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THE IMPACT OF LEAN KNOWLEDGE AND LEAN OPERATION ON CONSTRUCTION WORKERS' JOB SATISFACTION

Cristina T. Pérez[1], Malik Madushanka[2], Lorenzo Loyola[3], Melisa Ergul[4], Stephanie T. Salling[5] and Søren Wandahl[6]

ABSTRACT

This study is part of an ongoing research project that aims to understand workers' job satisfaction in the construction industry. For that, a survey was applied among construction workers in Denmark. This paper aims to identify the impact of Lean Construction on job satisfaction. Data from 2176 responses were analysed using framework analysis, shorting the answers into three categories: Lean knowledge; Lean application; and Lean operation, even though they declared not knowing Lean. The study investigated the impact of the different levels of Lean familiarity on job satisfaction within five aspects: Project progress; Management-employee relationship; Employee work monitoring; Workload; and Workflow. Findings indicate that only 15% of respondents have some knowledge of Lean concepts, with only 8% confirming its application. The strongest correlation (R^2=0.557) was found between the Lean practice of "organization attempt to keep workers informed" and the job satisfaction factor of "manager-worker relationship". Allowing the workers to evolve and improve presented, also, a strong correlation with job satisfaction. The study highlights that Lean practices that lead or require Respect for People are the aspects that impact the most on job satisfaction. The results emphasize that implementing Lean principles effectively matters more than merely being familiar with them.

KEYWORDS

Job satisfaction, Survey, Respect for people, Communication.

INTRODUCTION

Successful organizations are often characterized by an environment in which mutual respect prevails (Coetzee et al., 2019). With that in mind, Lean successful management philosophy, and its two principles Respect For People (RFP) and Continuous improvement can be a good choice when organizations want or need to improve. The concept of RFP is not of the emotional kind, but rather *ought-respect*; in other words, respect is due consideration (Coetzee et al., 2019). RFP corresponds to the Japanese term of "ningensei" - personhood/humanity - that according to Toyota is about bringing out the capacity of thinking and producing in every human being.

In the study conducted by a Ljungblom and Lennerfors (2021), the authors identified that "hitozukuri" – the development of people – is deeply connected to "monozukuri" – the art of

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making things or craftsmanship – and that the RFP principle is related to hitozukuri. This message of definition can be seen as: Toyota does not just build cars. They build people. This is in line with the motto that "monozukuri is hitozukuri". At the same time, RFP means enhancing workers' involvement and their voluntary efforts and drawing out their full capacity. This message of definition could be: Toyota build cars, using people (Ljungblom and Lennerfors, 2021).

Thus, implementing RFP in the organizational culture can positively impact team effectiveness. The principle is also strongly correlated with job satisfaction (McKinnon et al., 2003). In a construction context, job satisfaction has also been identified as one of the most influential motivators for improved labor productivity (Kazaz & Ulubeyli, 2007). Hence, knowledge about workers' job satisfaction is highly valuable. Job satisfaction includes all aspects of working life, including health and safety, leadership and management, communication, worker engagement, work environment, rewards, and compensation (Memon et al., 2023). In light of these considerations, the research seeks to address the following Research Question:

- How does the level of familiarity with Lean Construction (LC) impact on job satisfaction among construction workers?

LITERATURE REVIEW

Questionnaires, Interviews, and Checklist have been widely applied in research to investigate various topics that affect job satisfaction and the mental and physical well-being of employees. Table 1 offers a summary of the primary themes explored in the existing literature about job satisfaction surveys, particularly within the construction industry.

Table 1: Themes evaluated in job satisfaction surveys and their adopted approaches (Q=Questionnaire, I=Interview, C=Checklist)

Themes	Rani et al.	Nidadhavolu	Hassan et al.	Ni et al.	Kharo et al.	Raziq and Maulabaksh	Emmanuel et al.
Health and Safety	√		√	√	√	√	√
Leadership and Management	√	√	√	√	√	√	√
Communication	√	√	√	√	√	√	
Worker Engagement				√	√		√
Work environment	√		√			√	√
Rewards and Compensation		√	√		√	√	√
Method	Q+I	Q+I	Q+C	Q	Q	Q	Q

Rani et al. (2022) have identified critical factors influencing workplace well-being in construction projects, those being: Health and safety; leadership and management; communication; and work environment. However, the authors emphasize that the factors affecting workspace well-being were mainly highlighted by project managers, quantity surveyors, architects, and engineers, not hands-on construction workers worker. Thus,

suggesting that future scholars can conduct similar research using construction workers as the target population. There might be new and different factors that affect construction workers.

