poorly organized site impedes the movement of workers and equipment. This can cause site congestion, which affects the performance of a project (Thomas, et al., 2002) and is one factor that negatively impacts productivity (Ghoddousi and Hosseini, 2012). Conversely, a well-designed site layout that significantly influences operational efficiency and productivity (Small and Baqer, 2016) can optimize worker movement and enable smooth operations, thus boosting labor productivity.

Labor productivity can be influenced by the second group of factors, which includes information and communication-related factors. Firstly, ineffective information management and communication systems can have a significant impact on labor productivity. Construction projects involve multiple stakeholders, including architects, engineers, contractors, subcontractors, and suppliers, who have different objectives (Leung and Olomolaiye, 2010) and need to exchange information and collaborate effectively. However, if the information flow is hindered or communication among stakeholders is insufficient, it can result in more on-site rework, thus leading to productivity reduction (Naveed and Khan, 2022).

Secondly, the lack of standardized measurement and forecasting systems for labor productivity can hamper project performance. Standardized metrics and forecasting models help identify areas of improvement, enable benchmarking against industry standards, and aid in resource allocation and planning. Benchmarking is only effective when there are consistent methods in place to measure and evaluate the performance of operations (Mohamed, 1996). Coordination among stakeholders is another critical factor influencing labor productivity. A lack of coordination throughout the project often arises as stakeholders such as designers and contractors tend to work independently from each other (Ajayi, et al., 2016). This can cause conflicting priorities or delays in information sharing, which ultimately leads to disruptions, rework, and inefficiencies. Lastly, effective subcontractor management is crucial for labor productivity in construction. Most construction projects rely heavily on subcontractors for successful completion (Arditi and Chotibhongs, 2005). A significant shift in the construction industry over the decades has been the move from employing in-house workers to utilizing extensive subcontracting chains. Subcontracting, while offering flexibility and cost advantages, is associated with declining productivity and quality standards and increased difficulties in coordinating and supervising work due to the temporary nature of subcontractor relationships (Debrah and Ofori, 2001). These problems are exacerbated by the increased number of layers in the subcontracting chain (Tam, Shen and Kong, 2011).

Lastly, the third group including construction-related factors also impacts labor productivity. Ineffective construction techniques are a key factor that can hinder labor productivity due to wasted time or increased labor requirements. Evaluating and improving construction techniques allows projects to enhance processes, reduce errors, and improve labor productivity. Another factor is the adoption of new construction technology and methods. Using advanced technologies such as Building Information Modeling (BIM),

Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) is expected to enhance communication among stakeholders (Elghaish, et al., 2021), improve project delivery (Ammar, Russello and Crispo, 2018), decrease accidents and fatalities at the construction site (Aghimien, et al., 2020), and boost productivity (Leviäkangas, Paik and Moon, 2017). Also, prefabrication is a method of production that has the potential to significantly enhance productivity and sustainability in construction (Mossman and Sarhan, 2021).

The arrangement of personnel and effective supervision is another important factor. When workers are assigned tasks aligned with their abilities and receive adequate support and oversight, productivity is optimized. Mistakes during the construction process can have a detrimental impact on labor productivity. Errors and rework lead to delays, increased costs, and decreased overall efficiency. If robust quality control measures are implemented, clear instructions and standards are provided, and attention to detail is promoted, the mistakes can be minimized, productivity can be improved, and setbacks can be avoided. Incentive mechanisms also play a role in influencing labor productivity. Recognizing and rewarding workers for their performance, productivity, and innovation fosters a positive work environment and motivation. Furthermore, training and development programs for workers contribute to enhanced labor productivity. Developing skills is fundamental to achieving rapid, sustainable, and comprehensive growth in construction. Investing in the development of workers not only improves their performance but also creates a skilled workforce capable of meeting project demands effectively.

