A case study on the site supervisory attributes in construction labour management, performance assessment and productivity measurement practices

Received 1 January 2024
Revised 25 February 2024
6 April 2024
Accepted 19 April 2024

Kesavan Manoharan
Department of Construction Technology, Faculty of Technology, Wayamba University of Sri Lanka, Kuliyapitiya, Sri Lanka

Pujitha Dissanayake and Chintha Pathirana
Department of Civil Engineering, Faculty of Engineering, University of Peradeniya, Peradeniya, Sri Lanka

Dharsana Deegahawature
Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka, Kuliyapitiya, Sri Lanka, and

Renuka Silva
Centre for Quality Assurance, Wayamba University of Sri Lanka, Kuliyapitiya, Sri Lanka

Abstract

Purpose – The sustainability of the construction industry is associated with the productivity, profitability and competitiveness of the firms, which are significantly affected by inefficient site supervision and labour management approaches. This study aims to use a case study with mixed methods to evaluate the site supervisory characteristics in labour management, labour performance assessment and labour productivity measurement towards developing meaningful guidelines in polishing construction supervision attributes.

The academic and industry experts who enthusiastically participated in the meetings, discussions and review sessions for this research deserve the sincere gratitude of the authors. The University of Peradeniya and the Wayamba University of Sri Lanka were also acknowledged by the authors for their crucial support in organising the materials and resources for this study.

Disclosure statement: No potential conflict of interest was reported by the authors.

Data availability statement: The data that support the findings of this research work are available from the corresponding author upon reasonable request.

Journal of Responsible Production and Consumption
Vol. 1 No. 1, 2024
pp. 37-61
Emerald Publishing Limited
2977-0114
DOI 10.1108/JRPC-01-2024-0001

Design/methodology/approach – Well-developed modern apprenticeship elements were applied to 62 construction supervisors who were selected using the snowball sampling method, and their relevant competency characteristics were assessed using a comprehensively developed grading mechanism connected with useful training manuals/tools. Academic reviews, experts' consultations and other meticulous mixed approaches were applied at different stages of the research plan's sequential layout.

Findings – The mean performance scores of supervisors indicate proficient-level grades in the competency characteristics related to applying efficient labour management procedures and developing-level grades in designing productivity measurement tools, performing assessments on efficiency and productivity and proposing enhancement practices on efficiency and productivity for site operations. The findings point to a modern generalised guideline that establishes the ranges of supervisory attributes within the scope of the study. The validity, reliability, adaptability and generalisability of the findings were assured by using pertinent statistical tests and professional assessments.

Research limitations/implications – Though the study's conclusions/findings are primarily applicable to the construction environment of a developing country comparable to the Sri Lankan context, they will considerably impact current/future industrial practices in various other countries and emerging industries.

Originality/value – The research has produced a conceptualised modern tool that guides determining the capacity levels of supervisory attributes for carrying out labour management, labour performance assessment and labour productivity measurement aspects in construction. The research has opened a pump that inflows new values of highly workable supervision features for strengthening the site management structures and filling the industry's knowledge vacuum in the methodical execution of apprenticeships.

Keywords Construction supervision, Labour management, Performance assessment, Productivity measurement, Skill development, Training

Paper type Research paper

1. Introduction

The construction sector greatly supports the expeditious attainment of a nation's goals associated with economic and social aspects by creating a wide range of investment plans and employment opportunities (Hai and Tam, 2019). Prominently, higher productivity in the construction industry has a sizable impact on a nation's gross domestic product (Anil *et al.*, 2019). According to recent studies, the construction industry has strikingly the most labour-intensive structure because it employs millions of workers around the world for a longer period of time than any other industry (Victor, 2018; Kesavan *et al.*, 2022b). As a consequence, the effectiveness of labour operations has a significant impact on the outcomes of construction processes in terms of efficiency, quality, productivity and safety (Hai and Tam, 2019). But, due to the ineffectiveness of labour operations, thousands of construction firms have been facing various challenges in relation to capital flows and competition in many emerging nations (Victor, 2018; Hai and Tam, 2019; Kesavan *et al.*, 2022a), and that being the case for overrunning time and cost mostly (Silva *et al.*, 2018; Anil *et al.*, 2019; Hai and Tam, 2019) and productivity decline in the construction sector of numerous nations, including New Zealand (Serdar and Jasper, 2011), Trinidad and Tobago (Brent and Leighton, 2013), Australia (Hughes and Thorpe, 2014), Iran (Parviz *et al.*, 2015), Nigeria (Victor, 2018), Vietnam (Hai and Tam, 2019) and Sri Lanka (Kesavan *et al.*, 2020), in the past decade.

Many factors in construction operations have an impact on the effectiveness and productiveness of labour work (Victor, 2018; Anil *et al.*, 2019; Hai and Tam, 2019). Despite factors like poor manipulation practices associated with materials and tools (TVECSL, 2018; Hai and Tam, 2019), lack of labour motivation (Brent and Leighton, 2013), labour skill shortage (Parviz *et al.*, 2015) and other inevitable challenges/difficulties associated with advancement of technology (Abimbola, 2016; Victor, 2018) significantly influence such

labour effectiveness and productiveness, constructive site supervision approaches can provide practical answers and connections between these elements to handle efficiency-related issues and have a significant positive effect on work productivity. Site supervision skills are vital in determining how effectively labour is motivated to work and in bridging the gap between labour and employer (Victor, 2018; Hai and Tam, 2019; Kesavan *et al.*, 2020). Contemporary conditions, in particular in developing countries like Sri Lanka, show a very high level of impact of construction site supervision systems on the profitability of construction projects (Victor, 2018; Hai and Tam, 2019; Kesavan *et al.*, 2020). According to contemporary studies, the site supervisors employed in such developing countries need to work on sharpening their abilities to oversee labour activities that call for nimbler tool, material and equipment management (Victor, 2018; Kesavan *et al.*, 2022c).

The cognitive, manual and emotional abilities of employees have a direct impact on the components of the employment role, process and duties (Kesavan *et al.*, 2022a). According to recent research (Victor, 2018; Hai and Tam, 2019; Kesavan *et al.*, 2021) and consultation with industry experts, construction supervisors' capabilities in managing labour resources have substantial impacts on enhancing the effectiveness and productiveness of construction activities. This research emphasises the need for innovative labour monitoring procedures in light of this essential fact to guarantee the quality, quantity, safety and efficiency criteria for the work outputs of construction operations. It is critical to comprehend that apprenticeship components are vital to upgrading regular work practices, job responsibilities and specialised vocations of construction supervisory personnel connected to the problem-solving applications at work sites (Kesavan *et al.*, 2022a).

Since the above-illustrated facts can be unquestionably applied to many developing nations like Sri Lanka, it is beneficial for underlining the base of the study by analysing the Sri Lankan setting associated with the above facts. Sources concede that construction infrastructure development projects are crucial to the achievement of national objectives in a nation like Sri Lanka (Kesavan *et al.*, 2020). In the Sri Lankan setting, the construction sector has experienced enormous growth, attracting sizeable investments from governmental and private organisations after the protracted local war was resolved. As a consequence, the nation is currently operating on a variety of infrastructure development initiatives (TVECSL, 2018; Kesavan *et al.*, 2020). However, the Sri Lankan construction companies have reported major productivity-related facts highlighted in the above paragraphs on a huge number of those ongoing infrastructure development projects. Contemporary investigations highlight that this is largely due to poor supervision and labour management approaches (Silva *et al.*, 2018; TVECSL, 2018; Kesavan *et al.*, 2022b), further detailing that structural issues with the nation's system of vocational training and apprenticeships are the main reason for these shortcomings in Sri Lankan environment (TVECSL, 2018; Kesavan *et al.*, 2022b). Such investigations further state that the requirements of the construction business in the country and the educational system are wildly out of step (Kesavan *et al.*, 2020). The industry sector's lack of emphasis on apprenticeships and skill enhancement procedures is another issue that needs to be highlighted in this nation (Silva *et al.*, 2018; TVECSL, 2018; Kesavan *et al.*, 2022a).

In light of the aforementioned facts, recent investigations (Silva *et al.*, 2018; TVECSL, 2018; Kesavan *et al.*, 2021), as well as consultations with skill development authorities and industry experts have revealed that plentiful construction firms in numerous developing countries like Sri Lanka lack suitable methods and procedures to evaluate the skills of site supervisory workers in labour management, performance assessments and productivity measurements in construction tasks. Finding a solution to this issue is significant because of the ripple effects associated with inadequate apprenticeship

facilities and supervisory skill gaps/shortages that have been limiting the effectiveness of construction project activities in the contexts of Sri Lanka and numerous other emerging nations (Abimbola, 2016; Victor, 2018; TVECSL, 2018; Anil *et al.*, 2019; Kesavan *et al.*, 2020). The current background analysis highlights that only a little attention to these issues was received in past research.

