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AN ASSESSMENT OF SKILL AND COMPETENCY GAPS IN THE CONSTRUCTION INDUSTRY: THE CASE OF MECHANICAL, ELECTRICAL, AND PLUMBING WORKERS

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Abstract: Most countries including Sri Lanka suffer from the skill and competency gap of labours in construction projects. Mechanical, Electrical, and Plumbing (MEP) sectors are one of the main trades which takes maximum advantage of skilled labours. Although several researches have been conducted to find skills gap and labour shortage related to masonry work, carpentry, tiling, etc., few studies have been conducted related to MEP sector in the Sri Lankan construction industry. Hence, this paper focused on assessing skills gap and competency gap in MEP sector of Sri Lankan construction industry. Subsequent to the comprehensive literature review, questionnaire survey and expert interviews were carried out adopting mixed method approach, to analyze the skills gap. Quantitative and qualitative data were analyzed through mean weighted rating and manual content analysis respectively. The study revealed that learning, numerical, reading and writing are the skills which have highest skills gap while performing general physical activities, directing and training subordinates, and monitoring of activities have most competency gap. Enhancement of MEP related courses, improvement of training facilities, increment of awareness on MEP sector, and providing proper salaries can significantly address the current skills gap.

Keywords: *Competencies, MEP sector, Skills, Skills gap*

1. Introduction

The construction industry can be identified as a major sector, which contributes to the economic growth of a country (Manoharan, Dissanayake, Pathirana, Deegahawature, & Silva 2020). When it comes to Sri Lankan context, construction industry has contributed 6.9% and 6.2% of the GDP in 2019 and 2020 respectively (Central Bank of Sri Lanka 2021). Improvement of productivity in the construction industry directly impact on the Gross Domestic Product (GDP) of the country (Durdyev, Ismail, & Bakar 2013). Construction industry obtains maximum advantage of skilled labours especially in MEP works. Praveen et al (2013) identified that plumbing works and electrical works have skills shortages of 60% and 40% respectively. Many studies have been carried out regarding skills gap and labour shortage in Sri Lankan construction industry in terms of masonry work, carpentry, tiling, etc. (Praveen et al 2013; Manoharan et al 2020; Silva, Warnakulasuriya, & Arachchige 2018). However, few studies have been carried out regarding skills gap in MEP sector. Hence, researching on skills needs and skills gap in MEP sector can be more important and much needed under Sri Lankan construction industry.

This paper aimed to assess the skills and competency gap of MEP workers in the construction industry in Sri Lanka under the objectives of identifying the skills and competencies required for MEP workers and evaluating their skills and competency gap under Sri Lankan context. The paper is structured as follows. First, a brief introduction to the study, a compressed literature synthesis, an insight of the research methodology adopted for the study, and a discussion of findings. Finally, the conclusion is formed based on the key research findings of the study.

2. Literature Review

Literature findings explain the existing labour force, emerging technologies in MEP and skills gap in construction industry. Further, skills and competencies required for MEP Workers, and strategies to address skills gap and skills need in MEP sector were discussed.

2.1. LABOUR FORCE IN CONSTRUCTION INDUSTRY

Though the productivity in construction industry improved with innovative technologies, still it continues to be labour-intensive industry since the labour cost comprises a substantial portion of the overall cost (El-Gohary & Aziz 2013). Hiyassat, Hiyari, and Sweis (2016) revealed in their study that, the labour productivity in most developing

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countries is comparatively low and required a significant improvement. Labour shortage is simply the mismatch between worker qualifications and available jobs (Barnow, Schede, & Trutko 2010). Adams (2010) further highlighted that, skilled labour shortage is also a major constraint of construction productivity. As mentioned by Jayawardena et al (2008), special skilled labours are the workers who have formal and special qualifications in certain areas such as elevators, escalators, plumbing, electrical works, mechanical works etc. Skilled labours also expertise in certain skills which are essential in construction process. Authors further state that skilled labour involvement is crucial to make the architects' and engineers' design reality. Shortage of skilled labours can cause poor work quality and project delays. Unskilled labours are the group of workers who do not have any specific skill and they are just working under the supervision of skilled labours (Jayawardena et al 2008).

MEP trades of a construction project retain a considerable percentage of the overall project cost. Yik and Lai (2008) identified duct work, pipe work, electrical installation and control works, and testing and commissioning work as specialised sub-contracted works which require skilled labour. According to Horman, Orosz, and Riley (2006), electrical works in a construction project is crucial since electrical installations are interconnected and sophisticated with other building works such as structural, mechanical, and communication systems. Failure on completion for electrical work on time may lead to project delays due to space management and power supply issues (Chiu & Lai 2017). By mentioning the factors, Chiu and Lai (2017) highlighted that, high technical and quality requirements, and skilled labour shortage can cause electrical work delays. In their studies, Wong, Chan, Wong, Hon, and Choi (2015) and Yik and Lai (2008), categorized mechanical and plumbing work also under skilled trades. Thus, the improvement of efficiency and performances in MEP works may indirectly and directly impact on other trades and work planning sequence of a project (Horman et al 2006).