### Sub-category 2.2: Skill level

This section will discuss five skill-level-related factors and their significance in effective management, which are professionalism of third-party entities, capability and experience of the main contractor, capacity and responsibility of the supervision consultant, capability and experience of the design team, and proficiency and skill level of the workforce. Regarding the professionalism of third-party entities, such as subcontractors and suppliers, engaging professional and reputable third-party entities with a track record of delivering high-quality work and timely services is essential to mitigate potential delays, quality issues, and disruptions in the construction process. The capability and experience of the main contractor also influence labor productivity management. The main contractor must carry out all tasks according to the plans and specifications laid out in the contract documents, which are created by the designer (Oberlender, 1993). A contractor with a strong skill set and sufficient experience can effectively manage the workforce, allocate resources efficiently, and provide clear direction, ultimately enhancing labor productivity.

The capacity and responsibility of the supervision consultant are another critical factor. The responsibilities of the supervision consultants involve construction supervision, managing projects and programs, and ensuring quality (Choudhry, 2016; FIDIC, 2011). A competent and responsible supervision consultant can provide timely guidance, address issues promptly, and facilitate smooth progress, contributing to the optimization of labor productivity. The capability and experience of the design team also impact labor productivity. Well-designed construction plans, accurate drawings, and detailed specifications are essential for smooth execution. Exotic designs and unclear design details can lead to project issues such as design inconsistencies, the need for rework, and productivity reduction (Arain, Pheng and Assaf, 2006).

## CATEGORY 3: PROJECT CHARACTERISTICS AND FEATURES

### Sub-category 3.1: Characteristics of the construction project

The characteristics of a construction project encompass several key factors that influence labor productivity. These factors include the type of contract employed in the project, the scale of the project, the availability of investment capital, the frequent design changes, and the project's quality requirements. Various contract types, such as lump-sum contracts, cost-plus contracts, or unit price contracts, have distinct implications

for productivity. Poorly defined scopes of work or ambiguous contract terms can result in disputes (Koc and Gurgun, 2022), ultimately reducing productivity. Project scale is another crucial factor affecting labor productivity. The escalating complexities due to larger project sizes are mathematically evident, as the number of potential communication channels increases exponentially with the addition of each participant (Tucker, 1986). The complexities of managing larger projects, with their intricate logistics, multiple work fronts, and increased workforce, necessitate efficient management to avoid delays, coordination issues, and resource wastage.

The availability of investment capital for the project also plays a significant role. Timely payments from the project owner to contractors and subcontractors are crucial for maintaining a steady workflow (Xie, et al., 2019). Insufficient funding or payment delays can lead to a halt in material supply (Abdul Kadir, et al., 2005), disruptions, resource shortages, and decreased workforce motivation. Frequent design changes pose a challenge to labor productivity. Almost all civil engineering and building projects will experience changes in the scope, type, sequence, or duration of work after the contract has started (Kaming, et al., 1997). Changes in project design require adjustments in work processes, materials, and coordination among trades, leading to rework, delays (Kaming, et al., 1997), and increased labor hours. Moreover, the quality requirements for construction have an impact on labor productivity. Stringent quality standards often necessitate additional inspections, testing, and compliance measures, which can increase the time and effort required for completing tasks. Balancing quality requirements with productivity considerations is crucial to avoid excessive bureaucracy and potential inefficiencies.

**Sub-category 3.2: Working conditions**

Working conditions play a significant role in influencing labor productivity, and several factors within this category can have a substantial impact. These factors include location and transportation conditions of the project, limited workspace, workplace safety, and adaptability of construction site. The location and traffic conditions of a project play a significant role in labor productivity. In a populated urban area, designing a building may require a multi-stage construction approach to ensure adequate working space (Kaming, et al., 1997). Projects situated in congested or hard-to-reach areas can result in increased travel time for workers (Gupta, et al., 2018), which can adversely affect their overall efficiency. Furthermore, limited access to transportation and infrastructure can impede the timely delivery of materials and equipment (Ying, Tookey and Roberti, 2014), further hindering productivity.