Based on the background analysis and the problem statements stated above connected to recent studies (Silva *et al.*, 2018; Victor, 2018; TVECSL, 2018; Anil *et al.*, 2019; Kesavan *et al.*, 2021; Kesavan *et al.*, 2022a), this study identifies the knowledge gap with regard to how apprenticeship development and competency assessment need to be methodically handled in site supervision practices connected with the competency enhancement approaches in the work processes and obligations on the labour management, labour performance assessments and labour productivity measurements in routine activities towards raising the efficiency of operational flows and outputs. This study is significant and differs from other studies in that it emphasises the essential need for outlining the knowledge gaps in the creation of constructive apprenticeship protocols/frameworks necessary to test the capabilities of site supervisory staff and comprehend their work performance levels as replications of the sophisticated technical and scientific comprehensiveness of the industry.

As per the need to find out solutions for the problem statement, research gap and other facts highlighted in the above paragraphs, the aim of this research is to examine the ability of site supervisors to manage labour resources, test labour performance and measure labour productivity in construction. This research specifically focuses on different competency characteristics (CCs) related to the research aim in light of the difficulties and demands mentioned above. As a result, this study concentrated on achieving the following objectives:

- develop a new apprenticeship system containing the required CCs relevant to proficiency in managing labour resources, assessing labour performance and measuring labour productivity in construction operations;
- measure the construction supervisors' performance scores under the required CCs;
- propose a system for the classification of the construction supervisors under different grade categories based on their abilities in different CCs; and
- generalise the supervisory attribute levels in managing labour resources, testing labour performance and measuring labour productivity in construction operations.

The achievement of the above-stated research objectives may result in opening a new door for the development of more advanced scientific and technical approaches to comprehending the supervisory regulations, agreements and adherence to workforce employment limits in the construction industry. This will lead to create meaningful ways to address evolving challenges and opportunities associated with the current practices of the industrial and vocational training sectors in numerous developing nations.

2. Literature review

Industry analysts forecast that it will be difficult for construction companies to compete globally due to a huge skills gap and low productivity, and some claim that the early recessions were to blame for this gap (Silva *et al.*, 2018; Hai and Tam, 2019; Kesavan *et al.*, 2021). A variety of problems associated with a dearth of systematic skill development procedures have resulted in poor effectiveness and productiveness in construction processes, which have led to widely affecting the industrialised outcomes, particularly in Australian, Indian, Nigerian, South African, Sri Lankan and Vietnamese construction

sectors (Hughes and Thorpe, 2014; Abimbola, 2016; Anil *et al.*, 2019; Victor, 2018; Silva *et al.*, 2018; Hai and Tam, 2019).

2.1 Conceptual apprenticeship models to assess the effectiveness of site supervision and labour operations

A visionary model for optimising manpower in emerging construction industries was created by Uwakweh and Maloney (1991), which emphasised the need to create a pool of supervisory strategies and paths by improving training implementation practices. Besides, modern computerised models were introduced by Hai *et al.* (2018) in the later era to encourage the interaction of the apprenticeship and skill assessment components. These computerised models were found through the use of photography, videography and three-dimensional panorama technologies. However, the application of such computerised tools to perform work-based skill assessments at construction projects makes huge financial, technological, material and skilful human resource requirements. Thereby, construction organisations in many numerous developing countries hesitate to the application of such computerised tools. Nevertheless, recent investigations have offered useful practical models and systems that are optimistic and applicable to emerging construction industries within the small level of resource inputs. For instance, a tool for guiding construction supervisor apprenticeship by Kesavan *et al.* (2021) and a system for labour apprenticeship and grading by Kesavan *et al.* (2022b) can be significant among those. Noticeably, the apprenticeship guide of Kesavan *et al.* (2021) includes a list of skill enhancement procedures that might be provided to supervisory workers, whereas crucial labour apprenticeship procedures were determined methodically by Kesavan *et al.* (2022b). with the inclusion of labour performance testing and grading systems. Importantly, these tools and systems highlight the indispensability of enhancing the site supervisory abilities to effectively manage labour resources, evaluate labour performance and record labour productivity levels.

2.2 Crucial site supervisory competency aspects that affect the effectiveness of construction operations

An increase in worker motivation levels and enhancement of quality, safety and productivity aspects necessitate strong communication between site supervisory staff and labourers (Victor, 2018). The key driving forces behind the execution of labour apprenticeship components at construction project sites are supervision tactics (Kesavan *et al.*, 2021). Site supervisors who possess strong communication, leadership, planning and decision-making skills can inspire their team workers to work at their peak efficiency (Brent and Leighton, 2013; Victor, 2018). Notably, a study by Abdulaziz *et al.* (2012) of 84 Qatari building enterprises found that communication and leadership skills are the essential parts of the site management strategies used by supervisory workers. Besides, the site supervisors' planning abilities have been identified as one of the critical performance variables that greatly affect work efficiency in building project tasks in the Indian context (Anil *et al.*, 2019). Productive planning and management techniques on labour resources assure the effectiveness and productiveness of site operations by decreasing project costs and time constraints (Kesavan *et al.*, 2020). When integrating material and labour resources for construction activities, effective resource management and site coordination practices are required, especially to maximise resource utilisation (Serdar and Jasper, 2011). Moreover, moral conduct on the part of site supervisory personnel can significantly increase employees' job satisfaction and the company's commitment to performance development (Mahan, 2019). It is significant to note that moral conduct is the fundamental aspect of work integrity/honesty, as emphasised by Parviz *et al.* (2015).

In a variety of building projects in Australia, it was shown that the site supervisors' poor self-management skills in controlling the quality of labour work outputs are a major impacting factor on work efficiency (Hughes and Thorpe, 2014). Importantly, the likelihood of costly mistakes can be reduced, and project operations can be made safer by controlling the quality of labour work (Hughes and Thorpe, 2014). Besides, the lack of manual domains in site supervisors' comprehension of health and safety legislation was a key impediment to contractors' efforts to increase efficiency in Australian building projects (Hughes and Thorpe, 2014). It is also notable that numerous Nigerian construction projects have been found to be hampered by similar problems with construction site oversight practices (Victor, 2018).

A few studies have been conducted in an effort to enhance construction site oversight procedures, taking into consideration the construction environment of Sri Lanka. It is crucial to improve the self-management abilities of site supervisory workers employed in Sri Lankan construction projects in terms of health and safety laws as well as their capacity for testing labour capabilities (TVECSL, 2018). It is notable that Kesavan *et al.* (2020) have identified the primary issues associated with site supervision practices/tactics that affect the effectiveness of construction workflows in the Sri Lankan industry sector. Some of these problems highlight competency factors of site supervisors related to inadequate site administration, poor decision-making and poor practices associated with labour management and performance evaluation aspects. Additionally, consideration should be given to the 20 important behaviours for construction site supervision outlined by Kesavan *et al.* (2020) while creating new site supervisory apprenticeships. These resulted in the creation of 20 apprenticeship outcomes (AOs), giving a foundation for the creation of more potent apprenticeship facilities for construction site supervisors (see Table 1). These AOs clearly outline what industrial firms want from construction site supervisory workers in terms of project tasks.

2.3 Review of useful apprenticeships connecting with work-based processes

It is important for this study to review useful apprenticeship approaches connected with work-based processes, according to some past studies (Siregar, 2018; Dickinson *et al.*, 2011; Jeelani *et al.*, 2017; Ojha *et al.*, 2020). It is notable that useful methods of apprenticeship delivery and assessment approaches used in health and safety training practices were evaluated for construction workers by Ojha *et al.* (2020). The findings of Ojha *et al.* (2020) show that most organisations have been using traditional approaches, such as toolbox discussions and lecture-based workshops and they have not been putting much emphasis on modern work-based apprenticeship methods. Importantly, past studies emphasise the significance of the modern apprenticeship approaches connecting with work-based tasks than the traditional methods for the gradual and significant enhancement of construction workers' cognitive, transferable and self-management skills (Siregar, 2018; Dickinson *et al.*, 2011; Jeelani *et al.*, 2017; Ojha *et al.*, 2020).

An apprenticeship containing CCs of construction site workers on concrete works was studied by Siregar (2018) in Medan City, Indonesia. This study included the continuous delivery of relevant apprenticeship components to 30 construction workers with the main objective of assessing the work-based learning approaches. Siregar (2018) noted that although the study initially found low learner interest in work-based apprenticeship tasks, there was a progressive improvement in the apprenticeship followers' abilities throughout the apprenticeship connected to the work-based tasks. Siregar (2018) suggests using the learning domains associated with taking note of the apprenticeship explanations, asking questions, displaying confidence, speaking up and engaging in group activities, exchanging

Table 1. Mapping and weight distribution of relevant competency characteristics (CCs) in relation to learning domains

Competency characteristics (CCs)/competency unit (CU)	Weight (%)	Bloom's taxonomy of learning domains: Cognitive levels (CL) CL1	CL2	CL3	CL4	Psychomotor levels (PL) PL1	PL2	PL3	PL4	PL5	PL6	PL7	Affective levels (AL) AL1	AL2	AL3	AL4	AL5
CC1: applying efficient labour management procedures in site operations	25	2	4			4	7	1	3				1	3			
CC2: developing productivity measurement tools for site operations	25	3	4			2	4	4	4				1	3			
CC3: performing assessments on efficiency and productivity of site operations	25	3	4	3		2	1	4	4				1	3			
CC4: proposing enhancement practices on efficiency and productivity of site operations	25	2	3	2		2	3	1	4				2	1	5		
Competency unit (CU)	*100*	*10*	*15*	*5*	*0*	*10*	*15*	*10*	*15*	*0*	*0*	*0*	*5*	*10*	*5*	*0*	*0*

Notes: CL1= remembering and understanding; CL2 = applying; CL3 = analysing and evaluating; CL4 = creating; PL1 = perception; PL2 = set; PL3 = guided response; PL4 = mechanism; PL5 = complex over response; PL6 = adaptation; PL7 = origination; AL1 = receiving phenomena; AL2 = responding to phenomena; AL3 = valuing; A4 = organisation; A5 = characterisation

Source: Produced by Kesavan *et al.* (2021)

ideas and opinions with others, receiving input from others, responding to others' opinions, paying attention to other groups, summarising the contents and assessing the outcomes in work-based apprenticeship projects to evaluate the competencies of the trainees.