2.2. EMERGING TECHNOLOGIES IN MEP AND CORDINATION

According to Mccoy and Yeganeh (2021), complex and fragmented nature of the construction process which involves considerable number of stakeholders have decelerate the adaptation to innovative technologies. Authors further state that, with recent advancements, construction firms tend to adapt innovative technologies since they facilitate efficient, flexible, cost-effective, and adaptable working environment. With the time, industrialized construction emerged with innovations. Industrialized construction refers to a process which encourages intelligent manufacturing, and automation in construction (Qi et al 2020). Technologies such as Exoskeleton, Light Detection and Ranging (LiDAR), Internet of Things (IoT), reality capture technologies, robotics, and Unmanned Aerial Vehicles (UAVs) are broadly spreading in construction industry recently (Okpala, Nnaji, & Awolusi 2019).

When it comes to the MEP coordination, prefabrication of MEP systems in modular buildings become popular recently (Korman & Lu 2017). According to the authors, Building Information Modelling (BIM) software facilitates multi-level prefabrication and coordination process. Modular construction simply refers to prefabrication of building away from the work site and transport it to the site and assembling (Pasquire & Gibb 2002). In this process, MEP components has been installed up to considerable extent in prefabrication stage (Korman & Lu 2017).

According to Korman and Lu (2017), BIM 4D (3D model + Schedule), and BIM 5D (BIM 4D + Cost) technologies facilitate Just-in-time (JIT) delivery by reducing installation time and allows automatically generated and modified cost estimations for changes in each building modules. Augmented 3D applications for Communication, collaboration, and learning (CCL) of MEP system of buildings also becoming popular in the industry (Shen & Jiang 2012). Authors state that these applications can function using an iPad or a mobile device. 3D laser scanners also a leading technology in construction industry which helps to produce 3D model, orthophotos, and in reverse engineering (Pica & Abanda 2019). Moreover, automatic 3D reverse engineering technology which is used for MEP pipe object modelling can be also stated as a trending technology (Kang & Gwon 2016).

2.3. SKILLS GAP IN MEP SECTOR

Most of the challenges in the construction industry often occur due to lack of required skills and labour (Alshavi, Goulding, & Nadim 2007). According to the Economic Modelling Specialist International (EMSI), skills gap is the mismatch of the needs of employers for required skills verses the skills own by available workforce (Hamid, Khazid, Yunus, Halim, & Razak 2018). Authors find in their study that, skilled labour percentage in a construction project is around 29% and rest are semi-skilled and unskilled. Even though the level of gap is varied from trade to trade, every trade (including MEP) suffers from skills gap up to a significant level (Akomah et al 2020). National Council for Technical Education (2020) in Tanzania, identified that there can be two types of skills gaps as horizontal and vertical. Further authors mentioned, Horizontal skills gap occurs when workers work in a field that is different from their training and vertical skills gap occurs when the level of education is higher or lower than the level expected on the job.

Toni (2009) stated that duties of an electrician mostly include manual work which requires higher level of scientific and engineering knowledge and more experience in the field. When it comes to the plumbing sector, Engelbrecht (2006) revealed that there is a huge brain drain in the industry. Brain drain is basically, migration or emigration of professionally trained individuals or knowledge workers (Kinnear & Sutherland 2000). Most of the skilled, experienced, and trained plumbers migrate due to unfavorable condition in their country (Engelbrecht 2006). Findlay (2001) further elaborated that only the developed countries get the advantage of often migration of skilled

workers from developing countries. Engelbrecht (2006) demonstrated that these migrated workers are more likely to stay in migrated countries. Another vital factor which contributes to the skills gap in both civil and MEP trades is cost of foreign labour (Kissi, Mohammed, & Owusu-Diatuo 2018). According to the studies of Ayentimi, Burgess, and Dayaram (2018), labour shortage and skills gap in all trades (including MEP) can directly influence the project performances by leading to failures in project deliveries.

2.4. SKILLS AND COMPETENCIES REQUIRED FOR MEP WORKERS

Tong (as cited in Adi and Faiqun 2013) revealed that, technical skills and essential skills are important to interact and perform a good work. According to the author, essential skills are human skills which should have to perform a variety of tasks daily variations. However, the importance of each essential skills depends on the type of trade in construction project (Enshassi, Mohamed, & Ekarriri 2009). Identified skills and competencies have been summarised and presented in Table 1.

Table 1: Skills and competencies required for MEP workers

Required Skills for a MEP Worker	Required Competencies for a MEP Worker
• Technical skills • Continuous learning skills • Team working skills • Self-awareness/Self-discipline • Problem solving skills • Communication skills • Professional skills • Coping pressure • Management/Leadership skills • Numerical skills • Reading and writing skills	• Repairing and maintenance of systems • Assembling, installing, handling, and moving objects, circuits, or systems • Plan layout and installation based on job specifications and local codes • Awareness on safety policies, regulations, and procedures • Quality control and awareness • Read and interpreting drawings • Identifying objects, actions, and events • Monitor processes, materials, or surroundings • Inspecting and diagnosing equipment, materials, or systems • Direct and train subordinates • Performing general physical activities

Adapted From: Adi and Faiqun (2013) and Enshassi et al (2009)

Accordingly, eleven skills and same number of competencies required for a MEP worker have been identified though previous research studies.

2.5. STRATEGIES TO CATER THE FUTURE DEMAND FOR MEP

Muya, Mulenga, Bwalya, and Price (2004) stated that future effectiveness and productivity of construction industry in every country depends on the quality of the labour force. Because skilled labour is a vital factor to obtain quality products (Adi & Faiqun 2013). Thus, finding strategies to cater the future demand for labour is crucial. Highlighting Sri Lankan construction industry, Basnayake and Premathilaka (2015) identified seven major factors affecting the skilled labour shortage as Less wage relative to the other countries, Inadequate training, Skills drain, Less work experience, Shifting of the career for another profession, Negative social attitude towards the labour industry and Wastage of female skills without contributing for the development of country.

