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Testing the Construction Site Supervisory Attributes in Applying Green Practices in Construction Operations

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Abstract: Sources highlight that poor application of green practices, ineffective supervising strategies and inadequate apprenticeship facilities significantly impact the overall efficiency of construction project flows. Accordingly, this research attempts to test the construction supervisory traits in executing green concepts/practices in construction site operations. As part of a newly designed supervisory apprenticeship that was systematically designed utilising consecutive approaches, 59 construction supervisors were evaluated using four key sections of competency characteristics and the relevant learning domains. An assessment tool encompassing various levels of descriptions and criteria was developed using a comprehensive literary analysis and consultations with subject matter experts. The results point to a generalised modern guideline that describes the types of supervision traits related to the application of green concepts/practices that can be theoretically and practically taken into account during the construction process. Using appropriate statistical tests and professional evaluations, the validation and generalisation of the study's applications were ensured with the reliable-ness of the findings. New standards and recommendations for construction supervision procedures are produced by the research, which might elevate this profession and make it the key determinant of the sustainability of site operations. This paper elaborates on the study's broad implications and potential future applications in order to close the knowledge gap in the area of developing the application procedures and protocols related to skill enhancement/upgrading. The implementation of the research outcomes will significantly impact future practices in other developing nations and developing industries, even though the supervisory samples were used from the Sri Lankan construction setting.

Keywords: Developing Countries, Green Practices, Performance Evaluation, Productivity Improvement, Sustainability, Work-based Training

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1. Introduction

The construction industrial processes are essential to rising the demand for residential, commercial, industrial and infrastructural facilities due to recent urbanisation and population expansion (Min et al., 2019). The construction industrial outcomes contribute significantly to the economies of several nations (Wijewantha, 2018). The complicated nature of the construction activities has made the construction sector distinctive (Gurcanli & Mungen, 2009). The professionals in the construction industry need to be adaptable in a world that is constantly changing as a result of competition (Shi et al., 2014). The influence of the built environment on human social development, living conditions and health aspects has led to a growth in construction (Nawarathna et al., 2021). In order to combat climate change, the construction industry poses a number of issues and challenges (Ali et al., 2020). Further, the usage of non-renewable energy sources, bad architectural design aspects and a lack of consideration of sustainability aspects in urbanisation have all hindered the implementation of climate change mitigation measures in the construction sector (Bolpagni et al., 2022). As a result, in addition to strategies and programmes for reducing climate change, specified frameworks and norms are necessary to be implemented (Ali et al., 2020). Accordingly, the construction sector needs to address climate change by upholding laws and regulations, performing impact analyses, implementing low-carbon technologies and cutting energy usage (Ali et al., 2020). Consequently, the construction industry has a major obligation to ensure sustainable standards in construction projects (Bolpagni et al., 2022).

The fourth industrial revolution, which is now underway and is mostly based on cutting-edge technology, tends to encourage unconventional employment in various areas (Darshana, 2017). Due to subsequent technical advancements, rapid urbanisation and population increase, the industry sector is crucial in determining how development proceeds on a national and international scale (Manoharan et al., 2022a). Although such advancements have improved comfort and efficiency, many industrial firms in the construction sector of developing countries improperly take use of applications connected to engineering, technology and science to boost work efficiency and its associated effects (Min et al., 2019). Such activities by construction enterprises significantly impact the productivity, quality and safety of construction tasks (Tuan & Tam, 2019). This has been the main cause of the problems that many industrial firms have had with competitiveness, funding, price increases and task delays, which has had a big influence on a country's economic status (Nwosu, 2018; Anil et al., 2019). Recent sources, particularly those from Iranian (Parvis et al., 2015), Nigerian (Nwosu, 2018), Vietnamese (Tuan & Tam, 2019) and Sri Lankan (Kesavan et al., 2020, 2021b), confirm that such concerns were uncovered that had a substantial impact on the economies of many developing nations.

From the standpoint of the context of Sri Lanka, the construction industry accounts for more than half of its gross domestic fixed capital production (Darshana, 2017). The Sri Lankan construction sector has experienced significant growth following the conclusion of the "Eelam" war ten years ago, which has led to the extensive range of infrastructure development construction projects currently progressing in the country (TVEC, 2017; Kesavan et al., 2020) and allowed it to stake a claim as one of the top profit-making industry sectors in the country (Wijewantha, 2018). There is a higher need for personnel in the construction industry in the Sri Lankan setting by reason of the sector's continuing growth (Darshana, 2017). According to expert consultations, numerous infrastructure development projects and investment schemes currently underway in Sri Lanka fall into a number of categories, including transportation, energy, environment, water and waste management, maritime, aero, commercial hubs, high-rise constructions, housing schemes, township schemes, industrialisation zones and modern cities for tourism. These projects and investment schemes are all contributing to the industry's continued growth. Some local residential and commercial development projects are being carried out under soft-loan programmes offered by state and private banks, as was also shown in the expert debates. As a result, there is enormous potential for expansion in the construction industry in Sri Lanka (Darshana, 2017). According to Wijewantha (2018), the construction sector, which has seen a dramatic increase in job vacancies, is crucial to the economy and progress of the nation. Sources indicate that the Sri Lankan construction industry has created more than six lakhs of direct job vacancies in construction-related occupations, including construction engineering professionals, supervisory/technical staff, craftsmen (masons, welders, plumbers and other tradesmen) and tool operators (Wijewantha, 2018). Yet, sources point out that poor applications of greenery aspects have significantly worsened the efficiency and productivity issues that many Sri Lankan construction companies have been dealing with on a number of those development projects (TVEC, 2017; Silva et al., 2018; Manoharan et al., 2022a). Studies show that structural problems in the current system of vocational education/training are the primary causes of these difficulties in the Sri Lankan construction sector (TVEC, 2017; Kesavan et al., 2021a). The country's current vocational education policies are drastically out of sync with satisfying the needs of industry sectors now and in the future (Kesavan et al., 2020, Manoharan et al., 2022a). Another problem in this space is the lack of attention the sector places on work-based training techniques (TVEC, 2017; Kesavan et al., 2021a).