Another factor impacting labor productivity is the availability of workspace. Interference in workspaces often results in inefficiencies, the need for rework, and increased risks to workers (Tao, et al., 2020). When the workspace is limited, workers may encounter difficulties in maneuvering, storing materials, and setting up equipment as they constantly adjust their movements and find alternative solutions to accommodate the restricted space. Workplace safety is a crucial factor that influences labor productivity. When workers feel unsafe or are exposed to hazards, their focus and attention may be diverted from their tasks, leading to reduced efficiency. Additionally, accidents and injuries can result in time off work, and employees may be unable to perform at full capacity when they return (Arditi and Gunaydin, 1997), leading to potential delays in project completion. Moreover, the adaptability of the construction site significantly affects labor productivity. When a site can swiftly adjust to changes in project plans, weather conditions, or unexpected challenges, it ensures that workers can maintain a steady workflow, thereby boosting efficiency. Also, flexible use of space and easy access to tools and materials in the construction site reduce downtime and enhance the effectiveness of labor.

## CATEGORY 4: INTERNAL AND EXTERNAL IMPACTS ON THE PROJECT

### Sub-category 4.1: Safety and environment

Safety and environment encompass maintaining a clean and hygienic environment, managing adverse weather conditions, and implementing an occupational safety and health plan. Maintaining environmental cleanliness is crucial for optimal labor productivity. A clean and well-maintained work environment promotes better health, reduces the risk of illnesses and infections, and enhances worker morale and productivity. Establishing effective waste management systems, promoting cleanliness practices, and providing appropriate sanitation facilities contribute to a healthy and conducive work environment. Weather conditions, including natural disasters such as storms, floods, and extreme weather events, can significantly impact labor productivity. Construction projects exposed to severe weather face difficulties in carrying out activities, protecting materials and equipment, and ensuring worker safety (Schuldt, et al., 2021). For example, heat stress, resulting from global warming, can lead to fatigue, dizziness, and, in extreme cases, even death (Kovats and Hajat, 2008), causing a reduction in labor productivity. Occupational safety and health plan is a critical factor influencing labor productivity. Inadequate safety protocols, improper use of equipment, and lack of safety training can lead to accidents, injuries, and interruptions in work activities. Developing safety and health policies for construction projects can lower the chances of accidents, leading to improved project productivity (Gurmu, 2019).

### Sub-category 4.2: Economic and social

Labor productivity in construction projects can be influenced by economic and social factors including government intervention, compensation and land clearance, market price fluctuations, security around the construction site, and changes in laws and policies. Government intervention is a key factor that can impact labor productivity. Bureaucratic processes, permitting issues, and changes in regulations can lead to delays and disruptions in construction activities. Excessive administrative burdens and uncertainty surrounding government actions can hamper project progress and affect the motivation and efficiency of the workforce. Compensation and land clearance processes are also critical considerations in labor productivity. Projects involving land acquisition or the relocation of communities may encounter challenges in compensation negotiations (Long, et al., 2004), legal disputes, and delays in obtaining approvals. These issues can disrupt the project, decrease workforce morale, and reduce productivity.

Market price fluctuations can significantly affect labor productivity in construction projects. Changes in the costs of materials, equipment, and labor can disrupt project budgeting and planning, resulting in delays (Amoatey, et al., 2015; Sanni-Anibire, Mohamad Zin and Olatunji, 2022), procurement adjustments, and potential conflicts. Monitoring market trends, conducting regular market research, and implementing proactive strategies to address price fluctuations can minimize their impact on labor productivity. Maintaining security around the construction site is vital for ensuring uninterrupted work and optimal productivity. Security concerns, such as vandalism, theft, or protests, can create an unsafe and unstable environment for workers, leading to decreased productivity (Berg and Hinze, 2005). Implementing appropriate security measures, collaborating with local authorities, and engaging with the community can help mitigate risks and maintain productivity levels. Furthermore, changes in laws and government policies during project execution can significantly affect labor productivity. Modifications in regulations, building codes, or environmental standards may require adjustments to project plans, additional compliance measures, disruptions, or rework. For example, the pandemic led to multiple factors causing delays and disruptions, including travel bans, site closures, strict health guidelines, and virus spread among construction workers (Gammanage and Gunarathna, 2022).