Determination and persistency, ability to work in harmony with others, flexibility, honesty, communication skills, eager and willing to add to their knowledge base and skills, excellent reading and analytical skills, good hand–eye and body coordination, work ethic, loyalty, and problem-solving skills are the basic soft skills that are required by a skilled labour (Akomah et al 2020). However, according to the authors, in-depth knowledge in handling tools and equipment is ranked at last based on average indexes of the basic skills. Therefore, it is important to prioritize soft skills as well when bridging the skills gap (National Council for Technical Education 2020). Donohue (as cited in Chini et al 1999) recommends maintaining steady workflow, prompt payment and good supervision with sub-contractors to assure a loyalty and healthy relationship.

3. Research Methodology

This study was intended to analyze the skills and competency gap of MEP sector in Sri Lankan construction industry. Hence, this research was conducted using mixed approach considering its advantages.

Further, 'survey' strategy was used in this study with the purpose of evaluating skills and competencies gap. Data were collected by conducting a questionnaire survey and expert interviews. The questionnaire was developed based on the findings of the literature review. Identify the importance, and level of satisfaction of skills and competencies required by a MEP worker were the main purpose of the questionnaire.

During the questionnaire survey, the respondents were asked to respond using a 5-point Likert scale (where 5 = Highly important, 4 = Important, 3 = Moderately important, 2 = Less important, and 1 = Not important) considering the level of importance of identified skills and competencies.

Similarly, a 5-point Likert scale (where 5 = Highly satisfied, 4 = Satisfied, 3 = Moderately satisfied, 2 = Less satisfied, and 1 = Not satisfied) was used to study the level of satisfaction of identified skills and competencies of existing MEP workforce. The collected data were analyzed with the support of Mean Weighted Rating (MWR) as shown in Formula 1.

MWR=[∑ (Fi)]/N (1)

where, MWR = Mean Weighted Rating for an attribute;
Fi = frequency of responses in the range of 1–5, and
N = a total number of responses.

In order to analyze the skills and competency gap, the difference between MWR of Level of Satisfaction and MWR of Level of Importance was calculated under each skill and competency using formula (2).

Gap=MWR of Level of Satisfaction-MWR of Level of Importance (2)

With the aim of supporting literature findings and revealing more facts, a few open-ended type questions were also included in the questionnaire and analyzed qualitatively.

Subsequently, semi-structured interviews were conducted with professionals who are working at Vocational and Training Institutes to identify reasons for skills gap and to identify strategies to reduce skills gap of MEP.

4. Data Analysis and Findings

4.1. BACKGROUND OF THE RESPONDENTS OF QUESTIONNAIRES AND INTERVIEWEES
Questionnaire was distributed among 55 professionals who are closely monitor MEP workers in Sri Lankan building construction sector and 42 responses were received with the response rate of 76%. It was intended to study the level of importance and level of satisfaction of the identified set of skills and competencies through the literature findings. Moreover, it was essential to identify the reasons for the skills gap.

Table 2 presents the questionnaire respondents' details. Majority of the respondents who were Electronic Engineers as well as Mechanical Engineers. When consider the working experience of the respondents, 27 respondents had less than 5 years of experience in the construction industry while 10 respondents had 5-10 years, 4 respondents had 10-15 and only one had 15-20 years of experience.

Table 2: Profile of the Respondents

Designation	Electrical Engineer	Mechanical Engineer	MEP Quantity Surveyor	Assistant Engineer	Electrical Engineer Trainee	MEP Engineer	Technical Officer	Project Engineer	Other (Planning Engineers, Factory Managers, Executive Officers)	Total
Number of Respondents	7	6	5	5	5	4	3	2	5	42
%	16.7%	14.3%	11.9%	11.9%	11.9%	9.5%	7.1%	4.8%	11.9%	100%

Skill gap in MEP sector further examined with professionals who are working at the Vocational and Training Institutes and involved in MEP courses. Then five semi structured interviews were conduct-ed adopting purposive sampling method and respondents' background information is listed in Table 3.

Table 3: Profile of the interviewees

Respondent	**Institute**	**Designation**	**Experience in the Industry**
R1	National Apprentice and Industrial Training Authority (NAITA)	Director Principal	7 years
R2	Vocational Training Authority (VTA)	Senior Lecturer	17 years
R3	Ceylon - German Technical Training Institute (CGTTI)	Senior Training Engineer	31 years
R4	Industrial Engineering Training Institute (IETI)	Senior Lecturer	15 years

R5	Ceylon - German Technical Training Institute (CGTTI)	Senior Consultant	23 years

4.2. MEP SECTOR IN THE CONSTRUCTION INDUSTRY

Respondents were asked to rank the level of demand for MEP workers in the industry using a five-point Likert scale where, 5 denotes "Very high" and 1 denotes "Very low". Accordingly, 28.5% of the respondents have mentioned that there is an extremely high demand for MEP workers in the construction industry at present. Further, 43% have responded that the demand is high while 28.5% responded that the demand is moderate. So, this emphasizes that there is a certain demand for the MEP workers in Sri Lanka. Moreover, the respondents were questioned the level of satisfaction on the experience and knowledge of current MEP workers and training arrangements for the MEP sector. The respondents' general perceptions in terms of each are summarized in Figure 1. According to the survey findings, training arrangements for the MEP workers are at a poor level where majority of respondents believe, experience and knowledge of MEP workers are at an average level.