The efficiency and productivity of construction tasks are influenced by a variety of factors (Nwosu, 2018; Tuan & Tam, 2019; Anil et al., 2019). Since the lack of skills, inadequate methods for handling tools and materials, low worker motivation and other issues related to modern technologies are notable factors among them, changing the characteristics of supervisory roles can be important in offering real solutions in relation to these issues to deal with the challenges related to work efficiency (Parvis et al., 2015; TVEC, 2017; Nwosu, 2018; Silva et al., 2018; Tuan & Tam, 2019; Manoharan et al., 2022b). The primary responsibility of construction supervisors is to manage constraints and

close gaps between labour and organisations, and this responsibility has a significant impact on how effectively site operations are directed to perform (Nwosu, 2018; Tuan & Tam, 2019). In view of current circumstances, construction monitoring techniques have considerable impacts on the effectiveness of the industry in emerging nations like Sri Lanka (Tuan & Tam, 2019; Nwosu, 2018; Kesavan et al., 2020, 2021b). Studies show that in order to properly supervise worksite operations, construction supervisors from these countries need to practice refining their application-based learning methodologies on skilled management of green practices (Nwosu, 2018; Kesavan et al., 2021a). It is crucial to remember that these application-based learning techniques must be closely related to the duties, task flows and demands of learning in the workplace (Kesavan et al., 2021a, 2022). Recent investigations (Nwosu, 2018; Silva et al., 2018; Tuan & Tam, 2019; Kesavan et al., 2021b) and interviews with construction industry experts have shown that the ability of construction supervisors to utilise the application of green practices on worksite operations has a substantial level of impacts on enhancing the productiveness and effectiveness of construction processes.

1.1 Problem Statement

Recent studies (TVEC, 2017; Nwosu, 2018; Anil et al., 2019; Kesavan et al., 2021a, 2021b) and interviews with construction experts/specialists and relevant skill sector officials revealed that many developing nations with contexts similar to Sri Lanka lack appropriate methods and procedures to test the abilities of construction supervisory resources in utilising the application of green practices on project site operations. The importance of resolving this issue lies in its effects on the chain of inadequate apprenticeship infrastructure, skill shortages and competency gaps in construction supervision roles that have been the main obstacles limiting the efficacy of construction operational flows in the developing countries' perspectives similar to the Sri Lankan setting (Windapo, 2016; TVEC, 2017; Nwosu, 2018; Kesavan et al., 2020). The current study's background analysis points up that previous investigations did not adequately address such stated difficulties. The current study identifies knowledge gaps in the industrial development plans about how to methodically handle the tasks of competency evaluations, performance assessments and apprenticeship procedures targeted at the supervisory attributes on the application of sustainable and green approaches with a direct scope of enhancing the effectiveness, productivity, quality and safety of the functional aspects of the built environment. The study emphasises the necessity of restructuring the construction supervision job positions related to this knowledge gap in light of this crucial fact (Kesavan et al., 2021a).

1.2 The Study's Aim and Significance

In order to increase the efficiency in industrial workflows based on the difficulties and demands mentioned above, this research aims to test the abilities of construction supervisory resources in understanding the concepts related to green and sustainable built environment aspects as well as in putting their applications into practice. The primary focus of this study is on a range of supervisory practice competencies connected to its objectives. The industry lacks the knowledge necessary to develop the frameworks and application procedures needed to evaluate the skills of supervisory workers in construction and measure their performance in this setting, which is why this study is crucial. The research attempts to open a gate that receives potential knowledge characteristics to the industrial flows together with the required weight comparisons for the pertinent competency factors towards reshaping supervisory features and adding new traits to the industrial flows to predict, understand and quantify the levels of supervisory abilities can practically be applied in real operations.

2. Literature Review

Due to lower levels of productivity in project operations in recent years, construction firms in several nations, particularly those in Indian, Nigerian, South African, Sri Lankan and Vietnam contexts, face a number of challenges in competing globally, as per recent studies (Windapo, 2016; Nwosu, 2018; Silva et al., 2018; Tuan & Tam, 2019; Anil et al., 2019). All of these studies have identified a lack of systematic approaches for skill improvement as the root of the industry's issues.

2.1 Effective Training Tools and Techniques for Assessing the Performance of Construction Activities and Supervision Processes

A theoretical model developed by Uwakweh & Maloney (1991) more than 30 years ago for resource planning in the construction sector emphasises the need to enhance work-based training methods to produce a more skilled construction supervisory pool with a diversity of competencies. Uwakweh & Maloney (1991) highlight the importance of cooperative skills in supervisory techniques as well as the proper course of action when performing tasks and using tools. A collection of digitalised models for building studio-based smart classrooms have also been created during the past ten years by Pham et al. (2018), with a specific focus on encouraging situational awareness and interaction in the apprenticeship and skill evaluation elements. In addition to these, it is critical to take note of recent studies (Kesavan et al., 2021a, 2021b, 2022) that have presented a construction supervisory apprenticeship guiding tool, a construction labour training guiding tool and a contemporary system for scoring the labour performance and grading construction

labour as useful practical training frameworks that directly focus on enhancing the productivity and efficiency of construction operational processes. Construction supervisors may deliver a well-designed package of labour training exercises to craftsman-level workers, namely masons, welders, plumbers, tool operators, etc., from the labour apprenticeship guidance model/tool of Kesavan et al. (2021a). In their complete analysis of such labour apprenticeship exercises and their elements of outcomes, Kesavan et al. (2022) created a modern performance scoring system and grading scheme for construction labourers with generalised techniques to measure the success of construction activities inside a comprehensive mechanism. As this study has shown, it is significant to acquire construction supervision skills in the use of green and sustainable concepts to carry out the necessary tasks related to these training exercises, elements of training outcomes, performance scoring system and grading methods for labour.

2.2 Significant Supervisory Skills to Improve the Efficiency of the Construction Tasks

The primary impetuses for offering apprenticeship components to labourers on construction project sites are supervisory strategies (Kesavan et al., 2021a, 2021b). To maximise the performance of supervisory staff, construction management procedures should emphasise effective leadership, site management, planning, decision-making, teamwork and communication abilities (Hickson & Ellis, 2013; Nwosu, 2018). Such supervisory skills were shown to be crucial components in the strategies related to sustainable green practices, according to a study by Jarkas et al. (2012) of 84 Qatari construction enterprises. On the other hand, it has been established that the construction supervisors' ability to plan sustainable material usage is one of the crucial performance elements that significantly affect labour efficiency in a large number of construction projects in India (Anil et al., 2019). These supervisory abilities improve the efficiency of sustainable resource management components to prevent the issues associated with the functions of the built environment (Kesavan et al., 2020, 2021b). It was demonstrated in a number of building projects in Australia that the ineffectiveness of the construction supervisors' skills in applying quality assurance and control procedures associated with green/sustainable materials was a significant factor affecting construction efficiency (Rami & David, 2014). Project activities can be made safer, and the likelihood of expensive errors can be decreased by improving quality control systems related to sustainable material utilisation (Rami & David, 2014). Another significant barrier to contractors' efforts to boost efficiency in Australian building projects was the poor cognitive capacities of construction supervisory resources in terms of the health and safety requirements that need to be followed in green/sustainable material handling and management operations (Rami & David, 2014). On the other hand, Adi & Ni'am (2012) found that Indonesian construction supervisors' poor cognitive skills in green concepts, theories and practices associated with sustainable material/resource selection/use and their attributes significantly affect their work involvement associated with bill of quantities (BOQ) procedures. Moreover, it is necessary to employ scientific approaches effectively when integrating labour, material and environment related aspects for construction operations in order to maximise resource utilisation (Durdyev & Mbachu, 2011).