Apart from the above, it should be noted that useful digital environments were created by some studies using a variety of technologies, including virtual reality gaming technology (Dickinson *et al.*, 2011) and 360-degree panorama technology (Hai *et al.*, 2018), with the goal of promoting the workers' interaction and situational awareness in the competency assessments. On the other hand, Jeelani *et al.* (2017) emphasised the benefits of using photography and videography approaches to create authentic surrounding views of the building area for training assessment purposes. However, Ojha *et al.* (2020) draw attention to the significant expenses and technological requirements associated with using these digital technologies, which have been the main barrier preventing the training sectors in many developing nations from modifying their current methods to fit the digital world.

Besides, Gomez *et al.* (2021) introduced an apprenticeship model emphasising more on management, technical and soft skills of construction supervisory workers based on the construction industry's perspective in Chile. Notably, the emphasis on the supervisory competency categories stated by Gomez *et al.* (2021) was almost existing in the apprenticeship model developed by Izwan *et al.* (2019) based on the perspective of the Malaysian construction sector, further highlighting the need for attention on the competencies related to communication, team leadership and multi-disciplinary interaction, proactivity and self-learning and the use of project management tools in modern construction supervisory apprenticeship models. In light of the construction industry in the European Union countries, the apprenticeship tool of Akyazi *et al.* (2020) draws attention to the need for addressing a variety of supervisory abilities under the following listed categories to recover from the effects of the global financial crisis of 2007–2008 and meet the challenges posed by digitalisation, sustainability and environmental regulations:

- New measurement methodology and data acquisition.
- Building information modelling methodology.
- Project management.
- Sustainable resource management.
- *Circular economy*: waste management in construction.
- Challenges of climate change in the construction field: minimise impacts of works, efficiency of buildings and constructions and more sustainable transport infrastructures and mobility plans.

Based on a study conducted by Teixeira *et al.* (2006) across four European countries (Portugal, Spain, Poland and Lithuania), an apprenticeship model was introduced focusing on continuing professional development features of construction supervisors in the areas of project cost estimation and management, planning and scheduling, quality management, project feasibility and procurement and tendering procedures. While reviewing the apprenticeship model of Akyazi *et al.* (2020), it can be noted that even though the apprenticeship model of Akyazi *et al.* (2020) contains the advanced features of site supervisory attributes, the most relevant areas highlighted in the apprenticeship model of Teixeira *et al.* (2006) are missing, and this can be the major shortcoming of the apprenticeship model of Akyazi *et al.* (2020). On the other hand, Tony *et al.* (2014) examined the construction industry in Australia and found that a significant proportion of construction supervisory staff members work on projects without the necessary certifications. Tony *et al.* (2014) presented an apprenticeship model emphasising more on the

communication, decision-making, leadership and time management skills of construction supervisors. Tony *et al.* (2014) also noted that while the majority of large companies provide leadership and training programmes to help construction supervisors in Australia advance their careers by creating organisation-level training framework matrixes, the majority of small organisations typically do not. Detsimas *et al.* (2016) revealed that the majority of the construction employees in Queensland City, Australia, prefer to adopt informal training methods over formal ones to enhance their technical and general abilities. Apart from these, it is significant to note the apprenticeship tool presented by Vaz-Serra and Mitcheltree (2020) based on investigations carried out in Australia. Importantly, the top traits valued by the Australian construction industry, which are communication (verbal, written and presentation), resilience and persistence, emotional intelligence, commitment to personal development and commitment to professional development, were properly addressed in the apprenticeship tool of Vaz-Serra and Mitcheltree (2020).

The overall review of the above-discussed apprenticeship tools reveals that even though the applications of such tools are highly beneficial, the major shortcomings behind those tools are the poor features or methods connected to work-based training approaches and competency assessment procedures.

2.4 Flaws and limitations in past investigations

Even though the literary evaluation of this research reveals a wide variety of construction site supervisory factors that affect various construction systems, a few studies have provided models/tools to execute apprenticeship elements at project sites (Siregar, 2018; Dickinson *et al.*, 2011; Hai *et al.*, 2018; Jeelani *et al.*, 2017; Ojha *et al.*, 2020). The present research has shown that there are substantial limitations when using the models/tools presented by such studies (Siregar, 2018; Dickinson *et al.*, 2011; Hai *et al.*, 2018; Jeelani *et al.*, 2017) in accordance with the needs and characteristics of the industrial environment. The biggest flaws of those models/tools are the lack of specific competency qualities and performance evaluation procedures, despite touching on the subject of productivity development. The main factor causing this constraint at this stage is the fact that many construction enterprises in developing nations have a finite quantity of capital and are unable to adapt to the use of modern technologies. The computerised tools offered by recent studies (Dickinson *et al.*, 2011; Hai *et al.*, 2018; Jeelani *et al.*, 2017) are typically used by the construction sector in industrialised countries. However, the fact that these models/tools ignore methods for enhancing the generalisability of work activities is a serious flaw in their design.

2.5 The applicability of the apprenticeship tool of Kesavan et al. (2021) that matches the characteristics of the current research aim

Kesavan *et al.* (2021) have offered an important apprenticeship tool for creating new training courses for site supervisors that productively handle the industrial difficulties and requirements as it addresses them in more depth. Within the scope of enhancing the effectiveness and productiveness of construction workflows, the use of practices for labour management, labour performance evaluation and labour productivity measurements is outlined in one of the 12 competency units (CUs) highlighted in the apprenticeship tool of Kesavan *et al.* (2021). Additionally, this tool highlights some essential features of site oversight within this focus by generating relevant CCs, as shown in Table 2. Moreover, Kesavan *et al.* (2021) have also distributed the weights among such CCs vertically and Bloom's taxonomy of learning domains horizontally using comprehensive methods, as can

Table 2.
Mapping levels between the competency characteristics and the supervisory apprenticeship outcomes

Competency characteristics (CCs)/ competency unit (CU)	Site supervisory apprenticeship outcomes (AOs)																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CC1	IL	EL	EL	IL	IL	EL		IL	IL	IL	IL	IL	IL			IL	IL	EL	EL	EL
CC2		IL	IL			EL	IL					IL		IL	EL	EL				
CC3		EL	EL			EL						IL	IL	IL	EL	EL				
CC4		IL	IL			RL	IL	IL	IL	IL	IL	IL	IL		EL	EL	IL	EL	EL	EL
Competency unit (CU)	*LL*	*ML*	*ML*	*LL*	*LL*	*CL*	*LL*	*LL*	*LL*	*LL*	*LL*	*LL*	*LL*	*LL*	*ML*	*ML*	*LL*	*ML*	*ML*	*ML*

Notes: AOs of Kesavan *et al.* (2020): AO1 = monitoring the storage, delivery and usage of construction materials and tools in project operations; AO2 = planning the resources at project sites efficiently; AO3 = applying productive-based supervision approaches on the construction labour operations; AO4 = assisting in estimating and budgeting for the construction operational flows effectively; AO5 = following the site regulations associated with overcoming health, safety and environmental related problems during the project tasks; AO6 = implementing the constructive practices on enhancing labour performance in project operations; AO7 = applying self-learning approaches to learn modern concepts, advanced technologies and theories associated with construction works; AO8 = applying brainstorming approaches/techniques to enhance the labour skills in construction; AO9 = applying competency-based apprenticeship approaches to enhance the labour skills in construction; AO10 = instruct fundamental concepts, principles and applications to enhance the labour skills in construction; AO11 = providing experimental training exercises to the construction labourers for their skill enhancement; AO12 = assessing the labour performance at construction project sites; AO13 = implementing labour rewarding mechanisms at construction project sites; AO14 = applying suitable mathematical principles and theories to solve real problems at construction project sites; AO15 = conducting field surveys, investigations and tests associated with feasibility studies on construction project works; AO16 = maintaining the records of the project activities and assisting to prepare the relevant reports; AO17 = applying green concepts and sustainable development practices on construction project tasks; AO18 = performing tasks as a very good team player and communicator among construction workers; AO19 = performing tasks with positive thinking to effectively address the evolving challenges; AO20 = performing as a good guider for construction labourers in project sites

Source: Produced by Kesavan *et al.* (2021)

be seen in Table 1. With the use of these distributed weights, competency evaluation methods can be methodically developed.