## An assessment tool supporting labor productivity management

This section introduces a comprehensive tool designed to assess factors that significantly impact labor productivity. The tool comprised a detailed measurement scale and an easy-to-follow guide. The measurement scale, shown in Table 4, is crafted to mirror the current state of labor productivity management, drawing insights from the assessment scores allocated to each element within the factor groups. In the scale, each group of factors is assigned five levels of significance with a clear and concise explanation for each level. This design ensures that users can understand the significance of each level and effectively navigate through the assessment process. Building on this foundation, Table 5 shows the instruction questionnaire, filled with detailed descriptions and characteristics of the components that constitute each factor group. This serves as an invaluable guide, supporting users in conducting a thorough and accurate assessment. It should be noted that "Category 1: Resource utilization" is used as an example in these tables, and similar tables also exist for the other categories. The result of this assessment process is reflected in the overall score, a numerical representation of the levels of labor productivity management. This score is derived from the average of the component factors' scores. Table A1 in the appendices explores this score in greater detail, connecting it with the corresponding level of labor productivity management according to the suggested scale.

To effectively utilize the labor productivity management assessment tool, the process is started by addressing the guiding questions provided in Table 5 for each factor across the different factor groups and ensuring that the possible score for each factor aligns with the maximum scores indicated. For example, considering the factor group "Materials and equipment", after answering all the guiding questions in "availability of construction materials on the job site", "availability of tools, equipment, and construction machinery", "maintenance of machinery and equipment", and "the use of new materials", hypothetical scores of 3, 5, 4, and 3 might be assigned, respectively. The assessment of all factors is followed by summing the scores obtained in each factor group. In the instance of "Materials and equipment", the summation of scores

Table 4. Assessment tool of labor productivity management level.

| Main categories | Group of factors | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Maximum score |
|---|---|---|---|---|---|---|---|
| Resource Utilization | A1. Materials and equipment: | (0–4) | (5–9) | (10–14) | (15–18) | (19–20) | |
| | 1. Availability of construction materials on the job site<br>2. Availability of tools, equipment, and construction machinery<br>3. Maintenance of machinery and equipment<br>4. Use of new materials | Lack of preparation | No specific plan for implementation | Basic preparation and planning | Clear and detailed planning | Always being prepared and developing detailed plans from the beginning, and having contingency plans | 5 |
| | A2. Labor resources: | (0–5) | (6–11) | (12–17) | (18–22) | (23–25) | |
| | 1. Insufficient experienced workforce<br>2. Labor discipline<br>3. Cultural knowledge<br>4. Relationship between construction workers<br>5. Pay structure and amount | Lack of preparation | Low awareness and lack of preparation for management | Moderate level of experience and basic resource management plan | Extensive experience, clear understanding of the issues, and clear resource management plan | Comprehensive vision, organizing labor resources with planning from the start, and having contingency plans | 5 |
| ... | ... | ... | ... | ... | ... | ... | ... |

Table 5. Guidelines for determining the level of labor productivity management.