Another study discussed the crucial connectedness of types of leadership and job satisfaction on construction sites (Nidadhavolu, 2018). Enyan; Michael et al. (2023) have explored communication and how it plays a pivotal role in shaping employees' job satisfaction, as it functions as a keyway to share information and foster collaboration. Health and safety can be a wide term with different aspects and questions. Risk behavior is one topic of health and safety, which by Hassan; Che C.R. et al. (2007) was measured and analysed in construction. Furthermore, Ni et al. (2020) studied the mediating roles of work engagement and safety knowledge sharing. In contrast, Khahro et al. (2023), explored job satisfaction models and even proposed an integrated job satisfaction model for construction industry workers. Among many themes, work environment is an important factor in job satisfaction.

The work environment can be, according to Raziq and Maulabakhsh (2015), represented through topics such as salary packages, working hours, workflow, or relationships between management and employees. Additionally, Emmanuel et al. (2015) dived into the organizational factors influencing worker satisfaction. This included recognition, work environment, wage and so on. Finally, a study by Ullah (2018) dived into how the organization’s contribution through rewards and recognition is a must to enhance the contribution of the workers.

A common thread across the studies is the recognition of the complex interplay between organizational dynamics, leadership and management styles, communication between managers to workers, and employee engagement in shaping job satisfaction. Health and safety is also an ongoing theme across the studies. While the studies collectively emphasize the importance of different factors, there may be variations in their interpretations and research methodologies. In general, those studied did not associate those factors with the LC philosophy and how Lean practices could impact workers' well-being. For that reason, the present study aims to identify the impact of the adoption of LC on construction workers' job satisfaction.

RESEARCH METHODOLOGY

The study adopted the survey method as the main research approach. This paper represents an ongoing research project that aims to understand the job satisfaction of construction workers. The detailed activities conducted during the survey development were described in detail in Salling et al. (2023) and briefly described as follows:

1. **Link to the theoretical level:** The authors identified nine themes mainly applied for understanding job satisfaction through the literature review of survey studies in different industries. The authors categorized those job satisfaction themes into Project Management (PM), Work Environment (WE), and Health and Safety (HS).
2. **Survey design:** A 48-question questionnaire was designed. The study population was limited to all construction workers affiliated with a union and working in Denmark. The survey used non-probabilistic sampling to obtain as much data as possible.
3. **Pilot test:** Conducted two rounds of assessment, including an online meeting with experts and individual evaluations, resulting in a final 39-question questionnaire. The questions are grouped into: (1) 12 demographic questions; (2) 12 questions related to PM; (3) 8 questions of WE; and (4) 7 questions of HS. The questionnaire was available in the four predominant languages spoken on Danish job sites: Danish, Polish, Romanian, and Italian.
4. **Data collection:** The survey was administered through SurveyXact via email, open for responses from January to March of 2023. A sum of 3393 survey participants responded. In the previous study Salling et al. (2023), the authors presented a descriptive analysis of the answers related to the 12 PM questions. In the present paper, the goal of the study was to

understand the impact of the adoption of LC on workers' job satisfaction. Hence, the authors performed a data cleaning to handle missing values and inconsistencies in the data set.

5. **Data Cleaning:** To ensure result consistency, unanswered or mostly incomplete surveys were discarded. The percentage of responses per survey was calculated, and only those with 50% or more responses were considered, resulting in the exclusion of 1217 surveys. Despite the 62% reduction from the initial quantity, the set of 2176 surveys remain relevant for subsequent analysis and correlations. Subsequently, category mapping was performed, associating integer values with each response to facilitate the analysis of relationships between variables. These operations were carried out using routines programmed by the authors, allowing for a massive analysis and treatment of the information.
6. **Data analysis:** The analysis was designed with the aim of revealing the influence of LC on job satisfaction. Although, the survey had been constructed with the purpose of gathering comprehensive data in the fields of PM; WE, and HS; few sections in the questionnaire can be highlighted, as which the Lean knowledge and practices had been emphasized.
7. **Identify correlations:** For identifying questions with higher correlation, a correlation matrix was utilized. That is, by comparing all questions with each other, the Pearson coefficient is determined for each pair. Once this was done, the analysis focused on questions related to Lean Knowledge and Lean Operation. In particular, a list of the top twenty pairs showing the highest correlation coefficient was compiled, thus allowing the identification of the most relevant response pairs for analysis. To validate the obtained results, a cross-validation was performed, consisting of randomly dividing the data into subsets, on which Pearson coefficients were recalculated for each pair. The results obtained did not differ in the most unfavourable groups by almost 5%, which is acceptable and indicates consistent results.