Importantly, Green Building Council of Sri Lanka (2015) produced a green rating tool/system to assess the greenery effects in buildings within a systematic framework. It is significant to note that such a tool emphasises the need for upgrading the cognitive skills and manual abilities of civil/construction engineers, quantity surveyors, technical officers and supervisory workers in the following areas for ensuring the application of green concepts and sustainable practices associated with materials, resources and waste management plans.

- Erosion and sedimentation control, reuse of building materials, reuse of other resources, recycled content, usage of local/regional materials, usage of rapidly renewable materials, usage of certified wood and other building materials, global warming aspects in buildings, construction waste management and waste management of operational solids and hazardous materials

In addition to the above, Green Building Council of Sri Lanka (2015) accentuates the need for competency enhancement among construction engineers, quantity surveyors, technical officers and supervisory workers in the following six categories to assure the application of green practices for sustainable functions in the built environment.

- Planning and management (Building user guide, building tuning, environmental management)
- Sustainable sites (Erosion and sedimentation control, selection of sites, development density and community connectivity, brownfield redevelopment, reduced site disturbance, alternative transportation, stormwater design, quantity control, light pollution reduction, heat island effect)
- Water efficiency (Water landscaping, air-conditioning systems, water use reduction, innovative wastewater technologies)
- Energy and atmosphere (Building systems commissioning, optimise energy performance, Chlorofluorocarbons reduction in heating, ventilation and air conditioning (HVAC), renewable energy, green power, ozone depletion)
- Indoor environmental quality (IAQ) (Smoke control, increased ventilation, monitoring of outdoor air delivery, IAQ management plan, controllability of systems, indoor chemical control, indoor pollutant source control, thermal comfort, low-emitting materials, daylight and views, design and verification)
- Innovation and design (Social and cultural awareness, cultural identity, archaeological sites and heritage buildings, public health and safety, social well-being)

It is significant to note that only a few studies have attempted to identify construction supervision attributes in light of the built environment in the Sri Lankan context, according to the literary analysis of the current study. TVEC (2017) emphasises the importance of honing the cognitive skills of the Sri Lankan construction supervisory resources in terms of applying effective green approaches associated with the use of construction materials and tools if industrial flows are to continue in a sustainable cycle in the country. On the other hand, the study by Kesavan et al. (2020) indicated the issues with supervisory procedures that impact the efficacy of project activities in the construction sector of Sri Lankan setting must be emphasised. Moreover, Kesavan et al. (2020) identified 20 crucial characteristics of construction supervisory practices that must be properly addressed while developing modern training programmes for supervisory staff. As a result, a foundational layer was added to the creation of more effective training programmes for supervisory resources in construction, leading to the systematic production of a set of generalised 20 training programme outcomes (TPOs) (See Table 2). These TPOs clearly show what is expected from construction supervisory resources in terms of a wide range of tasks and operational flows in construction projects.

2.3 Flaws, Gaps and Limitations in the Past Study Findings

Some studies have offered some models/tools to enhance skill enhancement procedures and evaluate efficiency at construction project sites, despite the fact that the current study's literary analysis demonstrates a variety of supervisory abilities that affect construction efficiency. However, the current study demonstrates that there are significant limits when applying such models/tools in line with industry needs and characteristics. Although they insufficiently address the subject of productivity development, the main drawbacks of such models/tools are their lack of specialised competency features and performance evaluation techniques. If one looks at the underlying causes of this constraint, many construction processes in developing countries are unable to adapt to the usage of such advanced technologies, and they have a limited amount of financing accessible. The digitalised training environment models supplied by Pham et al. (2018) may be used largely in the building industry in industrialised nations. Further, it is a fundamental worry in their creation that these models and tools disregard techniques for improving the efficacy and safety of construction activities.

To improve the efficiency and productiveness of the construction process flow, there are still substantial knowledge gaps that need to be filled, according to this study's literary analysis. The effectiveness of construction oversight approaches supports this. It is challenging for the industry sector to determine what levels/stages of traits can be taken theoretically into account and realistically applied in supervision features because of the lack of knowledge in the field in relation to the creation of protocols and application techniques required to test the supervisory traits and track the performance of supervisory features.

2.4 The Importance of Adapting the Apprenticeship Guidance Tool Presented by Kesavan et al. (2021b) in Light of the Goal of the Current Study

A training guiding manual for reshaping construction supervisory qualities has been provided by Kesavan et al. (2021b), and it meticulously addresses the challenges that the industry sector faces as it expands. Within the scope of enhancing the effectiveness and productiveness of construction process flows, the guidance model/tool of Kesavan et al. (2021b) specifically comprises 12 competency units (CUs) and 64 competency elements (CEs), with one of those competency units emphasising the use of green practices and sustainable approaches related to construction processes. Four CEs dealt specifically with crucial supervisory qualities as part of the deployment of appropriate green/sustainable practices for boosting the effectiveness and productiveness of construction activities. Further, it is notable that the required competency traits accentuated by Green Building Council of Sri Lanka (2015) are collectively encompassed in a summarised form in the supervisory apprenticeship guidance tool of Kesavan et al. (2021b). This adds the values to consider those four CEs highlighted in the apprenticeship model of Kesavan et al. (2021b) for the current study's purpose. The weight distribution flow of these CEs in connection to Bloom's taxonomy framework of learning domains is shown in Table 1. This weighting scheme facilitates the development of competency evaluation methodologies and offers a thorough cross-section of the CEs.

The descriptions listed below were used to determine the mapping levels between the TPOs of Kesavan et al. (2020) and the four CEs of Kesavan et al. (2021b).

- Introduced level/stage (IL): The learning practices would give an overview of the intended outcome.
- Emphasised level/stage (EL): The learning practices would emphasise the desired result/outcome.
- Reinforced level/stage (RL): The learning practices would act as reinforcement for the materials in the direction of the desired result.
- Advanced level/stage (AL): The learning practices would represent an advanced level of interaction with the resources towards the achievement of the desired results.

The abilities of the supervisors, industry norms and practical considerations were all carefully considered before deciding on mapping levels. Given the mapping levels that arose between the TPOs and CEs, the mapping findings of the entire competency unit under the TPOs were established in accordance with the following statements.