| Main category | Group of factors | Factor | Guiding question | Maximum score for each factor | Total maximum score |
|---|---|---|---|---|---|
| Resource Utilization | A1. Materials and Equipment | 1. Availability of construction materials on the job site | • How do construction materials impact the construction process, and what is the extent of their influence?<br>• What criteria should the contractor and the supplier consider when selecting materials? (e.g., lifespan, design, origin, quality, aesthetic aspects)<br>• Do the parties involved in the project (contractor, supervisors, suppliers, etc.) have a clear vision and understanding of the project requirements?<br>• What challenges may arise if this aspect experiences negative changes? | 5 | 20 |
| | | 2. Availability of tools, equipment, and construction machinery | • Are the necessary tools and equipment for laborers readily available and properly arranged on-site according to the project plan?<br>• Do the relevant parties understand the significance of using machinery and equipment?<br>• Can the laborers' productivity be affected if they do not have access to sufficient tools, machinery, and equipment?<br>• Does the supplier have enough machinery and equipment to meet the construction schedule?<br>• What preparations are in place to ensure effective labor productivity? | 5 | |
| | | 3. Maintenance of machinery and equipment | • Is there a maintenance plan in place for the machinery and equipment? If yes, what does the plan entail?<br>• Is there a strict adherence to inspection and maintenance procedures for machinery and equipment as per regulations?<br>• Does the project utilize modern and reliable machinery and equipment? | 5 | |
| | | 4. Use of new materials | • Is there training provided to laborers when introducing new materials?<br>• Can the construction be carried out efficiently and within the specified time when using new materials?<br>• Does the supplier have experience using these new materials? | 5 | |
| | A2. Labor Resources | 1. Insufficient experienced workforce | • Has the supplier recruited additional skilled laborers?<br>• How does this shortage affect labor productivity? | 5 | 25 |
| | | 2. Labor discipline | • Do the laborers comply with the work regulations on the construction site, including personal conduct guidelines (hygiene, safety, handling violations, working hours, breaks, etc.)? | 5 | |
| | | 3. Cultural knowledge | • Does the company pay attention to the welfare and mental well-being of the laborers? Do they provide training to enhance their skills and improve their professional ethics and behavior? | 5 | |
| | | 4. Relationship between construction workers | • What preparations have been made to enhance a collective relationship among different groups of laborers? What positive and negative impacts can arise from the relationships among workers in both directions?<br>• Does the relationship among laborers affect labor productivity? If so, what measures are taken to address these impacts? | 5 | |

Table 5. continued

| Main category | Group of factors | Factor | Guiding question | Maximum score for each factor | Total maximum score |
|---|---|---|---|---|---|
| | | 5. Pay structure and amount | • Are the salary payment methods suitable for each type of job?<br>• Does the company have productivity incentives for the laborers?<br>• ... | 5 | |
| | ... | ... | | ... | ... |

3, 5, 4, and 3 results in a total score of 15. This total score is then utilized to ascertain the corresponding level of significance via Table 4. In this case, the total score of 15 aligns with Level 4, which corresponds to a score of 4. Upon replicating this evaluative and scoring process across all factor groups, the overall score is determined by averaging the scores assigned to each group. Finally, Table A1 is referred to match the overall score with the descriptions provided, enabling a clear understanding of the current state of labor productivity management.

By providing scores for individual components and an overall score, this tool empowers managers with insights into the current state of productivity management. This approach paves the way for increased awareness and strategic interventions to enhance labor productivity and management effectiveness.

## Validation of the assessment tool

The interpretation of scale is shown in Table A2 and the validation results are shown in Table A3 in the appendices. It is worth noting that the evaluation of the assessment tool by 12 experts reveals a notable consistency in the scores across various criteria. Expert 11, a project manager, and Expert 12, a foreman, both provided ratings that align closely with the scores given by the 10 site managers. This homogeneity in responses across different roles within the construction industry underscores the robustness and reliability of the tool.

Table 6 presents the validation results from 12 experts across nine different criteria. With an average rating of 3.08, the toolkit demonstrates a reasonable level of feasibility in practical applications. This suggests that while it can be implemented in real-world scenarios, there may be some challenges or areas for improvement to enhance its practicality further. The toolkit's contribution to the effectiveness of employee management received an average rating of 2.83, indicating that it offers a reasonable to limited level of support. While the toolkit aids in employee management, its impact is not significant, and there are potential areas that need enhancement to increase its effectiveness.

The clarity and simplicity of formatting and wording were rated at 3.25, showing that the content is generally clear and understandable, leaning toward being clear, concise, and user-friendly, with minor areas for improvement. This indicates that while the toolkit is mostly well-presented, some aspects could be refined for better clarity and simplicity. The appropriateness of the evaluation scale for the construction industry received an average rating of 3.00, suggesting that the scale is relevant but might require some adjustments to fully align with the specific needs and conditions of the construction industry in Vietnam.