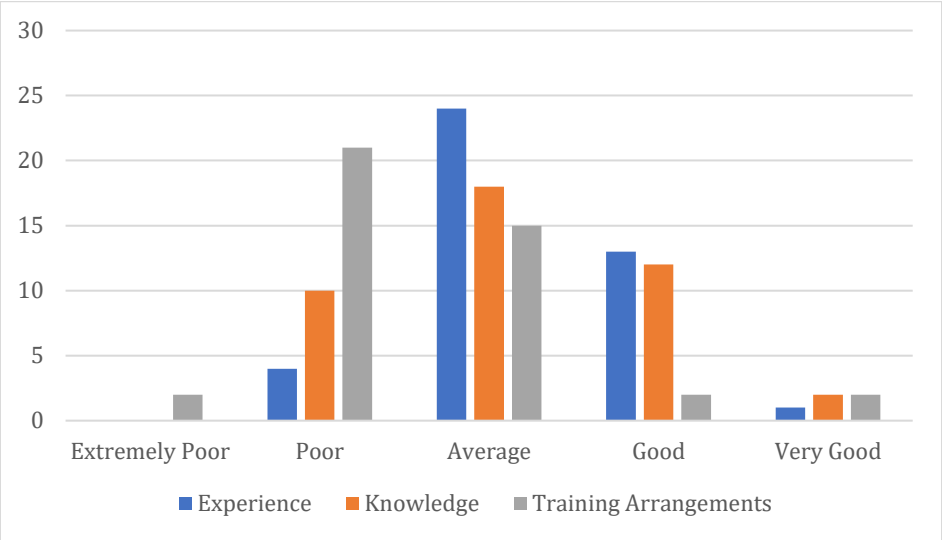

Figure 1: Perceptions in terms of experience, knowledge, and training arrangements

4.3. LEVEL OF IMPORTANCE AND SATISFACTION OF SKILLS OF MEP WORKERS

The first step was to identify the importance of skills of MEP workers then respondents were asked to evaluate the satisfaction level of skills of MEP workers. The purpose of this was to evaluate the skills gap of MEP workers in building construction projects. According to the survey results, Table 4 presents the MWR of Level of importance and level of satisfaction of the identified skills through literature review. Then derived the skills gap of MEP workers.

Table 4: Level of importance, level of satisfaction and skills gap of the identified skills

Required Skills for a MEP worker		Level of Satisfaction			Level of Importance			Skill Gap
		MWR	SD	Rank	MWR	SD	Rank	
S1	Technical skills	3.143	0.926	1	4.357	0.618	1	-1.214
S2	Continuous learning skills	2.714	0.805	9	4.190	0.773	2	-1.476
S3	Team working skills	2.833	1.034	6	4.095	0.906	5	-1.262
S4	Self-awareness/Self-discipline	2.952	0.825	5	3.786	0.717	10	-0.833
S5	Problem solving skills	2.976	0.950	3	4.119	0.705	3	-1.143
S6	Communication skills	3.024	0.924	2	3.595	0.885	11	-0.571
S7	Professional skills	2.976	1.000	3	4.095	0.906	5	-1.119
S8	Coping pressure	2.786	0.951	7	4.024	0.811	7	-1.238
S9	Management/Leadership skills	2.714	0.995	9	3.952	0.764	9	-1.238
S10	Numerical skills	2.738	1.037	8	4.119	0.861	3	-1.381
S11	Reading and writing skills	2.690	0.975	11	4.024	0.811	7	-1.333

If the MWR of Level of Satisfaction is greater than the MWR of Level of Importance of a particular skill or competency, the gap is a positive value. In such case, it can be concluded that there is no gap in that skill or competency. But in case where the MWR of Level of Satisfaction is less than MWR of Level of Importance, the gap gets a negative value. In such case, there is a gap in particular skill. Figure 2 presents the identified skill gaps for required skills for a MEP worker.

As per the calculations among the identified skills, Technical Skills (S1) has the highest level of satisfaction and importance. Lowest level of satisfaction comes under Reading and Writing Skills (S11) while the highest level of importance comes under Technical Skills (S1). When considering the calculated skills gap, Continuous Learning Skills

(S2) has the largest gap while Communication Skills (S6) has the minimum gap which has lowest level of importance as well.

