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ANALYSING THE SKILL GAPS OF PLANT AND EQUIPMENT OPERATORS IN BUILDING CONSTRUCTION PROJECTS IN SRI LANKA

WAIDYASEKARA K.G.A.S.[1*], RIDMIKA K.I.[2], SANDAGOMIKA N.M.G.H.[3] & KONARA A.N.[4]
[1, 2,3,4] University of Moratuwa, Katubedda, Sri Lanka
[1]anuradha@uom.lk, [2]isuridmika@gmail.com, [3]helaminisandagomika94@gmail.com

Abstract: The construction industry is labour intensive, and hence, skill development of the industry would yield both economic and social returns to the national economy. Among other occupational categories, plant and equipment (P&E) operators in the construction industry have significant importance since the skills and competencies of P&E operators are necessary to be well equipped to serve the higher demand and technological trends. Nevertheless, the available research in the said area is limited. Hence, this study aims to analyse the skill gaps of P&E operators in the perspective of construction professionals in Sri Lankan building construction projects. The study analysed the level of importance and level of satisfaction of P&E operators in the perspective of construction professionals. The research was designed with a quantitative research approach with a questionnaire survey administered among construction professionals with a response rate of 73%. The quantitative analysis depicted that maintenance skills of P&E operators have the highest level of satisfaction by construction professionals with more than 3.77 of mean weighted rating (MWR) and importance with over 3.87 of MWR in the industry. The smartness of handling machines and teamwork were identified as the next two essential and satisfied skills of P&E operators in each category. Out of sixteen skills identified, analytical, mechanical, innovative, and interpersonal skills show a slight skills gap among different categories of P&E operators. Compared to other skills, IT received less importance under each P & E category. Furthermore, the study has concluded the skill gaps in the categories of P&E operators in the Sri Lankan building construction industry. Having identified the gaps, the paper provides the means of measurement to present, which are the most identifiable skills gap of P&E operators in the building construction projects. Propose strategies to enhance the skills of P&E operators to overcome existing issues in the Sri Lankan building construction industry and investigate the skill gap of P&E operators in infrastructure projects can be highlighted as further research areas.

Keywords: *Building Construction; Skills; Skill Gaps; Plant and Equipment (P&E) Operators*

1. Introduction

The construction industry is a highly booming sub-sector in the Sri Lankan economy, which contributes vastly to the Gross Domestic Product (GDP) of Sri Lanka (Central Bank of Sri Lanka, 2019). According to the latest update by the Department of Census and Statistics (2020), the construction sector's contribution to GDP in Q1 has been 6.4%. Therefore, the development of the construction industry would yield both economic and social returns to the national economy. The construction industry of Sri Lanka is continuously growing since the Sri Lankan government has scheduled several infrastructures, residential, and commercial development plans (Silva, Warnakulasuriya, & Arachchige, 2018). The construction sector is primarily reliant on human resources, and the majority of them are low-skilled workers (Ceric & Ivic, 2020). Among the skilled and unskilled workers, Plant and Equipment (P&E) Operators play a vital role in the construction industry (Manikandan et al., 2018). Different types of P&E operators are present within the construction industry, carrying out specific jobs and functions (Kamaruddin, Mohammad, & Mahbub, 2016). Therefore, several researchers have highlighted the necessity of encompassing a significant set of skills of P&E operators (Naskoudakis & Petroutsatou, 2016).

The considerable expansion of the construction industry creates both challenges and opportunities for the human resources engaged in the industry. The shortage of skilled workers in the construction sector has become a critical

*Corresponding author: Tel: +94 718570781 Email Address: anuradha@uom.lk
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concern worldwide (Prajeesh & Sakthivel, 2016). According to Silva et al. (2018), the shortage of human capital, including professional and skilled and unskilled workforce, is one of the significant challenges in the Sri Lankan construction industry. The P&E operators are often in short supply in the Sri Lankan construction industry, both in terms of quantity and quality(Chandasiri, 2017). Hence the skill shortage can be typically identified in the category of P&E operators in Sri Lanka (Silva et al., 2018).

The lack of needed skills and competencies among occupants lowers construction worker quality (Prajeesh & Sakthivel, 2016). The Training Needs Assessment and Skills Gap Analysis report reveals Sri Lanka's skill deficit problem (Technical & Vocational Education Commission, 2016). Basnayake and Premathilaka (2015) have identified the importance of different skills such as plant or equipment operating skills, safe working skills, interpersonal skills, communication skills, team working skills, organising skills, and reading and interpretational skills for the P&E operators. Further, the significance of P&E operators to the success of construction projects have been comprehensively stated by Radadiya (2014) as proper use of P&E contributes to enhance the economy, quality safety, speed and timely completion of a construction project. This necessitated the further investigation of skill gap analysis of P&E operators to provide insight to the construction industry professionals in success of construction projects. However, there is a research dearth on the investigation on skills gap of P&E operators in building construction projects in Sri Lanka.Therefore, this study aimed to investigate the skill gap of P&E operators in building construction projects in the perspective of construction professionals in Sri Lanka.

Skill gaps describe the phenomenon whereby the skill levels of workers are insufficient to meet the requirements of their current job. Further, Mullin, Thurairajah, and Williams (2010) highlighted that skills gap of the human resources in construction sector can be calculated by evaluating what is expected from and what is delivered by those human resources. Therefore, two objectives were formed and followed to achieve this aim: identifying the level of importance of each skill in the perspective of construction professionals, and identifying the level of satisfaction by the construction professionals with respect to the each skill performed by the P&E operators. More comprehensively, the necessity of each skill to be inculcated within the P&E operators has been addressed through level of importance. Furthermore, how satisfied the construction professionals are with the each skill of P&E operators in building construction projects in Sri Lanka have been comprehensively elaborated through level of satisfaction as per the second objective. Thereby the identified skill gaps will provide insight into the necessary skills to be developed within the P&E operators under different categories to enhance the quality of the construction procedures in the perspective of construction professionals. More comprehensively, the construction professionals would be able identify the different perspectives, which necessary to be build and developed within the P&E operators.