In terms of the content presented fully addressing the tasks and objectives set forth, the toolkit scored 2.83. This implies that while it covers many necessary aspects, it falls short in some areas and needs improvement to comprehensively meet all tasks and objectives. The close integration with other management processes during the construction phase was rated at 3.42, indicating that the toolkit integrates

well with other processes, showing a moderate to high level of coordination, communication, and alignment. However, there is room for making this integration even more seamless and effective.

The flexibility, suitability, and practicality of the toolkit for employee management received an average rating of 2.33, suggesting that it has some adaptability and practicality but needs significant improvements to be more flexible and better suited to diverse employee management objectives. The information gathering and data collection methods were rated at 3.00, implying that while the methods used are generally suitable, there are areas that could be optimized to better meet the objectives. Lastly, the contribution to enhancing the awareness and knowledge of stakeholders regarding employee management received a rating of 3.33, suggesting that the toolkit is effective in educating stakeholders but could be enhanced to have a more profound impact.

Table 6. Summary of main points from the validation results.

| No. | Criterion | Average rating | Brief validation from the scale |
|---|---|---|---|
| 1 | Feasibility of the toolkit when applied in practice | 3.08 | The toolkit demonstrates a reasonable level of feasibility in practical applications. |
| 2 | Contribution of the toolkit to the effectiveness of employee management | 2.83 | The toolkit offers a reasonable to limited level of contribution to the effectiveness of employee management. |
| 3 | Clarity and simplicity of formatting and wording | 3.25 | The formatting and wording of the content are generally clear and understandable, leaning toward being clear, concise, and user-friendly, with minor areas for improvement. |
| 4 | Appropriateness of the evaluation scale for the construction industry | 3.00 | The evaluation scale has a moderate level of appropriateness for the construction situation in Vietnam. |
| 5 | The content presented fully addresses the tasks and objectives set forth | 2.83 | The content presented reasonably to partially addresses the tasks and objectives set forth. |
| 6 | Close integration with other management processes during the construction phase | 3.42 | The integration of the management processes with the construction phase is reasonably effective, showing a moderate to high level of coordination, communication, and alignment. |
| 7 | Flexibility, suitability with the objective, and practicality of employee management | 2.33 | The toolkit exhibits limited to reasonable flexibility, suitability, and practicality. |
| 8 | Information gathering and data collection fully appropriate to the objectives set forth | 3.00 | The information gathering and data collection methods exhibit a moderate level of appropriateness. |

Table 6. continued

| No. | Criterion | Average rating | Brief validation from the scale |
|---|---|---|---|
| 9 | Contributes to enhancing the awareness and knowledge of stakeholders regarding employee management | 3.33 | The toolkit makes a reasonable to significant contribution to enhancing the awareness and knowledge of stakeholders. |

## Implication of the assessment tool

This study makes a substantial contribution to both theoretical knowledge and practical applications in the field of construction management. From a theoretical viewpoint, it provides a comprehensive framework and an understanding of the various factors that influence labor productivity in construction projects. By categorizing these factors into distinct groups and establishing a measurement scale, the study enriches the existing body of knowledge, offering a structured approach to analyzing and assessing labor productivity.

On the practical side, the introduction of a specialized tool designed specifically for the construction industry stands as a significant advancement. This tool, comprising a measurement scale and an instructive guide, serves as a solution for managers and practitioners in the field, facilitating a more systematic and efficient evaluation of labor productivity. The clear categorization of factors, along with the assignment of significance levels, helps to precisely identify areas that need improvement, thereby enabling targeted interventions and strategies.

Furthermore, by providing scores for individual components and an overall productivity management level, the tool enhances transparency and objectivity in productivity assessment, encouraging a culture of continuous improvement. The inclusion of detailed descriptions and characteristics for each factor, along with the correlation of scores to productivity levels, ensures that the tool is user-friendly and accessible, even for those who may not have extensive expertise in productivity management.

In summary, this study not only contributes valuable theoretical insights that deepen our understanding of labor productivity in construction but also offers a practical tool that directly addresses the needs of the industry, narrowing the gap between academic research and on-the-ground practices.