Remarkably, the relevant CU of the apprenticeship tool specifies that 30% of the apprenticeship was dedicated to improving the cognitive (knowledge-based) site supervisory elements, particularly in terms of evaluating how the supervisors comprehend problems and apply solutions. Besides, 50% of the apprenticeship was intended to test the psychomotor (manual skill-based) site supervisory elements with an insistence on the perceptions and mechanisms of acts on problem identification and solving aspects. The final 20% of the apprenticeship focused on the affective (attitude and emotion-based) site supervisory elements, especially on how they pay attention and voluntarily act on the problem-solving aspects. The overall ratio of the knowledge-based, manual skill-based and attitude/emotion-based qualities of the site supervisors of this research application on the required elements of CCs was 3:5:2.

Furthermore, the following descriptions were used to illustrate the levels of mapping of those CCs with the AOs of Kesavan *et al.* (2020), as can be seen in Table 2:

- *Introduced level (IL)*: The contents of the apprenticeship provide a summary of the intended outcome at the required direction.
- *Emphasised level (EL)*: The contents of the apprenticeship strengthen the intended outcome at the required direction.
- *Reinforced level (RL)*: The contents of the apprenticeship add advanced strength of reinforcement to the intended outcome in the required direction.
- The supervisors' abilities, industry standards and practical considerations were all properly assessed during the determination of mapping levels. Given the levels of mapping that arose between the CCs and POs, the mapping findings of the entire CU under the AOs were established in accordance with the following statements.
- The mapping implies that the CU has a prominent level (PL)/considerable level (CL)/moderate level (ML)/low level (LL) fulfilment of the relevant AO's features.

Moreover, the apprenticeship tool of Kesavan *et al.* (2021) can be applicable not only in the setting of Sri Lanka but also in the contexts of numerous developed and developing countries.

3. Methodology

3.1 The layout of the methodology

The design of the research layout/methodology to accomplish the research aims is illustrated in Figure 1. With specific attention on the needed actions in construction site planning/management aspects for the facts and problems highlighted in Section 1 (introduction), continuous consultative processes were held among various industrial and academic specialists, as shown in Figure 1. Noticeably, university academicians who possessed more than five years of job experience with a doctorate or master-level education qualification in the civil engineering field participated in these consultative sessions. Additionally, industry experts who possessed chartered engineering qualifications and vast industry experience as project directors/managers/engineers were also actively involved in these consultative discussion sessions. At every level of the consultative process, problem-based communication techniques were used, particularly for comprehending difficulties, applying experience/knowledge and developing required actions/solutions. It is important to note that the layout design of the research methodology was based on the construction site supervisory apprenticeship manual of Kesavan *et al.* (2021), as shown in Figure 1. The

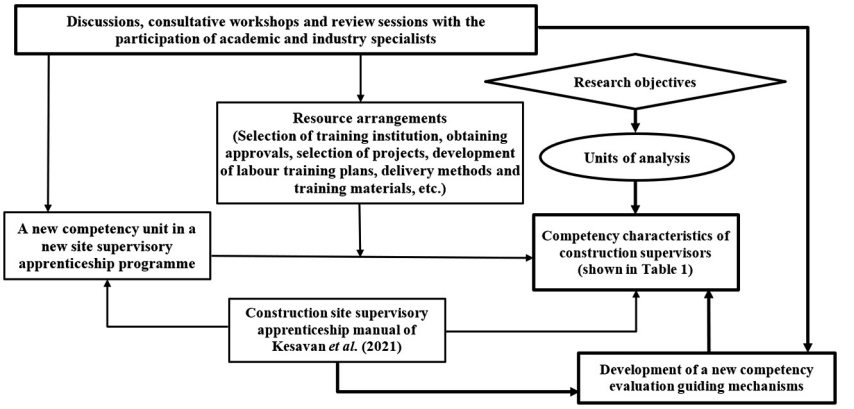

Figure 1.
Design of the research layout/ methodology

Source: Authors' own work

emphasis on the use of this apprenticeship manual was supported by the above-mentioned consultative outcomes and industry specialists' reviews while taking into account the aims of the research and other crucial aspects, as per the aspects highlighted in Section 2.4. This research uses a case study with mixed methods containing qualitative and quantitative approaches for the execution of the mechanism shown in Figure 1 to achieve the study's aim. A case study-based research mechanism was designed considering the importance of generating an in-depth and multi-faceted understanding of different groups of supervisors in a wide variety of disciplines. As per the study's aim, the supervisors' ability to manage labour resources, test labour performance and measure labour productivity is the major focus of the study, whereas the four CCs (CC1–CC4) shown in Table 1 are the units of analysis in this case study. This case study-based design allows to explore the meanings, key characteristics and implications of the case, as well as to determine what has worked well, what has not and what changes need to be made on the units of analysis. The following Sections 3.2 to 3.6 discuss how the case study based developed mechanism shown in Figure 1 was applied to assess the units of analysis and the case in a detailed manner. Mixed methods were used in this study since they enable the stated mechanism of this study conceptually and analytically to integrate quantitative and qualitative data. Notably, the quantitative approaches were used in measuring supervisors' performance score ratings and proportioning supervisors into grading levels under different CCs based on the developed grading criteria for the competency evaluation guide (shown in Table 3), whereas the qualitative approaches were mainly used to the development of the generalised guide for determining the grading levels of construction site supervisors based on the quantitative results.

3.2 Design of the modern site supervisory apprenticeship

As per the use of the apprenticeship manual of Kesavan *et al.* (2021), an advanced site supervisory apprenticeship was designed comprehensively, which has an occupational-focused and vocationally specific diploma qualification level of the Sri Lankan National Vocational Qualification Framework (NVQF). Several procedures were followed during this advanced site supervisory apprenticeship development while taking into consideration novel traits in light of the new typical circumstances in the industry. It is important to note

Grading descriptions	Grading levels	Performance score rating range
E (exemplary/superior)	E1 (slightly above)	95–100
	E2 (same level)	90–94
	E3 (slightly below)	85–89
A (accomplished/proficient)	A1 (slightly above)	80–84
	A2 (same level)	75–79
	A3 (slightly below)	70–74
D (developing/fair)	D1 (slightly above)	65–69
	D2 (same level)	60–64
	D3 (slightly below)	55–59
B (beginning/attempted)	B1 (slightly above)	50–54
	B2 (same level)	45–49
	B3 (slightly below)	40–44
I (inadequate)	I1 (weak)	30–39
	I2 (very weak)	20–29
	I3 (unacceptable)	0–19

Source: Authors' own work

Table 3. Grading criteria for the competency evaluation guide

that the qualification level of the designed apprenticeship was NVQF Level 5, which is comparable to the Sri Lankan Qualification Framework (SLQF) Level 3. Accordingly, the selection of candidates (site supervisory workers) was followed by the entry standard for the criteria of NVQF Level 5 or SLQF Level 3.

3.3 Selection of institution and relevant resource arrangements for the apprenticeship delivery

Following a SWOT analysis and expert deliberation, the apprenticeship provider/institution was selected. Prominently, the academic heads and directors from numerous departments/institutions participated in the consultative discussions associated with this SWOT analysis. Before the commencement of the apprenticeship, the necessary approvals related to curriculum formulation, ethics, quality assurance and finance were obtained through sequential processes performed with various academic and administrative committees functioning in the chosen institution. In addition, the formation of new Boards/Committees, the creation of programme by-laws, the appointment of human resources to various academic and administrative processes and other significant resources were arranged to provide systematic apprenticeship delivery at the chosen institution for a long-term emphasis.

3.4 Selection of the site supervisors

With the use of the snowball sampling technique, the potential site supervisory workers were initially identified and were made up to apply for the proposed apprenticeship. As suggested by Showkat and Praveen (2017) and Statistics Canada (2020), this sampling approach was helpful in handling the difficulties in collecting the samples with the necessary characteristics for the study's applications. The snowball sampling approach is a non-probability sampling tactic that can be applied in circumstances where obtaining samples with the necessary characteristics is difficult (Showkat and Praveen, 2017; Statistics Canada, 2020). This sampling approach provides ways to achieve a large number of samples from the initiation of a process with a small number of samples. By conducting a series of awareness sessions within a number of well-known industrial firms, a notable

number of construction site supervisors were first taken into the sample to find more site supervisors who could be potential in applying to the planned apprenticeship. In total, 62 construction site supervisors were conclusively chosen for the proposed apprenticeship in accordance with the regulations stated in the programme by-laws based on their educational and professional credentials with the marks scored in the selection interview session. In particular, the candidates' self-management skills related to communication, self-discipline, curiosity and commitment were mainly examined with their cognitive abilities on subject matters by a panel of academics in the interview sessions. It is notable that a nearly 2:2:1 ratio can be applied between the chosen site supervisory personnel who were working on buildings, roads and water supply projects, whereas none of them fell into the category of workers who had job experience of less than one year. Taking on the chosen site supervisors, the presence of a significant representation of Sri Lanka's nine provinces was also identified among their group noticeably.