- The mapping level denotes that the competency unit (CU) prominently (P) or considerably (C) or moderately (M) or slightly (S) meets the relevant TPO criteria.

Table 1 - Mapping and distributed weights of relevant competency elements (CEs) and competency unit (CU) relevant to applying/executing green practices in construction activities, along with learning domains of Bloom's taxonomy, produced by Kesavan et al. (2021b)

Competency Elements (CEs) / Competency Unit (CU)	Weight (%)	Levels of Learning Domains															
		Cognitive/ Knowledge Levels (CD)				Psychomotor/ Skill Levels (PD)							Affective/ Attitude Levels (AD)				
		CD1	CD2	CD3	CD4	PD1	PD2	PD3	PD4	PD5	PD6	PD7	AD1	AD2	AD3	AD4	AD5
CE-1: Describing the significance of green concepts for assuring the environmental sustainability	20	9				3	3						5				
CE-2: Applying green concepts in the construction materials/resource usage	30	2	10			2	2	4	5				5				
CE-3: Proposing suitable green practices for enhancing the quality and safety of construction tasks	30	2	2			2	2	2	5				5	10			
CE-4: Preparing training materials and resources for developing the competence of labourers in the execution of green practices in project tasks	20	2	3			3	3	4					5				
CU – Proficiency in applying green concepts and practices for enhancing the effectiveness of construction operations	100	15	15	0	0	10	10	10	10	0	0	0	20	10	0	0	0

CD1: Remembering and Understanding; CD2: Applying; CD3: Analyzing and Evaluating; CD4: Creating; PD1: Perception; PD2: Set; PD3: Guided Response; PD4: Mechanism; PD5: Complex Over Response; PD6: Adaptation; PD7: Origination; AD1: Receiving Phenomena; AD2: Responding to Phenomena; AD3: Valueing; AD4: Organzation; AD5: Characterization

Table 2 - Mapping levels of competency elements (CEs) and competency unit (CU) relevant to applying green concepts and practices in construction tasks, along with the training programme outcomes (TPOs) of Kesavan et al. (2020), presented by Kesavan et al. (2021b)

Competency Elements (CEs) / Competency Unit (CU)	Training Programme Outcomes (TPOs) of Kesavan et al. (2020)																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CE-1					IL		IL	IL	IL	IL	IL				IL	IL	RL	IL	IL	IL
CE-2	EL	IL	IL		EL		EL			IL	IL				EL		RL	EL	EL	EL
CE-3	IL	IL	EL		EL	EL	EL	IL	IL	IL	IL	IL	IL		EL	IL	RL	EL	EL	EL
CE-4	IL		IL			IL	IL	IL	IL	IL	IL						RL	IL	IL	IL
CU – Proficiency in applying green concepts and practices for enhancing the effectiveness of construction operations	S	S	S		M	S	M	S	S	S	S	S	S		M	S	P	M	M	M

TPOs of Kesavan et al. (2020): Monitoring the storage, delivery and usage of construction materials and tools in project operations (TPO1), Planning the resources at project sites efficiently (TPO2), Applying productive-based supervision approaches on the construction labour operations (TPO3), Assisting in estimating and budgeting for the construction operational flows effectively (TPO4), Following the site regulations associated with overcoming health, safety and environmental related problems during the project tasks (TPO5), Implementing the constructive practices on enhancing labour performance in project operations (TPO6), Applying self-learning approaches to learn modern concepts, advanced technologies and theories associated with construction works (TPO7), Applying brainstorming approaches/techniques to enhance the labour skills in construction (TPO8), Applying competency-based apprenticeship approaches to enhance the labour skills in construction (TPO9), Instruct fundamental concepts, principles and applications to enhance the labour skills in construction (TPO10), Providing experimental training exercises to the construction labourers for their skill enhancement (TPO11), Assessing the labour performance at construction project sites (TPO12), Implementing labour rewarding mechanisms at construction project sites (TPO13), Applying suitable mathematical principles and theories to solve real problems at construction project sites (TPO14), Conducting field surveys, investigations and tests associated with feasibility studies on construction project works (TPO15), Maintaining the records of the project activities and assisting to prepare the relevant reports (TPO16), Applying green concepts and sustainable development practices on construction project tasks (TPO17), Performing tasks as a very good team player and communicator among construction workers (TPO18),

Performing tasks with positive thinking to effectively address the evolving challenges (TPO19), Performing as a good guider for construction labourers in project sites (TPO20)

3. Methodology

The research strategy used to achieve the study's goals and objectives is depicted in Fig. 1. The steps that must be taken in construction site procedures to address the industry's fluctuating challenges, opportunities and needs in new normal circumstances were the focus of a series of consultation sessions that academic and industry experts (team leaders, project managers, construction engineers and senior technical officers) took part in throughout the process. Problem-focused techniques were used at every stage of the research process, particularly for understanding the challenges, sharing ideas and identifying solutions. Significantly, the study approach was built on the usage of the construction supervisory apprenticeship guiding tool provided by Kesavan et al. (2021b). Such a tool can be used while taking into account the present study's objectives and other related causes according to expert consultations, assessments and reviews.