## Conclusion

This study has established a comprehensive system for assessing labor productivity management, comprising four main categories and a total of 49 component factors. These categories are resource utilization, project characteristics and features, internal and external factors, and management methods.

Based on this system of factors, a practical tool has been proposed, consisting of a measurement scale and an instructive guide. The suggested measurement scale offers clear explanations for each level, aiding evaluators in effectively understanding the current situation of labor productivity management. Additionally, the proposed instructive guide provides detailed descriptions and characteristics of the factors using the instruction questionnaire, serving as valuable guidance for the assessment process. A scale was also offered to provide the users with the overall productivity management level based on the overall score.

After validating the completeness and applicability of the tool by inviting experts to assess a project they were recently involved in, the evaluation results highlighted both the strengths and areas for improvement in the tool. While the feasibility of implementing the toolkit in practical scenarios shows potential, further refinement and adaptation may be necessary to maximize its effectiveness. The support provided for enhancing labor management efficiency received mixed ratings, emphasizing the need for a more

comprehensive evaluation and refinement of the toolkit's features. On a positive note, the presentation format and clarity of the content are well-received, demonstrating that the toolkit effectively conveys its intended message. The appropriateness of the evaluation scale for the construction context is generally affirmed, with only minor adjustments suggested. There is room for enhancing the completeness of task objectives, as well as improving the toolkit's flexibility to better address the diverse needs and challenges associated with managing laborers in construction projects. On the other hand, the toolkit's information-gathering process is considered adequate, and its potential contribution to raising awareness and knowledge about labor management in construction projects is recognized.

The tool introduced in this study offers a structured and informative approach to assessing and enhancing labor productivity management in construction projects. These resources empower managers to make informed decisions and improvements, ultimately contributing to more efficient and successful project outcomes.

Future research will focus on improving the labor productivity management tool by addressing subjectivity in assessments. Implementing a multi-evaluator approach and developing standardized guidelines and training programs for evaluators will enhance objectivity and consistency. Additionally, future research will explore the creation of a dedicated software application to integrate the tool into daily operations, facilitating efficient data collection and real-time feedback. This software will streamline on-site productivity tracking and management. Validation across different construction projects and regions will ensure broad applicability and effectiveness. Comparative studies in diverse settings will refine the tool and provide insights into factors influencing labor productivity. Longitudinal studies will assess the tool's long-term impact on project performance and productivity, ensuring its sustained relevance and value in the construction industry. The ultimate goal is to develop a robust, user-friendly tool that enhances labor productivity management across various construction projects.

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## Appendices

Table A1. Scale of the overall level of labor productivity management.

| Overall score | Description |
|---|---|
| 1 | No planning preparation |
| 2 | No data and preparation for productivity management |
| 3 | Some necessary data have been prepared, and proposals for productivity management plans have been suggested |
| 4 | Many necessary data have been prepared, studied, and analyzed. Implementation of detailed productivity management plans has been carried out. |
| 5 | A significant amount of important data have been collected, studied, and analyzed. Detailed and specific productivity management plans have been established and readied for any situation. Flexibility, continuous updating, and innovation efforts have been implemented. |

Table A2. Likert scale for the evaluation of completeness and applicability of the tool.