3.5 The importance of the inclusion of the relevant competency unit that executes the components of the research applications

More significantly, the newly created apprenticeship contained a particular CU that used a variety of job-integrated learning methodologies to apply the needful attributes to site supervision skills in accordance with the main objectives of the current research. Principally, the pertinent CU addressed each of the CCs listed in Tables 4 and 2. It should be notable that a group of subject matter experts examined the elements of such a particular CU. Five academic specialists and seven industrial experts with extensive knowledge of construction project management aspects made up the panel. Competency characters and objectives, learning outcomes, contents of learning, delivery methods of teaching and competency assessments, weight distribution among learning outcomes, contents and assessments, the relevant mapping level outcomes and the kinds of necessary resources were the specific areas of focus of the review process, which also took into account the applicability of those components with respect to the aspects shown in Tables 1 and 2.

The academic delivery of the proposed apprenticeship was systematically processed among the chosen site supervisors by following the regulations associated with the programme by-laws and the institutional quality assurance policies. A grading criterion was methodically designed for the evaluation of supervisory CCs, as portrayed in Table 3. The created grading criterion was connected to the weighting of CCs with respect to the learning domains indicated in Table 1. This collective mechanism of the competency evaluation process further took into consideration the CCs with the 20 AOs of Kesavan *et al.* (2020)

Table 4.
Mean performance score ratings of supervisors under different competency characteristics

Competency characteristics (CCs)/ competency unit (CU)	Building construction work			Road construction work			Water supply work			Overall		
	AVG	SD	CV	AVG	SD	CV	AVG	SD	CV	AVG	SD	CV
CC1	72.35	11.24	0.16	72.53	12.71	0.18	70.41	10.75	0.15	72.56	9.95	0.14
CC2	69.57	9.56	0.14	65.42	8.58	0.13	54.38	9.25	0.17	65.15	8.46	0.13
CC3	61.23	6.45	0.11	57.45	7.24	0.13	64.34	7.12	0.11	60.28	6.32	0.10
CC4	54.16	5.89	0.11	51.37	5.87	0.11	69.53	5.21	0.07	56.41	5.63	0.10
Overall competency unit (CU)	*64.33*	*9.85*	*0.15*	*61.69*	*8.27*	*0.13*	*64.67*	*6.71*	*0.10*	*63.60*	*8.75*	*0.14*

Notes: AVG = average; SD = standard deviation; CV = coefficient of variation
Source: Authors' own work

(shown in Table 2). It is important to note that the designed grading guide was verified by the expert review panel. Such supervisors were evaluated for each CC in each area in accordance with the grading descriptions and criteria and were awarded a grading level that fell within the range of scores shown in Table 3.

3.6 Validation process on the applied research tools

A pool of academic, administrative and industry specialists, comprising of senior academicians serving in governmental state universities and private institutions, academic heads/directors and subject specialists from relevant academic departments/units, project directors and managers from various industrial authorities, governmental departments and private firms, as well as well-experienced chartered civil engineers, were involved in a sequential process of evaluations to validate the applied research tools and approaches for this study. It is remarkable to state that the majority of the members included in this pool had vast experience in the academic and industrial sectors of the construction engineering field, not only in the Sri Lankan environment but also in the settings of a variety of other developing countries. Importantly, the evaluation procedure consisted of a series of observations and evidence-based conversations focusing on the plans sketched and the research instruments used to the direction of the research objectives.

4. Results and discussion

As per the discussions in the methodology section of this study, the first objective of this study was achieved, which is the development of a new apprenticeship system containing the required CCs relevant to proficiency in managing labour resources, assessing labour performance and measuring labour productivity in construction operations. Sections 4.1 and 4.2 discuss the results associated with the achievement of the second and third objectives of the study, which are measuring the construction supervisors' performance scores under the required CCs and proposing a system for the classification of the construction supervisors under different grade categories based on their abilities. Section 4.3 discusses how the supervisory attribute levels in managing labour resources, testing labour performance and measuring labour productivity in construction operations are generalised, as per the last objective of this study.

4.1 The results of the supervisors' grading levels and the performance scores

Figure 2 displays the proportions of construction project supervisors for each CC/factor at various grading levels while also taking the complete CU into consideration when assigning the academic components.

Taking into applying efficient labour management procedures in site operations (CC1), three-quarters of the site supervisors demonstrated their abilities at accomplished or above level, and the remaining quarter of the supervisors was still in the developing/learning stage. Noticeably, none of the supervisors was found to be at the beginning or below levels. Compared to the results of CC1, it is unquestionable that the supervisor's performance ratings in the other three CCs were significantly lower. The major reason for these significant differences can be that the characteristics associated with those three CCs contain a substantial amount of new or unfamiliar work attributes when those are compared to the supervisors' previous/usual traditional work practices. Compared to the characteristics of these three CCs, the characteristic of CC1 somehow contains considerable familiar attributes related to the supervisors' previous/usual traditional work practices. In particular, the characteristic of CC1 specifies the labour management aspects with a mix of modern and traditional approaches in relation to recruitment and selection of labourers, job

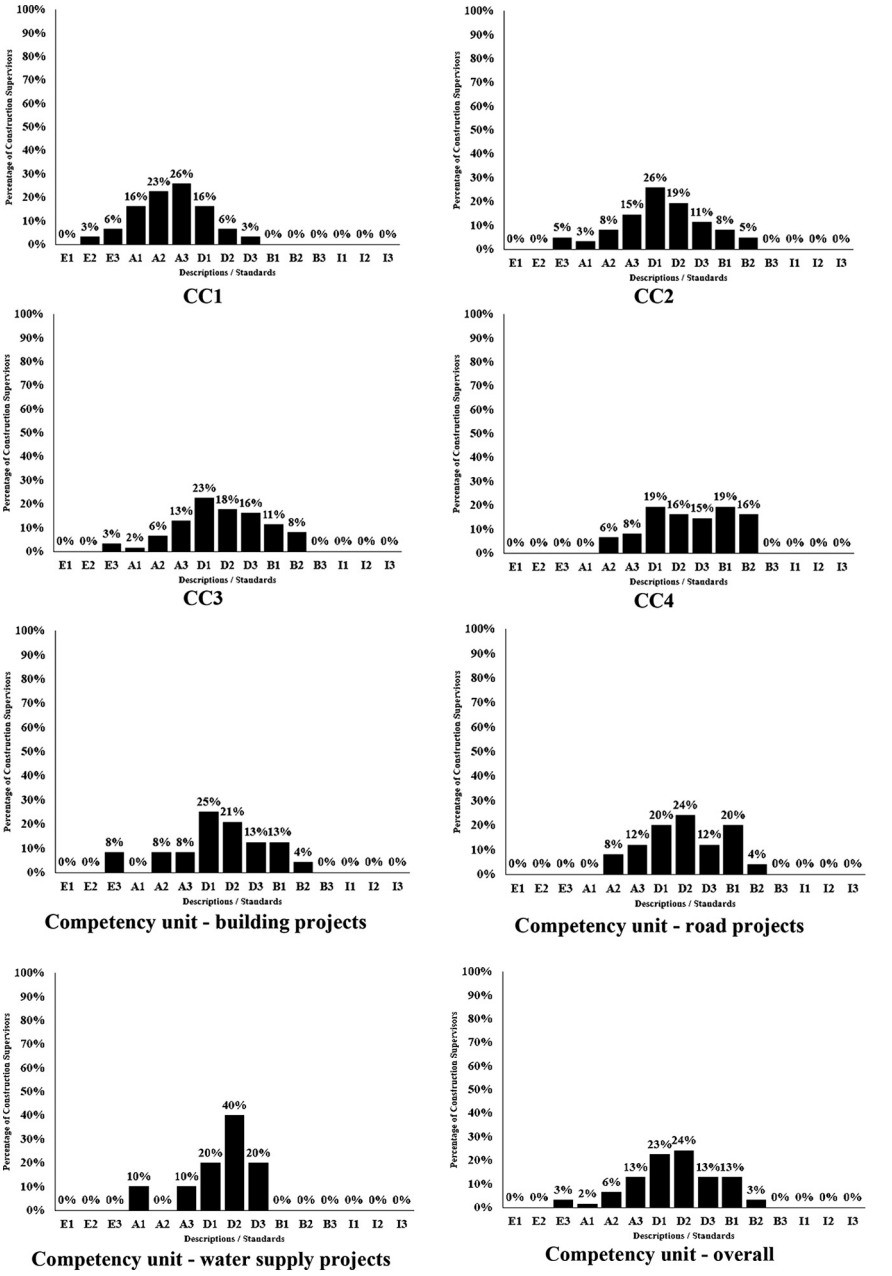

Figure 2.
Proportions of supervisors among the grading levels under different competency characteristics

Source: Authors' own work

attributes of labourers, monitoring of labour work, labour performance management, identification of strengths and weaknesses of labourers, labour motivation, discipline and information sharing aspects.