The scope of this study is set to investigate the skills gap of P&E operators in building construction projects in the perspectives of construction professionals in Sri Lanka. Further, the investigation of skills gap of P&E operators has been limited to the building construction projects. This paper is structured in five sections. Following the introduction, the second section describes the literature on P&E, the third section discusses the adopted research method, and the fourth section presents detailed research findings. The last section discusses the conclusions derived from the study.

2. Literature

2.1 PLANT AND EQUIPMENT OPERATORS

Modern construction P&E plays an important role where business objectives are rigorously time and margin-driven in the construction industry (Prajeesh & Sakthivel, 2016). Modern construction equipments are expeditious and stable and have in-built high-quality control systems as they have progressed over time in the construction industry. The proper use of this P&E enhances the economy, quality, safety, speed, and timely completion of the building projects (Naskoudakis & Petrout-satou, 2016). P&E operators in the construction industry are responsible for operating heavy machinery and equipment used in construction sites. More comprehensively, P&E operators have been defined as the human resources who are responsible for operating the self-propelled machines and all other types of mechanised construction work apparatus designed to do construction work (Edwards & Holt, 2009).

The construction industry uses different types of P&E under substantial technical advancement. In every construction, P&E is built to perform a specific function. The selection of different types of P&E depends on the size of the work and the project's economy, making the construction process easier and faster (Waidyasekara, Ridmika, Sandagomika, & Konara, 2021). These plants come in various sizes and perform a variety of tasks. Excavators, backhoes, front shovels, graders, loaders, and tractors are among the commonly utilised plants in construction projects. Komissarov et al. (2016) describe excavators as one of the massive construction equipment that consists of a stick, broom, bucket, and cab on a rotating platform. A backhoe plant can be used for excavating and is also known as a rear actor or back actor. It has a digging bucket on the end of a two-part articulated arm and can use for excavating. As a result, it can also apply high tooth pressure, allowing it to extract stiff material that would otherwise be impossible to excavate with a dragline.

Furthermore, according to Frankel (2003), backhoes are employed for various tasks, including cleaning up debris on worksites, smoothing out uneven surfaces, excavating holes, and digging trenches. Cranes, forklift trucks, beakers, compacters, concreting plants, earth-moving plants, and piling plants are some of the main plants and equipment utilised in the Sri Lankan construction industry (Basnayake & Premathilaka, 2015). According to the study conducted by Waidyasekara et al. (2021), the P&E have been identified under major two categories of movable and immovable. Accordingly, the earth moving machine, piling machine, crane, lifting equipment, generator machine, compressor, compacting machine, and vehicles have been identified under movable P&E while the Asphalt plant, Batching plant, Crusher plant, and Sand feeding machines have been highlighted under the immovable plant and machinery operators. Therefore, this study has considered the above P&E categories as the basis in this paper. Hence, the below-mentioned occupational category have been majorly considered in this manuscript as elaborated in Table 1.

Table 1. Main Occupational Category of P&E Operators

Code	Main P&E Category
P&E 1	Earth-Moving Equipment Operators
P&E 2	Piling Machine Operators
P&E 3	Crane Operators
P&E 4	Lifting Equipment Operators
P&E 5	Generator Operators
P&E 6	Compressor Operator
P&E 7	Compacting Equipment Operators
P&E 8	Vehicle - Driver
P&E 9	Immovable Plant and Machinery Operators (Asphalt plant, Batching plant, Crusher plant, Sand feeding, etc.)

(Source: Waidyasekara et al., 2021)

According to the occupational map developed by Waidyasekara et al. (2021), the P&E operator categorisation has been highlighted majorly under movable and immovable P&E operators as extracted above. Since the above-mentioned categorisation has considered as the basis of main P&E operator categories, earth-moving equipment operators, piling machine operators, crane operators, lifting equipment operators, generator operators, compressor operators, compacting equipment operators, vehicle-driver, and immovable plant and machinery operators have been considered in this manuscript.

2.2 WORKPLACE SKILLS OF PLANT AND EQUIPMENT OPERATORS

Skills are defined as the things learned to be able to carry out one or more job functions (Mullin et al. 2010). Competencies incorporate a skill but are more than the skills, and they include abilities and behaviours and the knowledge fundamental to the use of a skill (Detsimas et al., 2016). According to Detsimas et al. (2016), the absence of required skills and competencies among occupants negatively impacts the quality of the construction occupants. Since each P&E operator handles specific plants or equipment, these operators must encompass different skills in handling those plants or equipment. Like other occupants in other industries, P&E operators in the construction industry should equip themselves with those skills to perform their duties properly. Plant or equipment operating skills, safe working skills, interpersonal skills, communication skills, teamwork skills, organising skills, and reading and interpretational skills are the sets of skills expected from P&E operators (Basnayake & Premathilaka, 2015).This study has adopted sixteen skills for P&E operators by considering the skills above identified by several researchers worldwide, as elaborated in Table 2.

Table 2. Required Skills for P&E Operators

Code	Required Skills for P&E Operators
S1	Analytical Skills
S2	Maintenance Skills (Planned and Unplanned)
S3	Mechanical Skills
S4	Technical skills
S5	IT skills
S6	Electronic skills
S7	Smartness of handling machines
S8	Innovative Skills
S9	Health and safety skills (First aid, Safe working, etc.)
S10	Planning and Organising Skills
S11	Documentation skills
S12	Interpersonal skills
S13	Problem-solving skills

S14	Teamwork
S15	Communication skills
S16	Language Literacy and Numeracy Skills

(Source: Waidyasekara et al., 2021)

According to Waidyasekara et al. (2021), several skills necessary for P&E operators have been highlightedsuch as technical skills, mechanical skills, maintenance skills, analytical skills, preventive maintenance skills, problem-solving skills, interpersonal skills, IT skills, and health and safety skills. In addition to that, the authors have highlighted the importance of some other skills, namely organising skills, documentation skills, language literacy, punctuality, communication skills, proper ethical behaviour, planning skills, smartness of handling machines, and teamwork. Accordingly, Table 2 has been developed by incorporating the findings of Waidyasekara et al.(2021) as the basis for this paper.