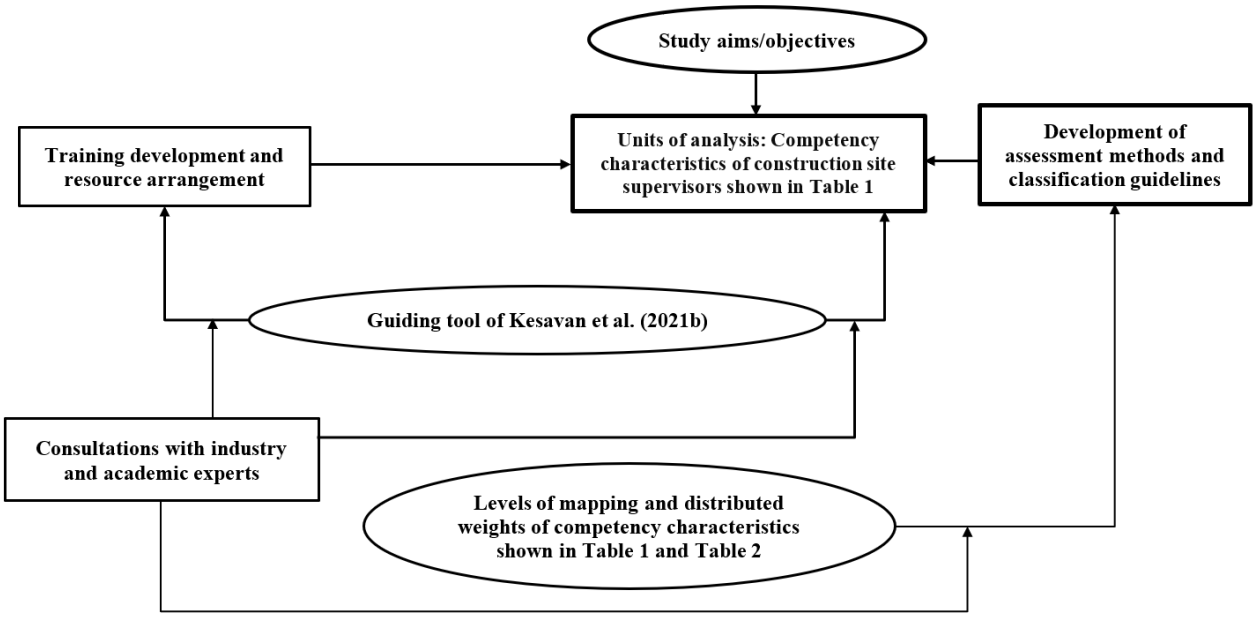

Fig. 1 - The flow of the mechanism associated with the study methodology

3.1 A New Supervisory Apprenticeship Programme and Resource Allocation

Subjected to the competency elements outlined in the apprenticeship guidance model of Kesavan et al. (2021b), a new occupationally and vocationally specific site supervisory apprenticeship programme was methodically developed to reach the diploma qualification level of the Sri Lankan National Vocational Qualification (NVQ) structure. The level 3 criteria of the Sri Lankan Qualification Framework (SLQF) structure, which is comparable to NVQ level 5, was used as the entry benchmark for choosing candidates. The Tertiary and Vocational Education Commission (TVEC) is the organisation responsible for authorising the Sri Lankan NVQ system, which protects the legitimacy of diplomas and certificates issued in Sri Lanka in accordance with rules and procedures that are acknowledged internationally (TVEC, 2021). On the other side, the SLQF is authorised by the Sri Lankan University Grant Commission (UGC), which also recognises degrees granted by commercial and governmental higher education institutions (University Grant Commission, 2015).

Sequential approaches were used during the training and development processes considering fresh characteristics in the new normal conditions of the industry. The training provider was chosen for the execution of the developed apprenticeship programme components after expert debates using the SWOT analysis. For starting the planned training programme, the relevant approvals were obtained from the relevant academic and administrative boards/committees of the selected training provider that are significant to academic development, curriculum design, planning, ethics, scholarships and finance. To ensure the systematic apprenticeship delivery at the chosen institution with an emphasis on the long-term run, resource preparations were made, including the nomination of teaching resources and the development of a Board of Study. It is noteworthy that the planned apprenticeship programme included a specific course unit that applied better practices to supervision skills based on the primary objectives of the current study by utilising a variety of work-integrated learning approaches. Significantly, each of the elements stated in Table 1 and Table 2 was covered by the relevant course/competency unit.

Five academic experts and seven industry professionals made up an expert panel that evaluated the specific course unit's detailed curriculum. The selection of these assessors was based on their involvement in approaches to the

creation of educational and training programmes and their work experience in the construction sector. It is crucial to note that 75% of them had chartered engineering credentials and that all of them had above 15 years of experience in their respective disciplines. It should also be mentioned that all of the assessors had a minimum master's degree qualification in construction engineering and technology, and half of them had also earned a doctor of philosophy degree in the fields of civil engineering and environmental science. The necessary discussions, observations and documentation were held in order to review the planned competency unit. These concentrated on the title of the course unit, the number of academic credits, the time allotted, the learning outcomes, the training materials, the teaching and learning strategies, the assessment strategies and the resource requirements within a specific analysis of the application and viability of those elements shown in Tables 1 and 2.

3.2 Selection of the Construction Supervisory Staff

The method of snowball sampling was employed to locate construction supervisory resources. It is crucial to mention that the snowball sampling technique is a strategy that can be used when it is challenging to gather samples with the required features (Showkat & Praveen, 2017). In order to locate additional supervisors who could be interested in applying to the planned apprenticeship programme, a small number of identified supervisory resources were first included in the sample. According to the guidelines outlined in the programme's by-laws, 59 construction supervisors in total were ultimately selected for the programme based on their educational and professional qualifications, work experience as well as performance shown during the selection interviews. The interviewing panel was composed of nine academic experts with backgrounds in construction engineering. The interviewers developed a two-part evaluation system (A and B), with Category A assessing the applicants' credentials in relation to the eligibility criteria and Category B assessing their subject/field knowledge, ability to apply contemporary practices, job experience, self-discipline, attitude, communication skills and other pertinent interests. The majority of the selected candidates (construction supervisory staff) worked on projects involving buildings (about 40%), while a considerable part of the supervisory resources worked on road projects (about 35%) and water supply works (about 20%). A notable aspect was that all the selected supervisory resources had at least one year of job experience in the construction site supervision aspects, and 30% of them had experience ranging from six to ten years. Each of Sri Lankan nine provinces is well-represented among the chosen construction supervisors. According to the instructions in the guiding model designed by Kesavan et al. (2021b), all of the chosen construction supervisors received the training materials.

3.3 Development of the Scoring Tool to Test Supervisory Competencies

Following consultations with academic authorities, a roadmap or instrument for evaluating the four CEs listed in Table 1 was created. The developed scoring guide/tool makes sure that the learning domains listed in Table 1 under Bloom's taxonomy have the proper weight distribution of CEs. When developing the evaluation guide/tool, the mapping of such CEs against 20 TPOs of Kesavan et al. (2020) (illustrated in Table 2) was also taken into account. Overall, 30% of the training materials in this competency unit were allocated to enhancing the cognition (knowledge) of supervisory resources, especially in terms of testing how they define terms and handle situations. In addition, 40% of the training material was intended to test the supervisors' manual/psychomotor competence that emphasises the use of sensory information, responsiveness and the development of habitual behaviour from taught reflexes. The supervisors' attitudes are the subject of the final 30% of the training materials, which promotes active engagement and responding phenomena in application-based assessments. The construction supervisors who participated in the study had a 3:4:3 ratio between cognitive, psychomotor and affective/emotional categories. According to the descriptions and criteria, each construction supervisor was evaluated for each CE under each area, and a score was given that fell within the range displayed in Table 3. The overall performance scores were then produced using the weights given to the CEs across all of the learning domains (as indicated in Table 1). Based on discussions with the assessor panel, the levels of descriptions/standards for CEs were determined with the range of scores, as shown in Table 3.