When it looks at the supervisory abilities in developing productivity measurement tools for site operations (CC2), only around 30% of the site supervisors were identified with a minimum accomplished level grade, whereas more than half of the supervisors (56%) were found to be still having developing level competencies and a notable portion of the supervisors (13%) were identified to be having still beginning level competencies. For further enhancement of supervisory performance ratings in CC2, the study suggests paying special attention to their understanding, applying and sensory awareness domains on various types of productivity benchmarking approaches in various project tasks. Additionally, the study emphasises preparing the site supervisory staff to be manually familiar with the application of the new useful roadmap for upgrading productivity benchmarking levels, which was produced by Kesavan *et al.* (2022c). This may also add further advancement to the supervisory attributes associated with CC2.

In the matter of supervisors performing assessments on efficiency and productivity of site operations (CC3), the results were almost similar in shape to CC2 with small differences, as per the variations shown in Figure 2. Here, nearly a quarter of the site supervisors had a minimum proficient level grade, whereas more than half of the supervisors (57%) had developing/fair level competencies and nearly one-fifth of the supervisors had beginning/attempted level competencies. In regard to the supervisors proposing enhancement practices on efficiency and productivity of site operations (CC4), it is clearly visible that the supervisors had very lower performance ratings compared to the above three CCs. Here, only a few supervisors (nearly 15%) were found at the proficient level grade, and none of them were at an exemplary level. It is further notable that exactly half of the site supervisory staff were identified at the developing stage/level grade, whereas a significant portion of the supervisors (35%) was found to be still at an attempted level grade. The site supervisors' limited levels of cognitive abilities in problem identification and problem-solving approaches can be pointed out as the major reason for their lower performance ratings observed in CC4. Here, it is suggested that the supervisors' conceptual understanding and sensory awareness of the aspects related to useful theoretical applications for improving labour motivation, efficiency and productivity, such as Adam's equity theory, Maslow's theory and McClelland's need theory, goal setting theory, Herzberg's two-factor theory, Skinner's reinforcement theory, Vroom's expectancy theory and Skill-Will matrix, will make high impacts on improving their CCs related to the determination of enhancement practices on efficiency and productivity of site operations. Though the overall results highlight the ways for further enhancement of the performance ratings of site supervisors under different CCs, none of the 62 supervisors had been deemed weak for any competency criteria at the conclusion of the apprenticeship.

Taking on the whole CU category, nearly a quarter of the site supervisors had a minimum proficient level grade, whereas 60% of the site supervisory staff were found at the fair level grade, and a notable portion of the supervisors (nearly 15%) was still at an attempted level grade. Moreover, it is notable that there are no significant differences in the results when comparing the proportions of the supervisors in each grade level based on the types of projects where they are used.

Figure 3 shows the curve of the frequency distribution of the performance ratings that the site supervisors received under different competency criteria, and Table 4 displays the average performance ratings they received for each competency factor. The lowest average scores overall were recorded by CC4, which was nearly 56 (indicating slightly below the

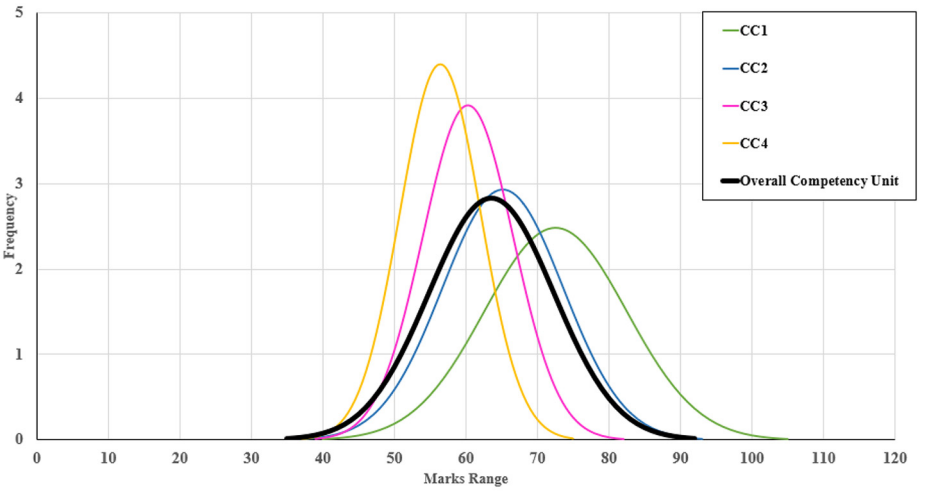

Figure 3.
Frequency distribution of the performance scores of site supervisors

Source: Authors' own wok

fair level competency grade), while the highest average score was obtained by CC1, which was nearly 73 (indicating nearly the proficient level competency grade). The overall average scores for the various project types did not significantly differ from one another and were almost closer to the mean score value of the supervisors' overall CU, which was nearly 64 (indicating a fair level of competency grade). This highlights that the given apprenticeship materials are created to be particularly adaptable and transferrable to the supervisory methods used in all different sorts of construction project work by following this procedure.

However, some differences can be noted between the average scores of project types in the competency criteria of CC2 and CC4. The supervisors who were employed in water supply project works had significantly lower performance ratings in CC2 when compared to other types of projects. It was the opposite in CC4, as those supervisors had substantially higher performance score ratings compared to other types of projects in CC4. When it comes to finding out the major reason for these differences, it can be justified that the characteristics of different types of project work might influence the competency attributes of developing productivity measurement tools (CC2) and determining productivity and efficiency enhancement practices (CC4).

4.2 Assurance of the research findings and outcomes with regard to validity, reliability, adaptability and generalisability

The coefficient of variation (CV) values of the performance rating scores was under 18% in all CC groups, ensuring that the results comply with the CV value range specified by Statistics Canada (2020) and that they are similar among raters. This raises the possibility that the given apprenticeship materials will be broadly applicable to the long-term uses of the industry sector. In addition to the data that had already been presented, the observations of a group of specialists (described in Section 3.5) on the results need to be specially considered. The pool of specialists intriguingly emphasised the significance of expanding the applications of this research process in numerous emerging industries and countries for

their rapid development of industrialised practices and judged that all of the competency factor categories were adequate overall.

4.3 The generalised guide for determining the grading levels of construction site supervisors

As illustrated in Table 5, the development of a new generalised guide that may be effective in forecasting and comprehending what degrees of skill/ability can be taken into consideration in supervisory qualities is a significant outcome of this work. In terms of advancements in technical proficiency and job outputs, this might considerably improve the processes for decision-making, knowledge management and performance management aspects in resource planning.

As per the conceptualised guidelines related to case study approaches provided by Yin (2002), the construct validation of the current case study applications was eminently clear since the study illustrates the evidence and justifications with the locations of each case of the major units of analysis (CCs). The results, as displayed in Table 5, undoubtedly reveal how randomly the units of analysis in the case study are related. The internal validation of the study's conclusions has been guaranteed by the depiction of patterns of variance in each CC while taking into consideration different kinds of project operations. More significantly, the results of the expert interviews and data analysis showed that the suggested methods and applications can be generalisable, valid and applicable for different scopes and scales of projects. This ensures both the outputs' quality and the external validation of the suggested applications/mechanisms. It also proves that any construction project, as well as initiatives in other growing industries, can apply the suggested methods and applications. Additionally, the case study's design logic, data collection methodologies and analysis techniques were all apparent. According to the peculiarities of the objectives at various phases, mixed approaches with quantitative and qualitative methods were used for the data analysis.

4.4 The influences of the current research findings on past research outcomes

The aforementioned results exhibit that this research has presented solution mechanisms up to some level for the issues associated with productivity and performance evaluation procedures that were raised by earlier studies (Victor, 2018; Silva *et al.*, 2018; TVECSL, 2018; Hai and Tam, 2019; Kesavan *et al.*, 2020). The research findings will push the industry practices of emerging countries like Sri Lankan context to instantly reach the anticipated outcomes in site supervision attributes emphasised by Kesavan *et al.* (2020) and the consequences associated with the efficiency-based classifications of construction workers highlighted by Kesavan *et al.* (2022b). In addition, the current research findings may lead to adding further advanced attributes to the roles of site supervision to conduct surveys

Competency characteristics (CCs)/ competency unit (CU)	Building construction work	Road construction work	Water supply work	Overall
CC1	A3	A3	A3	A3
CC2	A3	D1	B1	D1
CC3	D2	D3	D1	D2
CC4	B1	B1	A3	D3
Overall competency unit (CU)	*D2*	*D2*	*D2*	*D2*

Source: Authors' own work

Table 5. Generalised guide for determining the grading levels of construction site supervisors

permitting prompt detection of issues and problem-solving mechanisms associated with labour operations. It is notable that, though such necessities have been accentuated by a number of studies for a long time of period (Adi and Ni'am, 2012; Brent and Leighton, 2013; Kesavan *et al.*, 2020), no progressive changes in this regard could be observable in the construction site supervisory practices in many developing nations in the past.