3. Methodology

This study aims to analyse the skill gaps of P&E operators in the perspective of construction professionals in Sri Lankan building construction projects. Hence, a survey research strategy was adopted under a quantitative approach to ascertain the level of satisfaction and importance of each identified skill for each category of P&E operators in building construction projects in Sri Lanka according to the construction professionals. The quantitative approach is considered the most suitable research approach for the study as it would handle deductive interpretations for data (Saunders et al., 2015). Naoumi (2007) has defined quantitative approach as the process of finding data using the collected records and evidences. Further, Creswell (2003) mentioned that quantitative approach mainly focuses on the statistical procedures. Therefore, the quantitative approach has been adopted in this paper. Several data collection techniques including questionnaire surveys, interviews, and observations can be identified as data collection techniques in quantitative approach. Among them, questionnaire survey has been defined as the main data collection method of quantitative approach (Teddlie, 2003). Therefore, a questionnaire based on the literature findings was developed for the study. Moreover, Tongco (2007) stated purposive sampling is most effective if the study is about a specific domain that must study with experts within it. According to Tashakkori and Teddlie (2003, p. 713), purposive sampling involves selecting respondents ‘‘based on a specific purpose rather than randomly’’. Since the study is mainly focused on the skills of P&E operators, the questionnaire was distributed only among the eligible respondents. The construction professionals who have at least 5-year experience in construction industry and knowledge on managing P&E operators were selected as the respondents. Further, the construction professionals who are involving with P&E operators in day-to-day operations have been selected including 41 respondents. According to Roscoe’s (1975) rule of thumb in selecting sample size, sample size larger than 30 and less than 500 are appropriate for most of the research. Considering the aforementioned fact and eligibility criteria, 41 respondents were selected for the study. Among them, 30 completed questionnaires were returned with a 73% response rate. Table 3 presents the profiles of the respondents.

Table 3. Profile of Respondents of the Questionnaire Survey

Designation	**Number of Years of Experience**					**Total**
	5-9	**10-14**	**15-19**	**20-14**	**25 or more**	
Construction Manager		2	3	1		6
Project Manager		4	4		1	9
Site Engineer	2	2	3			7
Assistant Site Engineer	1	2				3
Quantity Surveyor	2		2		1	5
Total	5	10	12	1	2	30

The structured questionnaire guideline consisted of two questions to indicate the level of importance and the level of satisfaction for each skill of P&E operators. The questionnaire survey findings were analysed using the Mean Weighted Rating (MWR) calculated as stated in Equation [1] on Microsoft Excel platform.

$$MWR = (\sum [Vi \times Fi]) / N \quad \ldots\ldots[1]$$

where MWR = mean weighted rating for an attribute; Fi = frequency of responses in the range of 1–5, Vi = rating of each attribute, and N = a total number of responses.

The study conducted by Mullin et al. (2010) evidenced the similar calculation conducted for construction management through the measurement combination of level of importance and level of attainment of construction

professionals to build skill gap. Hence, the difference between the level of satisfaction and the level of importance was interpreted as the gap of each skill in respective P&E operators, as presented in Equation [2].

The gap of a Skill = MWR of Level of Satisfaction of a Skill - MWR of Level of Importance of a Skill….[2]

The interpretation given for the analysed data based on the above formula can be summarised as follows:

If the level of satisfaction is greater than the level of importance of a particular skill, the gap of a skill is a positive value; hence, there is no skill gap for a peculiar skill.

If the level of satisfaction is lesser than the level of importance of a particular skill, the gap of a skill is a negative value; hence, there is a skill gap for a peculiar skill.

4. Research Findings

4.1. LEVEL OF IMPORTANCE FOR THE SKILLS OF P&E OPERATORS IN THE PERSPECTIVE OF CONSTRUCTION PROFESSIONALS IN THE SRI LANKAN BUILDING CONSTRUCTION INDUSTRY

The first step was to identify the level of importance for each skill among each category of P&E operator, identified through literature synthesis.. Table 4 presents the MWR values based on the analysis of questionnaire survey?. Pursuant to Table 4, the smartness of handling machines (S7) is the most critical skill for the Earth-Moving Equipment Operators (P&E1). In addition, maintenance skills (Planned and Unplanned) (S2) are the next essential skill for the remaining eight categories of P&E Operators in the Sri Lankan building construction industries.

Table 4: MWR for the Level of Importance for each skill among each P&E operator

Code	*P&E 1*	*P&E 2*	*P&E 3*	*P&E 4*	*P&E 5*	*P&E 6*	*P&E 7*	*P&E 8*	*P&E 9*
S1	3.50	3.67	3.60	3.40	3.40	3.40	3.30	3.07	3.63
S2	3.87	***4.07***	***4.07***	***3.93***	***3.97***	***3.90***	***3.80***	***3.80***	***4.00***
S3	3.33	3.50	3.40	3.50	3.40	3.40	3.33	3.37	3.47
S4	3.57	3.57	3.53	3.27	3.57	3.40	3.13	3.07	3.50
S5	1.80	2.07	1.87	1.67	1.73	1.70	1.33	1.47	2.20
S6	2.00	2.43	2.23	2.17	2.57	1.93	1.60	1.97	2.60
S7	***3.90***	3.87	3.90	3.73	3.73	3.60	3.60	3.73	3.73
S8	3.00	3.37	3.27	2.93	3.20	3.07	2.90	3.00	3.43
S9	3.37	3.53	3.37	3.30	3.40	3.30	3.03	3.20	3.50
S10	3.03	3.23	3.23	2.93	3.17	2.93	2.67	3.00	3.40
S11	2.43	2.47	2.37	2.60	2.47	2.37	2.20	2.43	2.77
S12	3.13	3.20	3.13	3.13	3.13	3.07	3.03	3.33	3.33
S13	3.37	3.60	3.50	3.33	3.40	3.20	3.07	3.27	3.60
S14	3.70	3.70	3.73	3.63	3.60	3.37	3.43	3.67	3.67
S15	3.17	3.23	3.27	3.33	3.40	3.27	3.07	3.30	3.17
S16	2.83	2.87	2.83	2.87	2.80	2.73	2.67	2.90	2.97

Table 4 clearly depicts that mechanical skills (S3) and technical skills (S4) of P&E operators have gained a comparatively higher importance level in the industry. According to respondents' views, documentation skills (S11), electronic skills (S6), and IT skills (S5) are the least important skills for P&E operators within the industry.