Table 3 - The criteria of the developed scoring tool for the classification of construction supervisors into different groups/grades

Group/Grade	Descriptions/Standard	Score Range
A+	Superior Level	>= 85
A	Outstanding Level	75 – 84
B	Proficient Level	60 – 74
C	Satisfactory/Pass Level	45 – 59
D	Conditional Pass Level	35 – 44
E	Fail	<= 34

3.4 Verification of the Research Tools

A group of twelve experts carried out an evaluation process that comprised continuous observations on the process flows and documentation, as well as interviews, workshops and discussions with the resources involved in apprenticeship development with an emphasis on the research plans and instruments used, as described in the aforementioned sections. It should be noted that this process involved the same professionals who were mentioned in Section 3.1.

4. Results and Discussion

In Fig. 2, the proportions of supervisors in the construction industry are shown for each competency element at various descriptions and levels of standards, which also takes into account the entire competency unit.

Taking on the competency attributes of supervisors in describing the significance of green concepts for assuring the environmental sustainability (CE-1), three-fifth of the supervisors were determined to be at an outstanding or higher level, and one-third of such portion was at a superior level. Considering the remaining two-fifth of supervisors, the grades/groups of proficient and satisfactory/pass levels can be applied in a 3:1 ratio. There were no supervisors for CE-1 in the other grades/groups. The supervisors' performance notably decreased in the competency traits related to applying green concepts in the construction materials/resource usage (CE-2) compared to CE-1. In CE-2, only 30% of the supervisors were found to be at an outstanding or higher level, whereas the majority of supervisors (37%%) received satisfactory/pass grades, and a noticeable portion of supervisors (32%) were identified at the proficient level. Similar to CE-1, there were no supervisors found in the conditional pass or fail category for CE-2. Considering the abilities of supervisors in proposing appropriate green practices for the construction activities (CE-3), the results show significantly lower performance values among the supervisors compared to the first two CEs. There were no supervisors found at outstanding or above level, whereas it is significantly noted that a quarter of the supervisors were identified in the conditional pass category. Among the remaining three-quarter supervisors, a ratio of 2:3 can be considered between the proficient level and satisfactory level categories, respectively. It can be observable that the supervisory performance substantially increased in CE-4 (preparing training materials and resources for developing the competence of labourers in the execution of green practices in project tasks) compared to CE-2 and CE-3. In CE-4, the results show that almost equal portion (one-fourth) of supervisory staff were found in superior, outstanding, proficient and satisfactory levels, whereas none of the supervisors was identified in the bottom level two grades/groups.

Taking on the overall competency unit associated with supervisory proficiency in applying green/sustainable approaches to construction site operations, nearly 10% of the supervisory workers were identified at outstanding or higher levels. Considering the remaining 90% of the supervisory workers, a 1:1 ratio could be considered between the proficient and satisfactory level categories. Similar results with minor differences can be considered can be observable when it considers the supervisors working on different categories of projects. This signifies the applicability of the proposed apprenticeship materials assuring generalisation aspects among a wide range of project tasks. For any stage in the overall competency unit, none of the supervisors was identified in the conditional pass or lower than it. Further, it became clear that the supervisors' lower performance levels in CE-2 and CE-3 significantly impacted their grades in the overall competency unit category since the weights of those two CEs had relatively 50% higher than the other two CEs, as indicated in Table 1.

Table 4 gives the mean ratings that construction supervisors obtained for each relevant competency trait, whereas Fig. 3 shows the frequency distribution curves of these supervisory performance ratings. The mean scores of CE-1 and CE-4 were virtually just above 70 (showing the upper level of the proficient grade category), whereas the mean value was around 60 in CE-2 (indicating a lower level of the proficient grade category). The mean score was found to be around 48 in CE-3, denoting the lower level of the satisfactory grade category. These discrepancies were carefully examined through expert discussions. As a result, the supervisors' limited cognitive skills in waste management concepts and applications, water management concepts and applications, environmental sustainability and built environment and environmental management system (ISO 14001) were identified as the primary cause. Further, the experts' discussions highlighted that the following abilities associated with planning and management aspects, as well as the usage of sustainable construction materials/resources and the application of green rating systems/tools substantially influence the competency characteristics of CE-2 and CE-3.

- Checking drawings of floor plans and preparing the building user guide
- Preparing/assessing the environmental management plan
- Preparing/assessing the building tuning plan
- Preparing/assessing health, safety and quality policies
- Checking other necessary certifications/documents associated with the certificate of conformity, electricity supply confirmation certificate, urban development permit, solid waste management policies, etc.
- Checking/assessing the solid waste management plan/policies and controlling methods
- Checking/assessing bill of quantities and performing the calculations for assessing the recycled contents, local/regional material content and rapidly renewable material content

- Performing the calculations related to global warming assessments

Moreover, the expert discussions emphasised that the construction organisations need to understand the significance of polishing supervisory attributes linked to work with the documents and specifications related to BOQs, building schedules of rates, standard methods of measurements, material specifications, specifications of drawings, Green rating systems/tools and other authorised ordinances/regulations for achieving the above-mentioned abilities at the required level.