Based on the current study findings, competency-based new characteristics and conceptual applications connected to performance and productivity enhancement can be added to the apprenticeship models presented by Izwan *et al.* (2019), Akyazi *et al.* (2020) and Gomez *et al.* (2021). Importantly, modern conceptual practices can be added to enhance the multi-disciplinary interaction practices and the application of project management tools in the use of such supervisory apprenticeship models. Further, the current study's results make some contribution to developing new strategies associated with building information modelling methods, sustainable resource management practices and circular economy aspects for further reinforcing the apprenticeship tool of Akyazi *et al.* (2020) towards meeting the challenges posed by digitalisation, sustainability and environmental regulations. Moreover, the top traits valued by the Australian construction industry stated in the apprenticeship tool of Vaz-Serra and Mitcheltree (2020), which are communication, resilience and persistence, emotional intelligence, commitment to personal development and commitment to professional development, can also be added with efficiency and productivity enhancement characteristics based on the current study's findings. Besides, the current study contributes to addressing the shortcomings of such apprenticeship tools associated with poor features or methods connected to work-based training approaches and competency assessment procedures up to some level. Furthermore, the current research findings will bolster the conceptual foundations of the computerised models that previous studies (Dickinson *et al.*, 2011; Hai *et al.*, 2018; Jeelani *et al.*, 2017) have suggested for advancing skill evaluation approaches in apprenticeship practices. The current research applications can be further improved in the future stages with the help of computerised advanced technologies, in line with the recommendations made by previous studies (Dickinson *et al.*, 2011; Hai *et al.*, 2018; Jeelani *et al.*, 2017).

5. Conclusion

Overall, this research has generated a new apprenticeship system to generalise the supervisory attribute levels in managing labour resources, testing labour performance and measuring labour productivity in construction operations. The proposed system mainly contains a set of relevant CCs and systematic approaches to measure the construction supervisors' performance scores and classify the supervisors into different grading levels within this scope. Up to certain levels, this research has filled the knowledge gap of the industry associated with skill upgrading aspects to some level by filling with modern characteristics of construction site supervision attributes that might be important in raising the effectiveness and productiveness of construction operations.

The study deliverables generate noteworthy theoretical, practical and social implications and new values that link to industrial and institutional practices in present and future circumstances. In terms of the protocols that are necessary and how they should be put into practice to understand, this study displays what competency levels can be applied both theoretically and practically in supervision characteristics related to labour management, labour performance evaluation and labour productivity measurement connecting with the performance and productivity enhancement in construction operational flows. As a result, a fundamental base was laid for restructuring the job role of construction supervision, and opportunities to reorganise supervisory attributes under the categories of work process,

learning demand and responsibilities are presented. This theoretical implication, which is linked to some practical implications, gives construction management and planning practices new meaning. Accordingly, the research has further opened the pump to inflow the highly workable features for strengthening the site management structures by adding new standards to the site supervisory job elements and functions. This will provide effective ways for organisations to identify key performance indicators and possible frameworks for action plans that will help them achieve their objectives and continue to do so under normal circumstances. Further, the findings of the entire research may encourage modifications to various apprenticeship curricula in tertiary and technical education authorities and the sector of vocational apprenticeship to suit the industry sector's needs and challenges under the evolving next-normal characteristics.

The generalisation outcomes of the results allow for the derivation of certain theoretical inferences and consequences. The supervisory abilities can be limited up to the proficient level in applying efficient labour management procedures in site operations, whereas such abilities can be limited up to the developing level when it comes to designing productivity measurement tools, performing assessments on efficiency and productivity and proposing enhancement practices on efficiency and productivity for site operations. This theoretical conclusion is also somewhat influenced by the types of projects that the supervisors employ. For instance, the supervisory abilities related to the application of efficient labour management procedures can be limited up to the proficient level in building project works, developing level in road project works and beginning level in water supply project works. On the other hand, the supervisory abilities in relation to proposing enhancement practices on efficiency and productivity of site operations can be limited up to the proficient level in water supply project works and beginning level in building and road project works. Because of these theoretical implications, some vocational-technical competence frameworks will be pushed to update their conceptual frameworks. In particular, more technical or scholastic skills will be added to provide a wide range of procedures that must be prioritised to achieve better results in both familiar and unfamiliar contexts, thereby improving work processes. This will also have an impact on the supervisory learning requirements related to applying certain theoretical ideas, interpreting data analytically, making well-informed decisions and coming up with a variety of creative solutions for real-world but frequently unknown issues.

Even though site conditions, characteristics of operations, size and quality of resources, financial scales, organisational instructions and ethical regulations differed significantly among the chosen construction projects where the applications of this research were processed, it is significantly noted that only relatively modest differences were identified in the results, as well as the validation, dependableness, adaptableness and generalisation of the overall results and outcomes were assured using comprehensive approaches, as illustrated in Section 4. This guarantees that a variety of construction-related industries will find sustainable-based benefits from the applications and outcomes of this research.

Taking on a notable limitation that this research highlights on the use of site supervisors, only those employed as site supervisors in the construction industry, whose level of competence spans from technician to managerial level, are qualified to enter into this research's applications as the samples. Further, the generalised grading levels obtained in this study are based on a detailed examination of the supervisory attributes in the Sri Lankan construction setting. However, the idiosyncrasies of construction site supervision practices may vary in diverse contexts of developing countries and industries. Thereby, taking into the contexts of different developing countries, there may be slight differences in such grade levels, but not anticipated such differences at a substantial level. The expert consultative outcomes also revealed that the generalised grade levels obtained in this study

can mostly coincide with other developing nations' perspectives. Considering these aspects, it is meaningful to state that this research has presented a modern guide that overviews the construction site supervisory workers' capability levels associated with the relevant characteristics of the research problem, replicating the settings of the developing countries. Notwithstanding, this research recommends that future studies investigate the deviations in such grade levels by evaluating the supervisory roles and working patterns of different nations and different industrialised sectors. For such a purpose, the generalised approaches and mechanisms that the current study provided can be very useful for future studies. Accordingly, the current study's findings can make a substantial level of impact on the current practices associated with project management, resource utilisation and manpower planning in other rising industrial sectors and nations. Moreover, the current research recommends examining productivity variations compared to the changes in site supervisory performance ratings using mixed-method approaches in subsequent studies. Further, this research points to the need for future studies to focus on evaluating relevant additional competency-based traits and working practices of site supervision and other different job roles under various circumstances.

References

Abdulaziz, M.J., Charles, Y.K. and Jamal, H.Y. (2012), "A survey of factors influencing the productivity of construction operatives in the State of Qatar", *International Journal of Construction Management*, Vol. 12 No. 3, pp. 1-23.

Abimbola, O.W. (2016), "Skilled labour supply in the South African construction industry: the nexus between certification, quality of work output and shortages", *SA Journal of Human Resource Management*, Vol. 14 No. 1, pp. 1-8.

Adi, H.P. and Ni'am, M.F. (2012), "Improving skill's strategies of indonesian construction labours to have global competitiveness", *International Journal of Civil and Structural Engineering*, Vol. 3 No. 1, pp. 150-157.

Akyazi, T., Alvarez, I., Alberdi, E., Oyarbide-Zubillaga, A., Goti, A. and Bayon, F. (2020), "Skills needs of the civil engineering sector in the European Union countries: current situation and future trends", *Applied Sciences*, Vol. 10 No. 20, pp. 1-24.

Anil, M., Chitranjan, G.P. and Jayeshkumar, P. (2019), "Analysis of causes, effects and impacts of skills shortage for sustainable construction through analytic hierarchy process", *International Journal of Technical Innovation in Modern Engineering and Science*, Vol. 5, pp. 168-176.

Brent, G.H. and Leighton, E. (2013), "Factors affecting construction labour productivity in Trinidad And Tobago", *The Journal of the Association of Professional Engineers of Trinidad And Tobago*, Vol. 42 No. 1, pp. 4-11.

Detsimas, N., Coffey, V., Sadiqi, Z. and Li, M. (2016), "Workplace training and generic and technical skill development in the Australian construction industry", *Journal of Management Development*, Vol. 35 No. 4, pp. 486-504.

Dickinson, J.K., Woodard, P., Canas, R., Ahamed, S. and Lockston, D. (2011), "Game-based trench safety education: development and lessons learned", *Journal of Information Technology in Construction*, Vol. 16, pp. 118-132.

Gomez, M.A., Herrera, R.F., Atencio, E. and Munoz-La Rivera, F.C. (2021), "Key management skills for integral civil engineering education", *International Journal of Engineering Pedagogy (iJEP)*, Vol. 11 No. 1, pp. 64-77.

Hai, D.T. and Tam, N.V. (2019), "Analysis of affected factors on construction productivity in Vietnam", *International Journal of Civil Engineering and Technology*, Vol. 10 No. 2, pp. 854-864.

Hai, C.P., Nhu, N.D., Akeem, P., Quang, T.L., Rahat, H., Sungrae, C. and Chansik, P. (2018), "Virtual field trip for mobile construction safety education using 360-degree panoramic virtual reality", *International Journal of Engineering Education*, Vol. 34 No. 4, pp. 1174-1191.