4.2. LEVEL OF SATISFACTION OF THE SKILLS OF P&E OPERATORS IN THE SRI LANKAN BUILDING CONSTRUCTION INDUSTRY : THE CONSTRUCTION PROFESSIONALS' PERSPECTIVE

Respondents were asked to evaluate the satisfaction level of each skill of each category of operator based on their experience. It is complicated to measure the satisfaction level since it is highly subjective. Nevertheless, Table 5 presents the MWR values of the level of satisfaction for each skill among each category of P&E operators as elaborated in the Table 1. According to Table 5, maintenance skills (Planned and Unplanned) (S2) are the most satisfying skills among earth-moving equipment operators (P&E1), piling machine operators (P&E2), compacting equipment operators (P&E7), vehicle – driver (P&E8), and immovable plant and machinery operators (P&E9). In contrast, the smartness of handling machines (S7) is the most satisfying skills among other P&E operator categories.

Table 5: MWR for the Level of Satisfaction for each skill among each P & E operator

Code	P&E 1	P&E 2	P&E 3	P&E 4	P&E 5	P&E 6	P&E 7	P&E 8	P&E 9
S1	3.40	3.20	3.27	3.27	3.33	3.23	2.97	3.07	3.23
S2	**3.87**	**3.83**	3.90	3.77	4.00	3.87	***3.87***	***3.87***	***3.93***
S3	3.17	3.37	3.03	3.13	2.97	2.90	3.13	3.17	3.30
S4	3.37	3.43	3.73	3.60	3.90	3.67	3.30	3.13	3.40
S5	2.53	2.47	2.70	2.73	2.93	3.00	2.37	2.03	2.43
S6	2.83	3.00	2.30	2.43	2.73	2.43	2.80	2.30	2.83
S7	3.47	3.67	***4.10***	***4.00***	***4.07***	***4.00***	3.47	3.53	3.57
S8	2.77	2.80	3.03	2.77	3.13	3.03	2.50	2.80	2.77
S9	3.37	3.40	3.00	3.10	2.77	2.90	3.40	3.10	3.33
S10	3.10	3.17	3.00	2.87	3.10	2.93	2.97	3.03	3.40
S11	2.70	2.67	2.53	2.63	2.47	2.67	2.67	2.60	2.67
S12	2.87	2.87	2.90	2.93	2.83	2.83	2.70	2.90	3.03
S13	3.37	3.30	3.43	3.23	3.60	3.40	3.20	3.23	3.47
S14	3.33	3.27	4.00	3.93	3.97	3.97	3.20	3.47	3.43
S15	3.30	3.33	3.07	3.07	2.97	2.87	3.00	3.30	3.40
S16	2.87	3.00	2.83	2.80	2.80	2.87	2.87	2.87	3.00

Table 5 further depicts that mechanical skills (S3) and technical skills (S4) of P&E operators have gained comparatively higher satisfaction in the industry. IT skills (S5), electronic skills (S6), and documentation skills (S11) are the most underrated skills of P&E operators in terms of the level of satisfaction in the industry. Similarly, the respondents have identified S5, S6, and S11 as the least important skills of each operator.

4.3. SKILL GAP OF PLANT AND EQUIPMENT OPERATORS

The results yielded from analysing the findings of the level of importance and the level of satisfaction initiated to achieve the study's aim—to identify the skill gap of P&E operators in the perspective of construction professionals in building construction projects in Sri Lanka.

4.3.1. Skill Gap of the Earth-Moving Equipment Operators (P&E1)

As depicted in Figure 1, a skill gap exists for the analytical skills (S1), mechanical skills (S3), technical skills (S4), smartness of handling machines (S7), innovative skills (S8), interpersonal skills (S12), and teamwork skills (S14). The highest skill gap among earth-moving equipment operators is the gap for the smartness of handling machines (S7), which has a 0.43 difference between MWR of the level of satisfaction and the level of importance. Among other all P&E operators, earth moving equipment operators should be most prominently equipped with this skill as it is the most important skill according to the findings. Therefore, the earth moving equipment operators must qbe equipped with more techniques in handling the machines in an effective and productive way through the training programs. Then the satisfaction for S7 in Sri Lankan construction industry among this operator category can be increased. Analytical skills have the least skill gap among this occupant category. Analytical skills have the least skill gap among this occupant category.

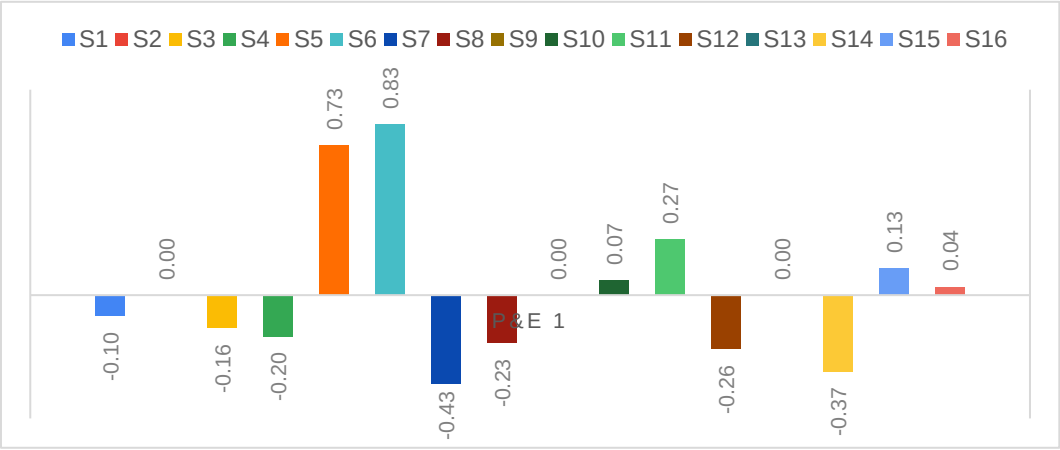

Figure 1. Skill Gap of the Earth-Moving Equipment Operators (P&E1)

4.3.2. Skill Gap of the Piling Machine Operators (P&E2)

Figure 2 shows the skill gap analysis for the piling machine operators in the Sri Lankan building construction industry.