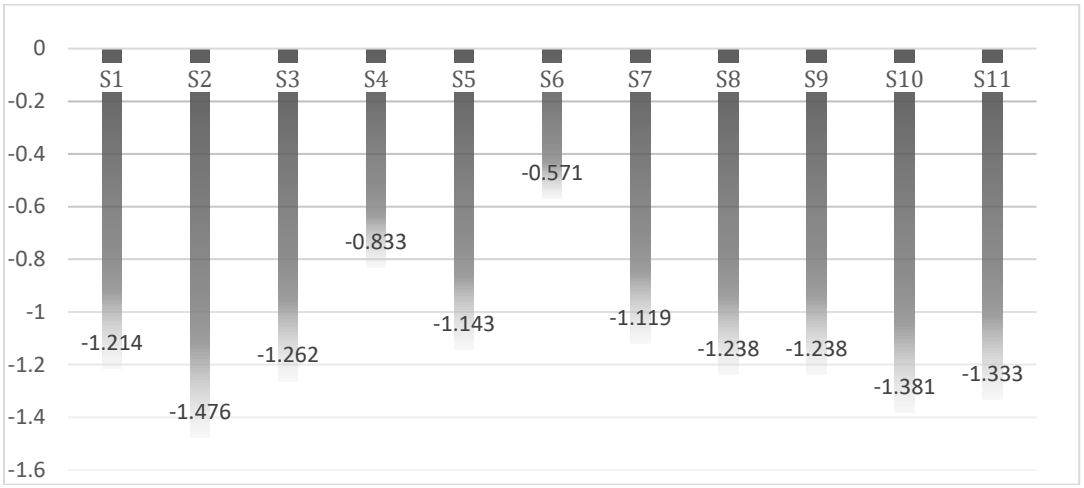

Figure 2: Skill gap of MEP workers

After the identification of the skill gap, the next step was to identify the importance of competencies of MEP workers. Then the respondents were asked to evaluate the satisfaction level of competencies of MEP workers. The purpose of this was to evaluate the competency gap of MEP workers in building construction projects. According to the survey results, Table 5 presents the MWR of Level of importance and level of satisfaction of the competencies. Then derived the competency gap of MEP workers.

Table 5: Level of importance, level of satisfaction and skills gap of the identified competencies

Required Competencies for a MEP worker		Level of Satisfaction			Level of Importance			Skill Gap
		MWR	SD	Rank	MWR	SD	Rank	
C1	Repairing and maintenance of systems	3.143	0.872	3	3.857	0.843	11	-0.714
C2	Assembling, installing, handling, and moving objects, circuits, or systems	3.119	0.968	5	4.167	0.908	2	-1.048
C3	Plan layout and installation based on job specifications and local codes	3.071	0.973	7	4.024	0.841	7	-0.952
C4	Awareness on safety policies, regulations, and procedures	3.143	0.814	3	4.024	0.924	7	-0.881
C5	Quality control and awareness	3.214	0.976	1	4.000	0.911	9	-0.786
C6	Read and interpreting drawings	3.214	1.001	1	4.310	0.869	1	-1.095
C7	Identifying objects, actions, and events	3.071	0.997	7	4.071	0.921	6	-1.000
C8	Monitor processes, materials, or surroundings	3.095	1.008	6	4.143	0.926	3	-1.048
C9	Inspecting and diagnosing equipment, materials, or systems	2.905	1.185	11	3.905	0.759	10	-1.000
C10	Direct and train subordinates	3.048	1.081	9	4.095	0.850	5	-1.048
C11	Performing general physical activities	2.976	1.000	10	4.119	0.832	4	-1.143

Figure 3 presents the identified competency gaps for required skills for a MEP worker.

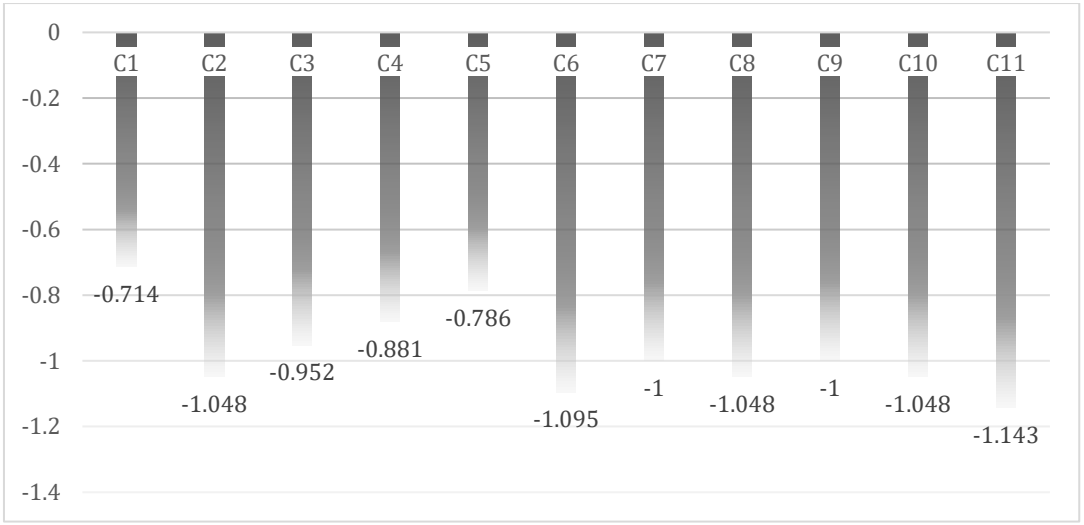

Figure 3: Competency gap of MEP workers

According to the calculations done in Table 5, all the competencies get negative values concluding that all of them have certain gap. Quality control and awareness (C5) and reading and interpreting drawings (C6) have the highest level of satisfaction while inspecting and diagnosing equipment, materials, or systems (C9) has the minimum level of satisfaction. When considering the level of importance, reading and interpreting drawings (C6) has the highest level of importance and repairing, and maintenance of systems (C1) has the minimum level of importance. Performing general physical activities (C11) has the highest gap and repairing and maintenance of systems (C1) has the lowest gap as per the calculations.