Hughes, R. and Thorpe, D. (2014), "A review of enabling factors in construction industry productivity in an Australian environment", *Construction Innovation*, Vol. 14 No. 2, pp. 210-228.

Izwan, J., Sayuti, I.M. and Ramli, N.I. (2019), "The knowledge competency of civil engineers in construction industry", *Earth and Environmental Science*, Vol. 244, pp. 1-5.

Jeelani, I., Albert, A., Azevedo, R. and Jaselskis, E.J. (2017), "Development and testing of a personalized hazard-recognition training intervention", *Journal of Construction Engineering and Management*, Vol. 143 No. 5, pp. 1-11.

Kesavan, M., Pujitha, D., Chintha, P., Dharsana, D. and Renuka, S. (2020), "Assessment of critical factors influencing the performance of labour in Sri Lankan construction industry", *International Journal of Construction Management*, pp. 1-12.

Kesavan, M., Pujitha, D., Chintha, P., Dharsana, D. and Renuka, S. (2021), "A curriculum guide model to the next normal in developing construction supervisory training programmes", *Built Environment Project and Asset Management*, pp. 1-31.

Kesavan, M., Pujitha, D., Chintha, P., Dharsana, D. and Renuka, S. (2022a), "A guiding model for developing construction training programmes focusing on productivity and performance improvement for different qualification levels", *Construction Innovation*, pp. 1-24.

Kesavan, M., Pujitha, D., Chintha, P., Dharsana, D. and Renuka, S. (2022b), "A labour performance score and grading system to the next normal practices in construction", *Built Environment Project and Asset Management*, pp. 1-20.

Kesavan, M., Pujitha, D., Chintha, P., Dharsana, D. and Renuka, S. (2022c), "Assessing the performance and productivity of labour in building construction projects through the application of work-based training practices", *Construction Innovation*, pp. 1-26.

Mahan, T. (2019), "How to define ethical behavior and why it's important in the workplace", available at: https://workinstitute.com/how-to-define-ethical-behavior-why-its-important-in-the-workplace-2/ (accessed 16 December 2019).

Ojha, A., Seagers, J., Shayesteh, S., Habibnezhad, M. and Jebelli, H. (2020), "Construction safety training methods and their evaluation approaches: a systematic literature review", *Proceedings of the 8th International Conference on Construction Engineering and Project Management*, *Hong Kong*, pp. 188-197.

Parviz, G., Omid, P., Nicholas, C. and Reza, M.H. (2015), "Labour productivity in Iranian construction projects", *International Journal of Productivity and Performance Management*, Vol. 64 No. 6, pp. 811-830.

Serdar, D. and Jasper, M. (2011), "On-site labour productivity of New Zealand construction industry: key constraints and improvement measures", *Australasian Journal of Construction Economics and Building*, Vol. 11 No. 3, pp. 18-33.

Showkat, N. and Praveen, H. (2017), "Non-probability and probability sampling", e-PG Pathshala.

Silva, G.A.S.K., Warnakulasuriya, B.N.F. and Arachchige, B.J.H. (2018), "A review of the skill shortage challenge in construction industry in Sri Lanka", *International Journal of Economics, Business and Management Research*, Vol. 2 No. 1, pp. 75-89.

Siregar, S. (2018), "A study of work-based learning for construction building workers", *Journal of Physics: Conference Series*, Vol. 970, pp. 1-6.

Statistics Canada (2020), "Guide to the labour force survey 2020, Canada", available at: www150.statcan.gc.ca/n1/pub/71-543-g/71-543-g2020001-eng.pdf (accessed 16 July 2021).

Teixeira, J.M.C., Minasowicz, A., Zavadskas, E.K., Ustinovichius, L., Migilinskas, D., Pellicer, E., Nowak, P. and Grabiec, M. (2006), "Training needs in construction project management: a survey of 4 countries of the EU", *Journal of Civil Engineering and Management*, Vol. 12 No. 3, pp. 237-245.

Tony, M., Luong, C. and Zuo, J. (2014), "A study of the skills of construction project managers in Australia and their needs for training and certification", *5th Engineering, Project, and Production Management Conference Proceedings*, *Port Elizabeth, 26-28 November*, pp. 45-54.

TVECSL (2018), "Construction industry sector training plan 2018 – 2020, Sri Lanka".

Uwakweh, B.O. and Maloney, W.F. (1991), "Conceptual model for manpower planning for the construction industry in developing countries", *Construction Management and Economics*, Vol. 9 No. 5, pp. 451-465.

Vaz-Serra, P. and Mitcheltree, H. (2020), "Understanding the key master of construction project management graduate competencies required to meet industry needs in Australia", *International Journal of Construction Education and Research*, Vol. 17 No. 3, pp. 222-241.

Victor, O.N. (2018), "Impact of low labour characteristics on construction sites productivity in Ebonyi state", *International Journal of Advanced Research in Science, Engineering and Technology*, Vol. 5 No. 10, pp. 7072-7087.

Yin, R.K. (2002), "Case study research design and methods", 3rd ed., Vol. 5, *Applied Social Research Methods Series*, SAGE Publications, London.

About the authors

Dr Kesavan Manoharan is presently serving as a Senior Lecturer in the Department of Construction Technology, Faculty of Technology, Wayamba University of Sri Lanka (Sri Lanka). Dr Kesavan Manoharan is also serving in various key roles in the academic, administrative and industry sectors in Sri Lanka. He has academic teaching experience in Civil Engineering, Construction Management, Construction Planning, Structural Analysis, Structural Design, Construction Materials and Construction Technology. Dr Kesavan Manoharan has specific interest/experience in quality assurance practices in higher education, curriculum development and mapping processes. He has also been supporting the academic activities of other universities/institutions by conducting visiting lectures/guest lectures and workshops. Dr Kesavan Manoharan graduated from the University of Peradeniya (Sri Lanka) with a BSc Eng (Hons) degree specialised in Civil Engineering. He also obtained PhD in Civil Engineering from the Faculty of Engineering, University of Peradeniya (Sri Lanka). He has professional memberships with the Institution of Engineers Sri Lanka (IESL), the Society of Structural Engineers Sri Lanka (SSESL), the Green Building Council of Sri Lanka (GBCSL) and the National Science Foundation of Sri Lanka (NSF-SL). Dr Kesavan Manoharan has numerous research publications in reputed journals and conference proceedings, as well as received a number of research awards in recognised forums. His academic/research interests expand to the areas such as construction planning and project management, productivity measurements, performance assessment, modern benchmarking systems, resource management, labour and job quality improvement, project delay control, building information modelling, construction education, multi-disciplinary research bridging industrial and institutional practices, education, training and curriculum development, quality assurance practices in education and training and optimisation methods. Kesavan Manoharan is the corresponding author and can be contacted at: kesavan@wyb.ac.lk

Dr Pujitha Dissanayake is serving as a Senior Lecturer in the Department of Civil Engineering, Faculty of Engineering, University of Peradeniya (Sri Lanka) at present. He graduated from the University of Peradeniya (Sri Lanka) with a BSc Eng (Hons) degree specialised in Civil Engineering in 1991 and obtained his PhD from the University of Hong Kong (Hong Kong) in 1999. Dr Pujitha Dissanayake also worked as a Project Manager/Planning Engineer at Maunsell AECOM (Hong Kong) from 1998 to 2007. His current research interests are related to the field of Civil Engineering and Construction Management track.

Dr Chintha Pathirana is serving as a Senior Lecturer in the Department of Civil Engineering, Faculty of Engineering, University of Peradeniya (Sri Lanka) at present. She obtained her BSc Eng, MSc Eng and PhD in Civil Engineering from the University of Peradeniya (Sri Lanka). Dr Chintha Pathirana also has Chartered Engineering qualifications from the Institution of Engineers, Sri Lanka. Her current research interests are related to civil engineering, construction materials and construction management.

Prof Dharsana Deegahawature is serving as a Professor in the Department of Industrial Management, Wayamba University of Sri Lanka (Sri Lanka) at present. He obtained his BSc (Business Administration) from the University of Sri Jayewardenepura (Sri Lanka) in 1999, MBA (Technology Management) from the Asian Institute of Technology (Thailand) in 2006 and PhD in Management from the Huazhong University of Science and Technology (China) in 2014. Prof Dharsana Deegahawature is also presently serving as the Director of the Staff Development Centre, Wayamba University of Sri Lanka. His current research interests are related to industrial management and technology management.

Prof Renuka Silva is presently serving as the Professor (Chair) in the Department of Applied Nutrition, Wayamba University of Sri Lanka (Sri Lanka). He obtained his BSc (Hons) in Agriculture from the University of Peradeniya (Sri Lanka) and PhD in the discipline of Human Nutrition from the University of Reading (UK). Prof. Silva held several academic and administrative positions at the Wayamba University of Sri Lanka, presently serving as the Director of the Centre for Quality Assurance. Prof Renuka Silva's research interests span wider areas in nutrition, also in quality assurance-related practices in education/training.