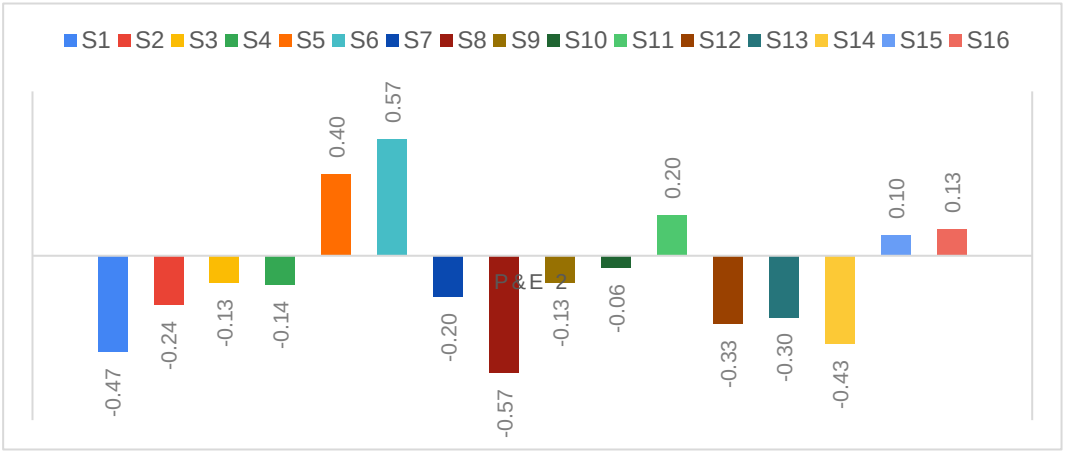

Figure 2. Skill Gap of Piling Machine Operators (P&E2)

Figure 2 depicts a skill gap for the analytical skills (S1), maintenance skills (planned and unplanned) (S2), mechanical skills (S3), technical skills (S4), smartness of handling machines (S7), innovative skills (S8), health and safety working skills (S9), planning and organising skills (S10), interpersonal skills (S12), problem-solving skills (S14), and teamwork skills (S14). The highest skill gap among piling machine operators is for the innovative skill, with a 0.57 difference between MWR of the levels of satisfaction and importance. The technological advancement introduces more productive and effective methodologies to improve the construction processes. Hence, the piling machine operators should have confidence and flexibility to operate the machines with innovative manners which maximise the productivity in the industry. For that, the soundness in new technologies and the context is important for them. Furthermore, mechanical skills have the least skill gap among this occupant category. Therefore, the effort in equipping the piling machine operating trainees with mechanical skill through the training programs should be praised.

4.3.3. Skill Gap of Crane Operators (P&E3)

Figure 3 depicts the skill gap for the analytical skills (S1), maintenance skills (planned and unplanned) (S2), mechanical skills (S3), innovative skills (S8), health and safety working skills (S9), planning and organising skills (S10), interpersonal skills (S12), problem-solving skills (S13), and communication skills (S15). The highest skill gap in crane operators is the gap for mechanical skills (S3) and health and safety working skills (S9), with a 0.37 difference between MWR of the level of satisfaction and the level of importance. The crane operators must handle their machines throughout the construction sites while carrying out the other works in the site. Hence, the crane operators must encompass the safety skills not only for themselves but also for the whole active site operators. Hence, it is obvious that the importance of S9 is higher among this occupant category.

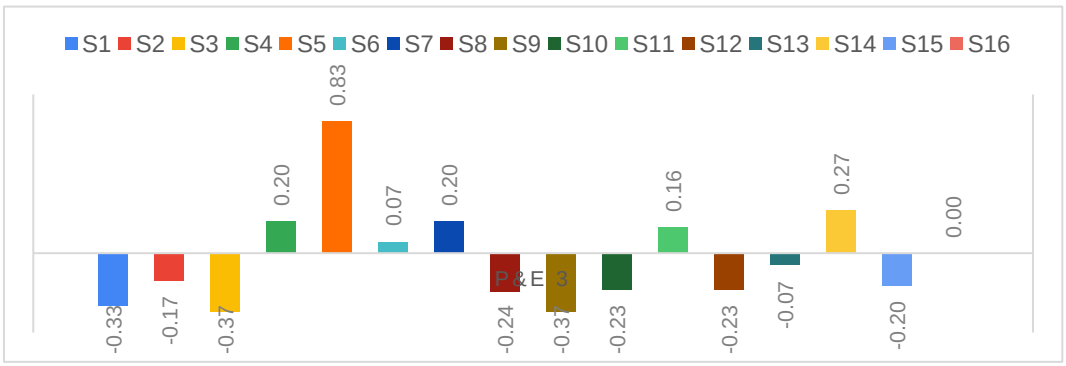

Figure 3: Skill Gap of Crane Operators (P&E3)

4.3.4. Skill Gap of Lifting Equipment Operators (P&E4)

Figure 4 depicts the skill gap for the analytical skills (S1), maintenance skills (planned and unplanned) (S2), mechanical skills (S3), innovative skills (S8), health and safety working skills (S9), planning and organising skills (S10), interpersonal skills (S12), problem-solving skills (S13), communication skills (S15), and language literacy and

numeracy skills (S16). The highest skill gap among lifting equipment operators is the gap for mechanical skills (S3), with a 0.37 difference between MWR of the satisfaction and importance levels. Therefore, the equipping lifting equipment operating trainees with sufficient mechanical skills should be considered and implemented through particular training programs. The remaining set of skills has a higher level of satisfaction than their importance level within the industry among lifting equipment operators.