4.4. EMERGING TECHNOLOGIES AND OCCUPATIONS ENTERING INTO MEP SECTOR

Emerging technologies and occupation in the MEP sector are rapidly evolving. Hence, it is crucial to equip workers with the knowledge in new technologies to survive in the industry. Table 6 presents the identified emerging technologies and occupations based on respondents' answers. Number of responses are given within the parenthesis.

Table 6 : Emerging technologies and occupations in MEP sector

Emerging Technologies
Building Information Modelling (BIM) [10], Internet of Things (IoT) [6], Automation [3], Artificial Intelligence [4], Mechatronics [3], Laying Patterns Virtual Reality [2], Laser Scanning [2],,Laying Patterns [2], Robotics [2], Building Management System (BMS)[1], Augmented Reality [1], Machine Learning [1], Laser-Based Building Scanning [1], Revit drawings [1], Sensors, Wireless connections [1], Light Detection and Ranging (Light)[1], MEP cost modeling [1], Security Surveillance Systems [1] .
Emerging Occupations
BIM Operators [5], Consultants [1], IoT Specialists [1], IT specialized MEP workers [1], Machine Operators [1], MEP BIM Modeler [1], Production Line workers [1]

In accordance with the respondents, Building Information Modelling (BIM) was identified as the most frequent emerging technology where BIM operators are the most frequent emerging occupations related to MEP sector.

4.5. SKILLS GAP IN MEP SECTOR: REASONS AND STRATEGIES

Literature review and questionnaire survey identified that there is a significant skills gap in MEP sector in Sri Lanka. In order to validate data, experts' ideas also further collected through the interviews. Main intention of the interviews was to find reasons for the skills gap and suggestions to reduce the skills gap. The respondents highlighted that less facilities and resources are main limitations with MEP courses now adays.

4.5.1. Reasons For the Skills Gap in MEP Sector

Reasons for the skills gap in MEP sector mentioned by the respondents including interviews can be catego-rized under 3 main types as, Knowledge and experience issues, Lack in facilities and Less awareness in MEP sector. Respondent's ideas are summarized in Figure 4.

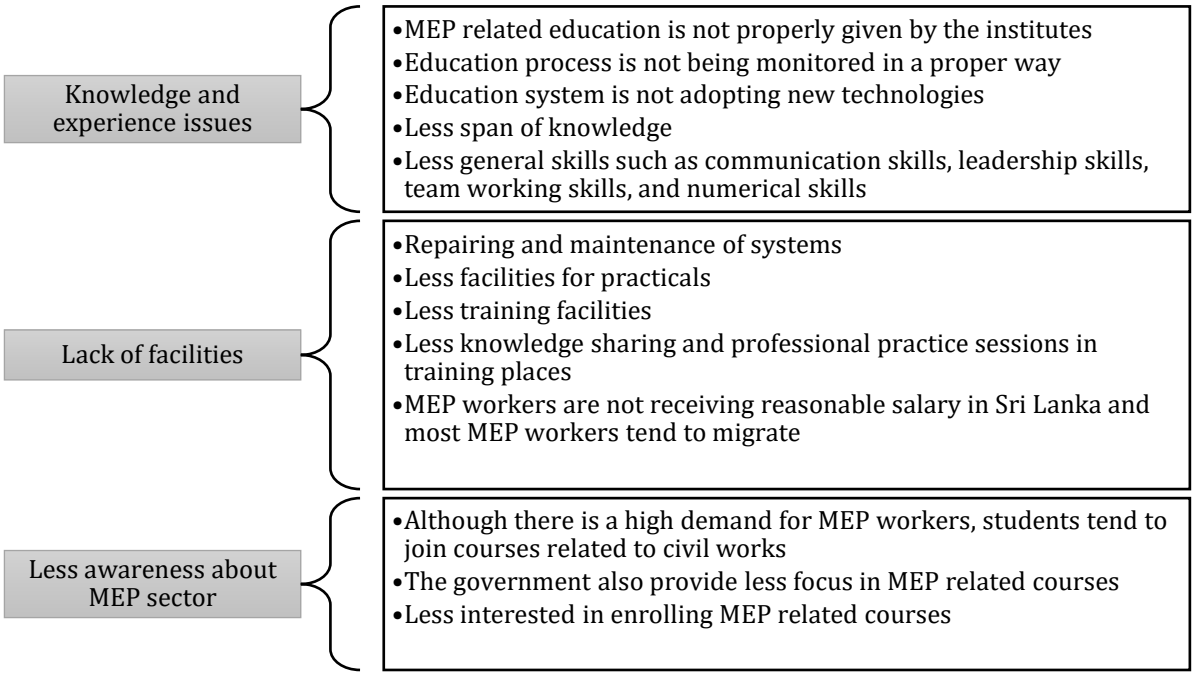

Figure 4: Reasons for Skill Gap

4.5.2. Suggestions to Reduce the Skills Gap

All the respondents who participated the interviews identified that a considerable skills gap is in the MEP sector in Sri Lanka. Although there is a huge demand from the industry. Further, they have identified that the contribution from small-scale institutes is not at a satisfactory level and following suggestions are recommend by the respondents for reduce the skills gap.

- Providing more facilities to move on with new technologies.
- Pay more attention on regional institutes.
- Research and identify students' skills set and preferences from little ages and direct them to most suitable path to them.
- Introduce Vocational Training Authority (VTI) courses to school syllabus.
- Make students and parents aware on online facilities to find courses.
- Improve the facilities in large-scale institutes without establishing new regional institutes and increase the intake to fulfill the national requirement.
- Provide practical knowledge other than theoretical knowledge.