| No. | Criteria | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|---|---|
| 1 | Feasibility of the toolkit when applied in practice | The toolkit is highly impractical and nearly impossible to implement in real-world scenarios | The toolkit has some limitations and challenges when applied in practice | The toolkit demonstrates a reasonable level of feasibility in practical applications | The toolkit is highly practical and can be readily applied in real-world situations | The toolkit is exceptionally feasible and practically ready for widespread adoption |
| 2 | Contribution of the toolkit to the effectiveness of employee management | The toolkit makes a negligible or insignificant contribution to the effectiveness of employee management | The toolkit provides limited support and has a minor impact on the effectiveness of employee management | The toolkit offers a reasonable level of contribution to the effectiveness of employee management | The toolkit highly contributes to the effectiveness of employee management | The toolkit makes an exceptional contribution to the effectiveness of employee management |
| 3 | Clarity and simplicity of formatting and wording | The formatting and wording of the content are highly convoluted, confusing, and difficult to understand | The formatting and wording of the content have some clarity issues and are relatively complex | The formatting and wording of the content are generally clear and understandable, but some areas may still require improvement | The formatting and wording of the content are clear, concise, and presented in a user-friendly manner | The formatting and wording of the content are exceptionally clear, simple, and well-crafted |
| 4 | Appropriateness of the evaluation scale for the construction industry | The evaluation scale is highly unsuitable for the construction situation in Vietnam | The evaluation scale has limited relevance to the construction situation in Vietnam | The evaluation scale has a moderate level of appropriateness for the construction situation in Vietnam | The evaluation scale is generally appropriate for the construction situation in Vietnam | The evaluation scale is highly suitable and tailored specifically for the construction situation in Vietnam |
| 5 | The content presented fully addresses the tasks and objectives set forth | The content presented inadequately addresses the tasks and objectives set forth | The content presented partially addresses some of the tasks and objectives, but it falls short in several areas | The content presented reasonably addresses the majority of the tasks and objectives set forth | The content presented effectively addresses the tasks and objectives set forth | The content presented fully and excellently addresses all the tasks and objectives set forth |
| 6 | Close integration with other management processes during the construction phase | The integration of the management processes with the construction phase is extremely limited or non-existent | The integration of the management processes with the construction phase is limited and fragmented | The integration of the management processes with the construction phase is reasonably effective to a moderate extent | The management processes are closely integrated with the construction phase, resulting in a high level of coordination, communication, and alignment | The integration of the management processes with the construction phase is exceptionally close and seamless |

Table A2. continued

| No. | Criteria | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|---|---|
| 7 | Flexibility, suitability with the objective, and practicality of employee management | The toolkit lacks flexibility, suitability, and practicality | The toolkit has limited flexibility, suitability, and practicality | The toolkit exhibits a reasonable level of flexibility, suitability, and practicality | The toolkit demonstrates a high degree of flexibility, suitability, and practicality | The toolkit exhibits exceptional flexibility, suitability, and practicality |
| 8 | Information gathering and data collection fully appropriate to the objectives set forth | The information gathering and data collection methods employed are highly inadequate and unsuitable for achieving the set objectives | The information gathering and data collection methods have some limitations and fall short of fully meeting the objectives set forth | The information gathering and data collection methods exhibit a moderate level of appropriateness in relation to the objectives | The information gathering and data collection methods are highly appropriate and well-aligned with the objectives set forth | The information gathering and data collection methods are exceptionally appropriate and tailored specifically to the objectives at hand |
| 9 | Contributes to enhancing the awareness and knowledge of stakeholders regarding employee management | The toolkit has minimal or no contribution to enhancing the awareness and knowledge of stakeholders regarding employee management | The toolkit provides limited contribution to enhancing the awareness and knowledge of stakeholders regarding employee management | The toolkit makes a reasonable contribution to enhancing the awareness and knowledge of stakeholders regarding employee management | The toolkit significantly contributes to enhancing the awareness and knowledge of stakeholders regarding employee management | The toolkit makes an exceptional contribution to enhancing the awareness and knowledge of stakeholders regarding employee management |

Table A3. Validation results from 12 experts with nine different criteria.

| | Expert 1 | Expert 2 | Expert 3 | Expert 4 | Expert 5 | Expert 6 | Expert 7 | Expert 8 | Expert 9 | Expert 10 | Expert 11 | Expert 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Criterion 1 | 3 | 2 | 3 | 3 | 4 | 3 | 4 | 3 | 3 | 3 | 3 | 3 |
| Criterion 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| Criterion 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Criterion 4 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 2 | 3 | 3 |
| Criterion 5 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| Criterion 6 | 4 | 4 | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 4 |
| Criterion 7 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 |
| Criterion 8 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Criterion 9 | 3 | 4 | 4 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 4 |

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