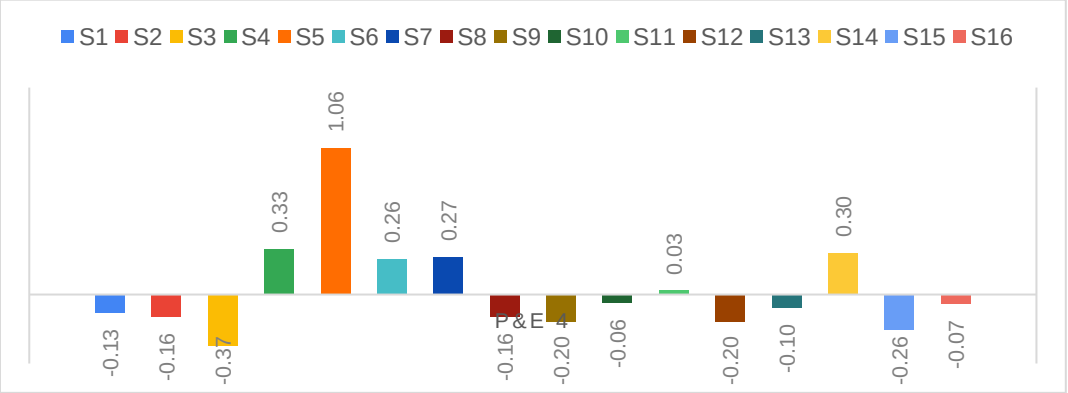

Figure 4: Skill Gap of Lifting Equipment Operators (P&E4)

4.3.5. Skill Gap of Generator Operators (P&E5)

Figure 5 illustrates the skill gaps for generator operators in terms of analytical skills (S1), mechanical skills (S3), innovative skills (S8), health and safety working skills (S9), planning and organising skills (S10), interpersonal skills (S12), and communication skills (S15).

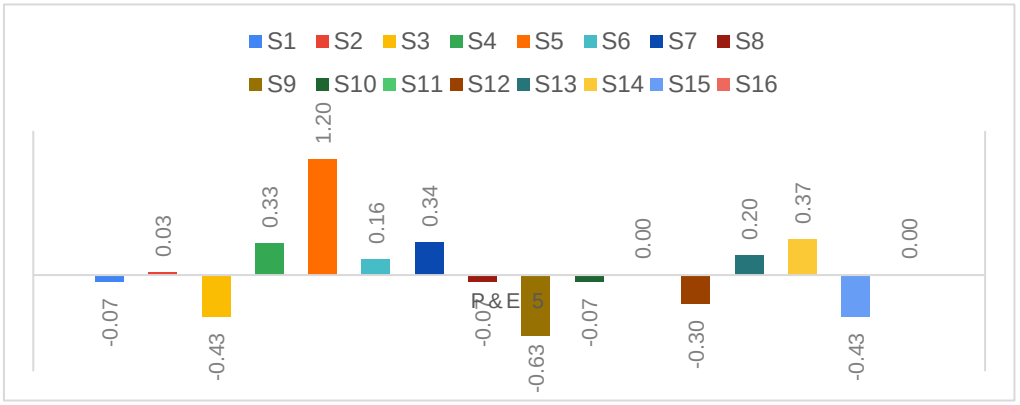

Figure 5: Skill Gap of Generator Operators (P&E5)

The highest skill gap among generator operators is noted for health and safety working skills, with a 0.63 difference between MWR of the satisfaction level and importance level. As generator operators manages the energy supplying equipment for the whole site, the capacity and/or number of machines to be handled are higher. Hence, they should have sufficient working skills to perform the duty in the safest manner. As there is a gap for this particular skill, the recapping the training programs and on-site guidance should be considered for generator operators.

4.3.6. Skill Gap of Compressor Operators (P&E6)

Figure 6 illustrates skill gaps for compressor operators in terms of analytical skills (S1), maintenance skills (planned and unplanned) (S2), mechanical skills (S3), innovative skills (S8), health and safety working skills (S9), interpersonal skills (S12), and communication skills (S15). The highest skill gap among compressor operators is the gap for mechanical skill, which has a 0.50 difference between MWR of the level of satisfaction and level of importance. Therefore, the equipping compressor operating trainees with sufficient mechanical skills should be considered and implemented through particular training programs. Furthermore, innovative skills (S8) have the least skill gap in this category.

Planning and organising skills (S10) hold equal satisfaction and importance levels in the Sri Lankan construction industry. The remaining set of skills has a higher level of satisfaction within the industry compared to their importance level among compressor operators.

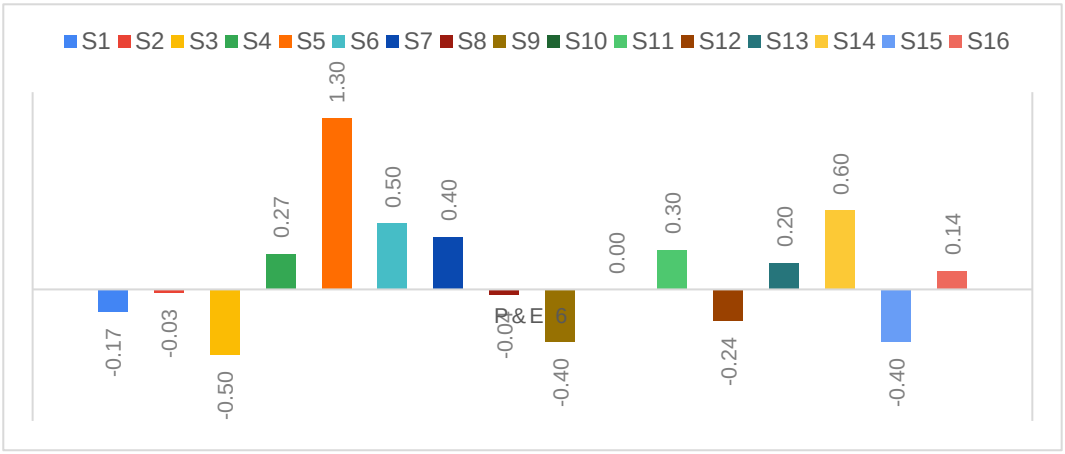

Figure 6: Skill Gap of Compressor Operators (P&E6)

4.3.7. Skill Gap of Compacting Equipment Operators (P&E7)
Figure 7 illustrates the skill gap among compacting equipment operators (P&E7).