Hence, according to the experts, skills gap can be significantly address within the vocational institutes itself. Rather finding solutions after they enter the industry, it is more practicable to solve the issues within the vocational and training institutes.

5. Conclusions

The construction industry is a labour-intensive industry which is currently facing many problems due to labour shortage. MEP sector in Sri Lankan construction industry also suffers from skilled labour shortage. Major reason for the skilled labour shortage is lack of required skills and competencies in MEP workers. Hence, identifying the required skills and competencies for MEP workers became a main objective in this study. This study mainly involved with providing findings on skills gap in MEP sector in Sri Lankan construction industry. Hence, the outcomes of this study will be beneficial for practitioners in construction industry to identify the level of satisfaction of required skills and competencies in MEP workers, to enhance the important skills and competencies among them and to introduce training programmes within organizations to make the MEP workers familiar with new technologies.

Identified skills and competencies were provided for the respondents to analyze their importance and the level of satisfaction. According to the analysis, it was revealed that there is a significant importance in identified skills and competencies. Moreover, identified skills and competencies are not at a satisfactory level in existing MEP workers. As per the calculation for the gap, all identified skills and competencies have negative values, which means all of them have significant gap. Accordingly, it can be concluded that there is a considerable gap between required level and available level of skills and competencies. It means there is a significant skills gap in MEP workforce in Sri Lanka and researchers should try to find new strategies to overcome this challenge.

6. References

Adams, O: 2010. Contractor development in Nigeria : perceptions of contractors and professionals. *Construction Management and Economics*, *15*(1), 95–108. https://doi.org/10.1080/014461997373141

Adi, H. P., & Faiqun, M: 2013. Identifying Essential Skills Requirement in Indonesian Construction Sector. *International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249-8958*, *3*(2), 307–309.

Akomah, B. B., Ahinaquah, L. K., & Mustapha, Z: 2020. *Skilled Labour Shortage in the Building Construction Industry Within the Central Region*. (August). https://doi.org/10.2478/bjreecm-2020-0006

Alshavi, M., Goulding, J., & Nadim, W: 2007. Training and Education for Open Building Manufacturing: Closing the Skills Gap Paradigm. In *Open Building Manufacturing: Core Concepts and Industrial Requirements* (pp. 191–214).

Ayentimi, D. T., Burgess, J., & Dayaram, K: 2018. Skilled labour shortage: a qualitative study of Ghana's training and apprenticeship system. *Human Resource Development International*, *21*(5), 406–424. https://doi.org/10.1080/13678868.2018.1447881

Barnow, B. S., Schede, J., & Trutko, J. W: 2010. Occupational labour shortages: concepts, causes, consequences, and cures. *Occupational Labour Shortages*, (September).

Basnayake, L., & Premathilaka, R: 2015. *Shortage of skilled labour in construction industry in Sri Lanka*. University of Peradeniya.

Central Bank of Sri Lanka: 2021. *National Output, Expenditure, Income and Employment 2.1*.

Chini, A. R., Brown, B. H., & Drummond, E. G: 1999. Causes of the Construction Skilled Labour Shortage and Proposed Solutions. *ASC Proceedings of the 35th Annual Conference*, 187–196. Retrieved from http://ascpro0.ascweb.org/archives/1999/chini99.htm

Chiu, B. W. Y., & Lai, J. H. K: 2017. Project delay: key electrical construction factors in Hong Kong. *Journal of Civil Engineering and Management*, *23*(7), 847–857. https://doi.org/10.3846/13923730.2017.1319410

Durdyev, S., Ismail, S., & Bakar, N. A: 2013. Construction Productivity in Turkmenistan: Survey of the Constraining Factors. *International Journal of E-Education, e-Business, e-Management and e-Learning*, *3*(1). https://doi.org/10.7763/ijeeee.2013.v3.186

El-Gohary, K. M., & Aziz, R. F: 2013. Factors Influencing Construction Labour Productivity in Egypt. *Journal of Management in Engineering*, *30*(1), 1–9. https://doi.org/10.1061/(asce)me.1943-5479.0000168

Engelbrecht, L. K: 2006. Plumbing the brain drain of South African social workers migrating to the UK: Challenges for social service providers. *Social Work*, *42*(2), 127–146. https://doi.org/10.15270/42-2-307

Enshassi, A., Mohamed, S., & Ekarriri, A: 2009. *Essential Skills and Training Provisions for Building Project Stakeholders in Palestine*. *14*(1).

Findlay, A. M. :10. 1177/03091325010250042: 2001. Book review: The migration of knowledge workers: Second-generation effects of India's Brain Drain. *Progress in Human Geography*, *25*(4), 678–680. https://doi.org/10.1177/030913250102500425

Hamid, A. R. A., Khazid, N. I. M., Yunus, R., Halim, H. A., & Razak, A. R. A: 2018. The emerging of employment gap in the Malaysian construction industry. *Journal of Physics: Conference Series*, *1049*(1). https://doi.org/10.1088/1742-6596/1049/1/012033

Hiyassat, M. A., Hiyari, M. A., & Sweis, G. J: 2016. Factors affecting construction labour productivity: a case study of Jordan. *International Journal of Construction Management*, *16*(2), 138–149. https://doi.org/10.1080/15623599.2016.1142266

Horman, M. J., Orosz, M. P., & Riley, D. R: 2006. Sequence Planning for Electrical Construction. *Journal of Construction Engineering and Management*, *132*(4), 363–372. https://doi.org/10.1061/(asce)0733-9364(2006)132:4(363)

Jayawardena, H. ., Senevirathne, K., & Jayasena, H. S: 2008. Skilled Workforce in Sri Lankan Construction Industry: Production vs. Acceptance.