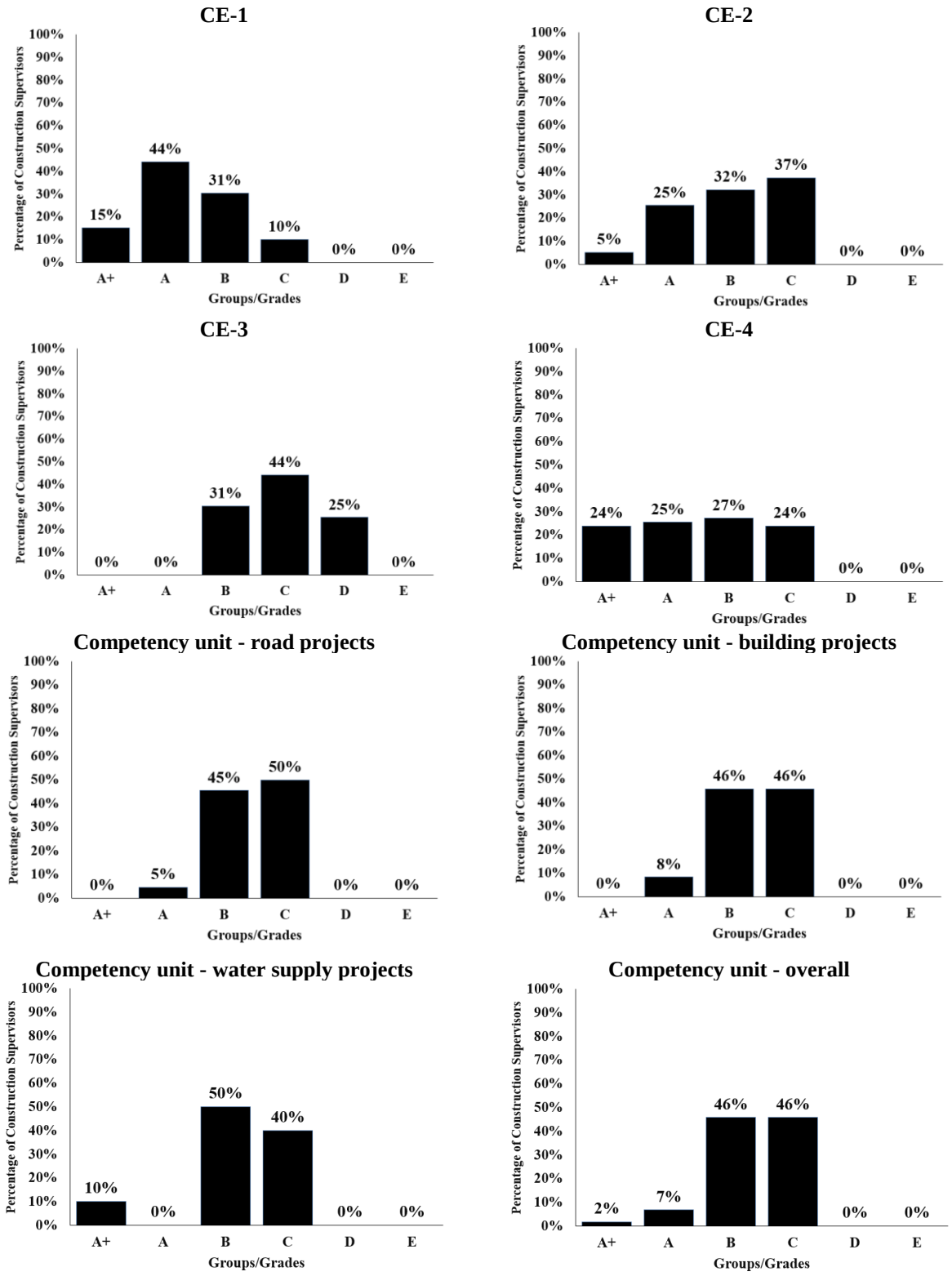

Fig. 2 - Classification of construction supervisors into different groups/grades

Table 4 - Average score values of construction site supervisors under the required competency characteristics relevant to applying green concepts and practices in construction tasks

Competency Elements (CEs) / Competency Unit (CU)	Road Projects			Building Projects			Water Supply Projects			Overall		
	AVS	STD	CV	AVS	STD	CV	AVS	STD	CV	AVS	STD	CV
CE-1	69.64	9.55	0.14	75.83	8.91	0.12	76.42	9.97	0.13	73.28	9.71	0.13
CE-2	57.44	9.14	0.16	61.68	9.65	0.16	64.38	11.17	0.17	60.35	9.58	0.16
CE-3	48.38	8.33	0.17	44.09	7.81	0.18	53.74	8.95	0.17	48.43	8.62	0.18
CE-4	71.85	9.88	0.14	71.03	8.87	0.12	66.52	10.91	0.16	71.07	9.75	0.14
CU – Proficiency in applying green concepts and practices for enhancing the effectiveness of construction operations	60.04	9.07	0.15	61.10	8.95	0.15	64.02	10.12	0.16	61.50	9.56	0.16

AVS – Average score, STD – Standard deviation, CV – Coefficient of variation

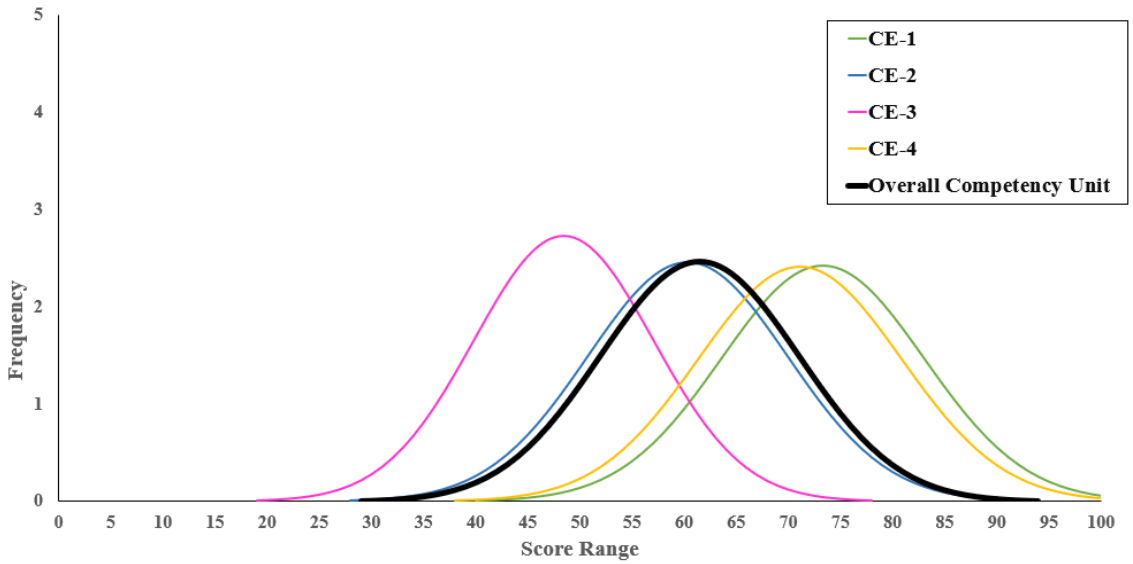

Fig. 3 - Curves showing frequency distributions of construction supervisors' scores under the required competency characteristics

The overall mean score values for the various project types were similar, whereas the supervisors' performance in the overall competency unit had a mean score of 61.5 (indicating the lower proficient level of competency standard). This ensures that the suggested training materials are extremely customisable and appropriate to the supervisory approaches used in different types of construction project work. The supervisory staff employed in road construction project work displayed slightly lower levels of performance than the supervisory staff employed in other types of project work for CE-1, whereas similar disparities can be applied to the supervisors working on water supply projects when it comes to CE-4. But, the supervisors employed in water supply projects had notably higher performance scores in CE-3 compared to the other two project types. These minor discrepancies can be attributed to the fact that different materials are utilised for different sorts of projects, and this influences the work processes and affects the effectiveness and proficiencies of supervision systems.

The CV values for the supervisors' performance scores across all CE categories looked to be no higher than 18%. This ensures that the results are comparable between raters and are within the CV value range specified by Statistics Canada (2020). As a result, there is a greater chance that the training components provided will be generally beneficial for the industry's long-term uses. Together with the preceding data, the observations of the expert panel were also incorporated. It should be noted that the panel also had academic specialists from the apprenticeship providing institution and other universities, in addition to industry professionals. Overall, the panel expressed a high level of satisfaction with all the categories of competency elements and emphasised the need to broaden the reach of the suggested training initiatives in emerging countries like Sri Lanka.