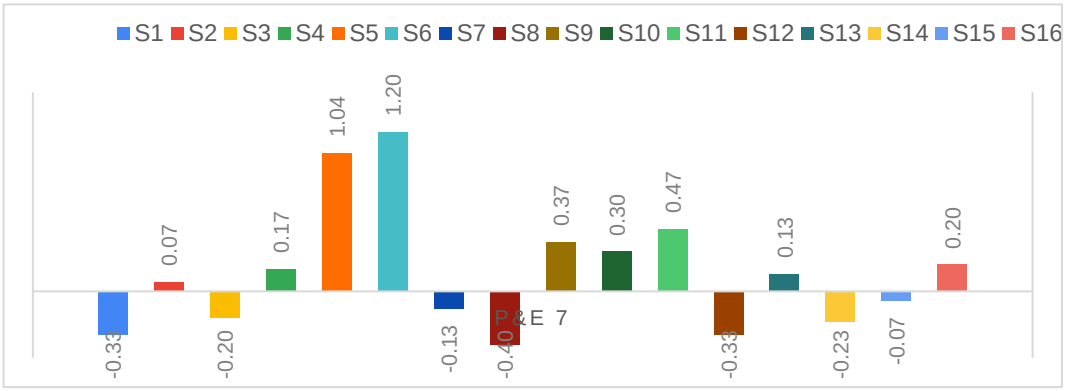

Figure 7: Skill Gap of Compacting Equipment Operators (P&E7)

Accordingly, innovative skills (S8) possess the most significant skill gap. However, the importance level of the S8 for this category is comparatively lesser. Most significant communication skills (S15) hold the least skill gap among compacting equipment operators.

4.3.8. Skill Gap of the Vehicle Driver (P&E8)
Figure 8 represents the skill gap analysis for the driver's (vehicle) (P&E8) occupant category.

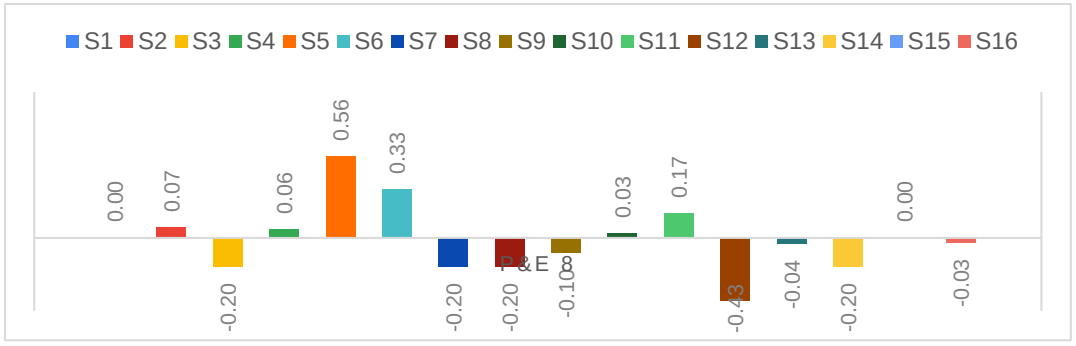

Figure 8: Skill Gap of the Vehicle Driver (P&E8)

Accordingly, mechanical skills (S3), smartness of handling machines (S7), innovative skills (S8), health and safety working skills (S9), interpersonal skills (S12), problem-solving skills (S13), teamworking skills (S14) and language literacy and numeracy skills (S16) possess a skill gap within the P&E operators in building construction projects in Sri Lanka. Interpersonal skills (S) possess the most significant skill gap with 0.43 of MWR difference, while language literacy and numeracy skills (S16) hold the least skill gap among drivers. Drivers have to deal with different stakeholders in a construction project. Hence, the interpersonal skills assist in maintaining good relationship with

other for an effective working environment in the construction industry. Therefore, assessing those skills when recruiting the drivers can be suggested as a strategy since they are not separately trained for the construction industry.

4.3.9. Skill Gap of Immovable Plant and Machinery Operators (P&E9)

Figure 09 presents the skill gap for the analytical skills (S1), maintenance skills (planned and unplanned) (S2), mechanical skills (S3), technical skills (S4), smartness of handling machines (S7), innovative skills (S8), health and safety working skills (S9), documentation skills (S11), interpersonal skills (S12), problem-solving (S13), and teamwork skills (S14).