Kang, T., & Gwon, B: 2016. Performance evaluation of automated 3D image-scan-based reverse engineering in architectural MEP pipe object modeling. *Spatial Information Research*. https://doi.org/10.1007/s41324-016-0066-2

Kinnear, L., & Sutherland, M: 2000. Determinants of organisational commitment amongst knowledge workers. *South African Journal of Business Management Provided*, *31*(3), 106–112.

Kissi, E., Mohammed, S. . ., & Owusu-Diatuo, K. J: 2018. Challenges facing public works departments in construction project delivery within metropolitan municipal and district assemblies in Ghana. *UDS International Journal of Development (UDSIJD)*, *5*(1), 129–143.

Korman, T. M., & Lu, N: 2017. *Innovation and Improvements of Mechanical Electrical and Plumbing Systems for Modular Construction using Building Information Modeling*. 448–455.

Korman, T. M., Siminian, L., & Speidel, E: 2008. Using Building Information Modeling to Improve the Mechanical, Electrical, and Plumbing Coordination Process for Buildings. *Building Integration Solutions*.

Manoharan, K., Dissanayake, P., Pathirana, C., Deegahawature, D., & Silva, R: 2020. Assessment of critical factors influencing the performance of labour in Sri Lankan construction industry. *International Journal of Construction Management*, *0*(0), 1–35. https://doi.org/10.1080/15623599.2020.1854042

Mccoy, A., & Yeganeh, A: 2021. *An Overview of Emerging Construction Technologies*.

Muya, M., Mulenga, M. N., Bwalya, D. C., & Price, A. D. F: 2004. *long period analysis of construction skills supply in Zambia*. *1*(September), 67–76.

National Council for Technical Education: 2020. *Mapping skills gap and skills needs for technician graduates in the selected economic sectors for industrial growth in Tanzania*.

Okpala, I., Nnaji, C., & Awolusi, I: 2019. Emerging Construction Technologies: State of Standard and Regulation Implementation. *Computing in Civil Engineering 2019: Data, Sensing, and Analytics - Selected Papers from the ASCE International Conference on Computing in Civil Engineering 2019*, (June), 153–161. https://doi.org/10.1061/9780784482438.020

Pasquire, C., & Gibb, A. G. : 2002. Considerations for assessing the benefits of standardisation and pre- assembly in construction Article. *Journal of Financial Management of Property and Construction*, *7*(3), 151–161.

Pathirana, L. P. D. S: 2021. Construction Industry and Factor Condition Prospective of Sri Lanka: A Special Reference to Skill Labour Shortage. *Journal of Business and Management*, *23*(2), 35–41. https://doi.org/10.9790/487X-2302073541

Pica, D., & Abanda, F. H: 2019. Emerging BIM-3D-Laser Scanning Integration in Construction Practice. *11th International Conference (CITC-11)*, (September).

Praveen, R., Niththiyananthan, T., Kanarajan, S., & Dissanayake, P: 2013. Understanding and mitigating the effects of shortage of skilled labour in the construction industry of Sri Lanka. *Digital Library,University of Moratuwa*, 1–14. Retrieved from http://dl.lib.mrt.ac.lk/handle/123/9439

Qi, B., Razkenari, M., Li, J., Costin, A., Kibert, C., & Qian, S: 2020. Investigating U.S. industry practitioners' perspectives towards the adoption of emerging technologies in industrialized construction. *Buildings*, *10*(5), 1–21. https://doi.org/10.3390/BUILDINGS10050085

Shen, Z., & Jiang, L: 2012. An Augmented 3D iPad Mobile Application for Communication, Collaboration and Learning (CCL) Of Building MEP Systems. *Computing in Civil Engineering*, (July), 204–212.

Silva, G. A. S. K., Warnakulasuriya, B. N. F., & Arachchige, B. J. H: 2018. A review of the skill shortage challenge in construction industry in Sri Lanka. *International Journal of Economics*, *2*(1), 75–89. Retrieved from www.ijebmr.com

Sweis, G., Sweis, R., Hammad, A. A., & Shboul, A: 2008. Delays in construction projects : The case of Jordan. *International Journal of Project Management*, *26*, 665–674. https://doi.org/10.1016/j.ijproman.2007.09.009

Wong, F. K. W., Chan, A. P. C., Wong, A. K. D., Hon, C. K. H., & Choi, T. N. Y: 2015. Electrical and mechanical safety in construction. *Icsu*, *2015*, 106. Retrieved from https://scholar.google.com/citations?view_op=view_citation&hl=en&user=fuQCDaEAAAAJ&cstart=500&pagesize=100&citation_for_view=fuQCDaEAAAAJ:IyxfXMz2bNAC

Yik, F. W. H., & Lai, J. H. K: 2008. Multilayer subcontracting of specialist works in buildings in Hong Kong. *International Journal of Project Management*, *26*(4), 399–407. https://doi.org/10.1016/j.ijproman.2007.05.009