The development of a modern generalisable guideline that can help to effectively comprehend what degrees/levels of features can be considered in supervisory qualities is a significant outcome of this research endeavour (See Table 5). Depending on advancements in technology, business, training, adherence to employment restrictions, scientific

research and work outputs/productivity, this could considerably help in enhancing the planning procedures associated with construction flows sustainably.

Table 5 - The developed guideline generalising the results associated with the construction supervisory attribute levels in applying green concepts and practices for enhancing the effectiveness of construction operations

Competency Elements (CEs) / Competency Unit (CU)	Road Projects	Building Projects	Water Supply Projects	Overall
CE-1	B	A	A	B
CE-2	C	B	B	B
CE-3	C	D	C	C
CE-4	B	B	B	B
CU – Proficiency in applying green concepts and practices for enhancing the effectiveness of construction operations	B	B	B	B

Given the aforementioned conclusions, it can be stated that this study has attempted to solve the issues raised by earlier investigations regarding performance evaluation features (TVEC, 2017; Nwosu, 2018; Silva et al., 2018; Tuan & Tam, 2019; Kesavan et al., 2020) to a certain extent. The industry practices in numerous emerging countries will soon be able to adequately achieve the necessary apprenticeship results on the workforce operations and construction supervision procedures indicated by Kesavan et al (2022). The results discussed above will improve the conceptual foundations of digitalised training environment of Pham et al. (2018) for apprenticeship and skill testing methodologies. In line with the suggestions made by Pham et al. (2018) regarding the use of photography/videography methods/techniques for the delivery of apprenticeship and skill testing, the methods for apprenticeship delivery and evaluations described in the present study may be improved in the near future with the aid of those digital technologies. A thorough investigation of the peculiarities of construction supervisory procedures in different contexts of developing countries and industries serves as a starting point for the standard/description levels provided in Tables 4 and 5.

Because of the increased competence of construction supervisory workers in preparing training materials and resources for developing the competence of labourers in the execution of green practices in project tasks (CE-4), the majority of the labour resources employed under their supervision or management have acquired the necessary skills to perform their jobs to some extent independently. Significantly, the labourers acquired a variety of information and skills that allowed them to achieve the following elements of outcomes emphasised by Kesavan et al. (2021a) in their labour apprenticeship guiding tool.

- With a comprehension of the significance of environmental sustainability, workers adhere to green practices in labour-related activities, such as water supply, disposal of waste, material utilisation, etc.
- Workers educate their co-workers on the value of implementing energy-saving techniques and other environmentally friendly activities.

These adjustments to the behavioural patterns of work processes may reduce the disparity between the working hours and degrees of supervision of labourers. This highlights how employees' ability to adapt their operational competence to the interaction of the job process, demands of learning and obligations is fundamental to creating the essential components of supervisory techniques. The construction management team (CMT) members of the chosen projects claimed that the quality of work accomplished in construction labour operations has greatly improved. The CMTs also noted that, in accordance with the guidelines/conditions of the recognition of prior learning (RPL) system specified in the NVQ Circular 02/2021, the construction supervisors were qualified to conduct the assessments required to award those labourers with the NVQ credentials. The majority of CMTs concurred that they were prepared to offer future raises in salary and advancement prospects to the construction supervisors. Accordingly, the current study's findings also help to comprehend what construction supervisors referred to as 'NVQ assessors' and 'labour training mentors' on occasion. The aforementioned effects are linked to CE-4 characteristics to ensure the requirements emphasised by **Kesavan** et al. (2021b) for the enhanced attainment of the labourers in their life needs, lifestyles, employment standards, financial condition and prospects for professional progress.

5. Conclusion

The study has found useful strategies for motivating construction supervisors to attain improved levels of efficiency and productivity in project assignments by extending skill enhancement practices in the usage of methodologies connected to green/sustainable approaches in construction. Unquestionably, as shown in the findings and conclusion sections, there has been a substantial impact on the duties of construction supervisory resources, the quality, safety and productivity of work processes, job progress and the sustainable career enhancement of industry workers. The overall findings of the study are important because they significantly impact how industrial firms approach reskilling and upskilling procedures in terms of the necessary frameworks and how they are required to be

tested in practice to comprehend what competency levels can be applied both practically and conceptually in supervision features connected to the assurance of the effectiveness and productiveness of construction processes.

In an effort to enhance the values and job roles/functions of construction supervisors in the construction industry, this research offers advanced attributes to construction supervision methods that may be crucial in improving the efficiency of construction work processes. Construction supervisory employees may discover a useful technique to become authorised NVQ assessors by emphasising the results of CE-4, one of the key analytical units of the research mechanism. Due to the potential additional effects that these upgradings in supervision outcomes may have influences on the work characteristics of civil engineers and project managers, it is vital to assure the sustainability of the process flows and outcomes. The findings of the study may spur changes to training curricula in the field of vocational education to better address the difficulties and changing needs of businesses in the new normal situations. The study has additional ramifications because the findings regarding CE-4 features are consistent with the link between labour operations and supervision strategies and the efficiency of construction workflows. In turn, this strengthens the working connection between workers and employers, ensuring the construction industry's long-term viability. Additionally, it is anticipated that the skilled labour pool will grow quickly and that more workers will transition from temporary to permanent job positions in the construction sector. Consequently, this study helps local businesses use less foreign labour and improves the quality of jobs at construction sites.

Although there were different organisational policies, types of project activities, availability of resources and financial capabilities in the chosen construction organisations where the applications of this research were processed, the statistical tests' reliability assurances, along with the overall results, demonstrated that there were barely any variations between the different categories of projects. This ensures that these study applications can be utilised by numerous construction-related industries. To participate in the study as supervisory resource samples, candidates must be employed as supervisory staff in the construction field with competency levels ranging from the technician stage to the managerial stage. Developing countries can employ comparable strategies to obtain comparable results and outcomes in their industrial operations, even though the study used supervisory samples from the Sri Lankan context. The results of this study could influence how numerous developing industrial sectors operate their workflow processes, enhancing their guiding concepts and operational practices for their human resource management aspects. This research emphasises that future investigations should focus on examining the characteristics and methods of operation of the different work categories in the various trades under varied conditions. Further, future research may use quantitative measurements to compare the skills of construction supervisory resources with advancements in labour productivity and efficiency. Future investigations may also focus more intently on how digital technology might be used to improve training procedures in the construction industry.

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