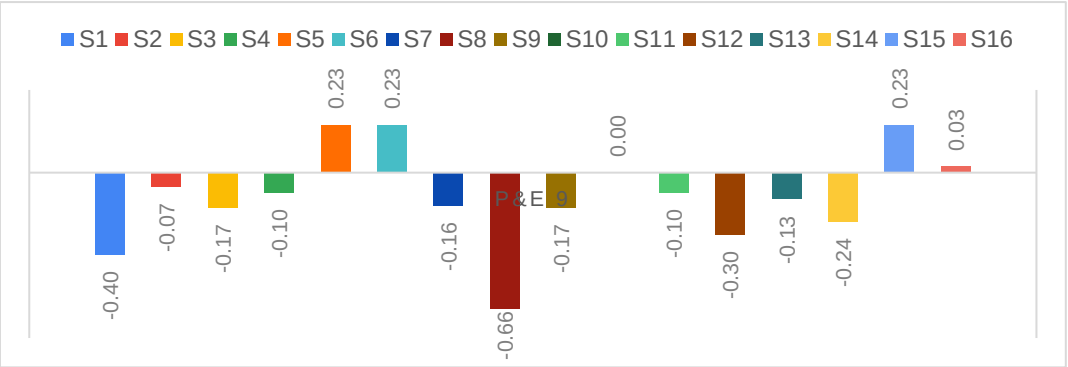

Figure 9: Skill Gap of Immovable Plant and Machinery Operators (P&E9)

This highest skill gap has been arisen due to a lesser satisfaction rather a higher importance. Accordingly, the innovative skills (S8) have the highest skill gap among this occupant category with 0.66 of MWR difference. Without limiting to the theorical practices, encompassing innovative ways in operating any kind of machines is important to effective execution of works. The maintenance skills (planned and unplanned) (S2) have the least skill gap (0.07).

4.3.10. Overall Skill Gap of Movable and Immovable Plant and Machinery Operators

As mentioned earlier, skill gaps describe the phenomenon where the workers' skill levels are insufficient to meet their current job requirements. Figure 10 illustrates the overall picture of each skill gap analysis against each P&E category. Accordingly, both positive and negative gaps (values) could be identified. Positive values denote the satisfaction level is higher than the level of importance. In negative values, the satisfaction level is lower than the level of importance.

The study identified maintenance skills (planned and unplanned) as the highest satisfying skill among most P&E operators, and IT and electronics skills were comparatively less important than other skills for P&E operators. As depicted in Figure 10, analytical skills (S1), mechanical skills (S3), innovative skills (S8), and interpersonal skills (S12), the level of satisfaction is lower than the level of importance in each P&E category.

Based on the quantitative analysis, the results revealed that skill gaps ranged between -0.66 to +1.30. This proves that there are fewer issues with skill gaps of current P&E operators in the construction industry. The study provides a clear picture of existing skill gaps according to each P&E category and areas that the future should consider for effectively utilizing the P&E sector in the construction industry.

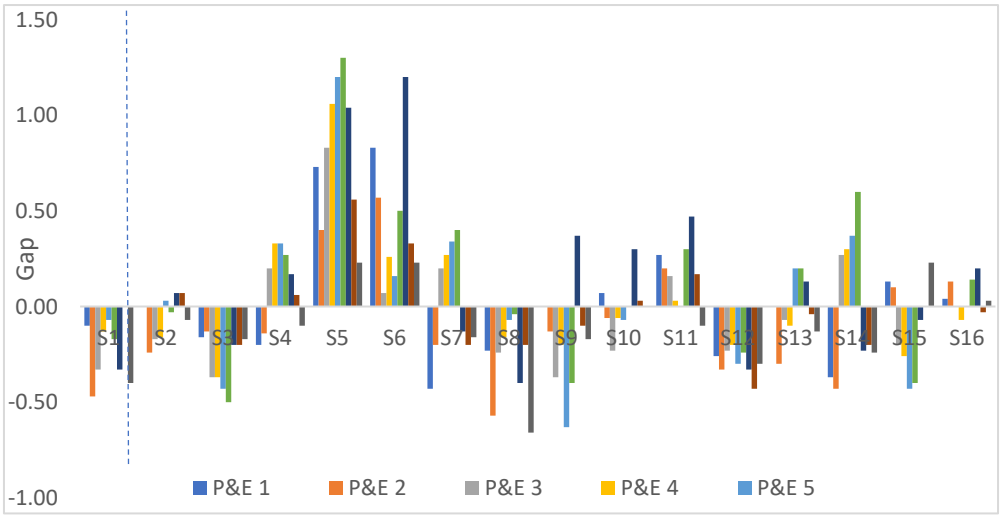

Figure 10: Overall Skill Gap of Movable and Immovable P&E Operators

5. Conclusions

P&E operators play an important role within the Sri Lankan construction industry, as different and advanced P&E are used in a large- or a small-scale project. Further, there is a research dearth on the skill gap of P&E operators in building construction projects in Sri Lanka. Therefore, the present study successfully addressed three (02) main objectives: identifying the level of importance of each skill in the perspective of construction professionals and identifying the level of satisfaction by the construction professionals with respect to each skill performed by the P&E operators.

Accordingly, this study focused on sixteen skill types required by nine different categories of P&E operators, which were identified from the literature synthesis. Accordingly, maintenance skills (planned and unplanned) were identified as the most satisfying skill of P&E operators as per the construction professional opinion for P&E operators representing each category except crane, lifting equipment, generator and compressor operators. Accordingly, smartness of handling machine was identified asthe most satisfying skill of P&E operators as per the construction professional opinion for P&E operators representing the above-mentioned P&E operator categories.

Achieving the study's second objective, maintenance skills (planned and unplanned), was identified as the most important skill for all types of P&E operators, other than the earth-moving equipment operators. For earth-moving equipment operators, it is the smartness of handling machines. The analysed quantitative data were utilised to identify the skill gap of P&E operators in the Sri Lankan building construction industry. Mechanical skills, analytical skills, innovative skills, interpersonal skills, smartness of handling machines, and health and safety working skills have identified the prominent skills gaps among different P&E operators. The skill gap for technical skills is limited to the occupant categories of earth-moving equipment operators, piling machine operators, and immovable plant and machinery operators.

This research has summarised the skill gaps in the respective categories of P&E operators in the Sri Lankan building construction industry. Accordingly, the study provides further insights to the construction professionals regarding the skills, which is necessary to be embrace within different P&E operator categories to enhance their performance. Therefore, further research can be conducted to analyse and propose strategies to sharpen the P&E operators' skills to overcome existing issues in the Sri Lankan building construction industry. Moreover, further research study can also be conducted to investigate the skill gap of P&E operators in infrastructure projects in Sri Lanka as P&E operators are largely contributing to infrastructure projects as well.

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