DATA ANALYSIS CONDUCTED

The analysis has been performed using Python and MS Excel. Python was used majorly in correlation analysis while Excel was used in data visualization. The authors selected 10 questions from the questionnaire that can be related to the knowledge and/or application of Lean as expressed in Table 2. Data were analysed using a framework analysis, which consisted of classifying the answer into three categories: (1) Lean Knowledge; (2) Declaration of Application of LC, named for short Lean "Application"; and (3) Lean application even though they declared not knowing LC, named for short "Lean Operation". The study conducted four kinds of analysis: (1) descriptive analysis of the Lean knowledge and Application, (2) impact of Lean Knowledge on job satisfaction; (3) impact of Lean Operation on job satisfaction; and (4) comparison between knowing Lean and applying Lean.

Table 2: Analysis framework

No.	Questions	Answers classification			ref. Fig 8
		Lean Know.	Lean Appli.	Lean Operation	
2.3	I participate in planning meetings on site.	-	-	Always, very often	A
2.4	I finish my work on time according to the plan.	-	-	Always, very often	B
2.5.1	Regarding the project schedule, I know… ...the tasks that I should do according to the plan	-	-	Strongly agree, Agree	C
2.5.3	Regarding the project schedule, I know… ... my tasks one week from now.	-	-	Strongly agree, Agree	D
2. 7	I am encouraged to come up with better ways of doing things.	-	-	Strongly agree, Agree	E
2.11	State whether you know the following LC concept/tools/methods.	Yes	-		-
2.12	State whether the following LC concepts/tools/methods are applied on the project you work on.	-	Yes		-
3.1.	How satisfied are you with the following factors in your current job:	-	-	Very satisfied, Satisfied	-
3.3.1	This organisation does an excellent job of keeping employees informed about matters affecting us	-	-	Strongly agree, Agree	F
3.3.4	My work gives me the opportunity to evolve and improve my skills (also through formal training)	-	-	Strongly agree, Agree	G

1. Descriptive analysis of the knowledge of Lean

The first analysis consists of a general overview of the answers regarding the LC knowledge and application (knowingly) of six tools/methods/concepts in questions 2.11 and 2.12, those being: (1) Last Planner System (LPS); (2) Percent Planned Completed (PPC); (3) Location-Based Scheduling (LBS); (4) Just-in-time (JIT); (5) Value Stream Mapping (VSM); and (6) Work Sampling (WS). The answers have also been examined by trade, nationality, position in the company, and size of the current project.

2. Impact of Lean Knowledge on job satisfaction

The second analysis aimed to understand how Lean knowledge impacts on **some** job satisfaction factors. It was considered that a worker knows Lean if at least he knows three of the six tools/methods/concepts asked in question 2.11, however the question does not provide in detail whether the worker (a) has heard about Lean or (b) has a thorough grasp of the concept. But, assumed it can be both (a), (b) or in between. Under section 3.1 of the questionnaire, workers had been asked to answer about their job satisfaction under 14 aspects. For this study, only five aspects are being discussed, namely (1) Workflow of the work; (2) Project progress; (3) Relationship between management and employees; (4) Employee work monitoring; and (5) Workload.

3. Impact of Lean Operation on job satisfaction

The third analysis aimed to evaluate the impact of applying Lean on job satisfaction. Workers who have declared that they know the LC, necessarily do not have to practice them. Apart from direct declaration, indirect implications of Lean practices also had been identified. In the questionnaire, there are seven questions, which it can be assumed about the application of Lean practices in the job site. Despite not knowing about LC, workers have been practicing it unknowingly on the site. The seven indicators of Lean application at the job site are summarized in Table 2 (see letters from A to G). To make sure that workers are practicing Lean, only certain answers were selected. As an example, for the question 2.3 where it obtains the statement "I participate in planning meetings on site"; people who had given answers "Always" and "very often", were categorized as workers practicing Lean (can be seen as example of the LPS) in their site. Another example is "2.7. I am encouraged to come up with better ways of doing things", it can be considered as a RFP practice. Compliment to that, answers given as "sometimes", "rarely" and "I don't know" would suggest that they might not follow Lean strictly. Hence, those workers were categorized as the workers who do not practice Lean.

4. Comparison between Lean knowledge and Lean operation

Lastly, a correlation analysis was carried out to explore the degree of influence of Lean knowledge and Lean operation per the analysis framework, impact on job satisfaction factors (selected) by the seven Lean operation factors will be investigated. As per the criteria in Table 2, a correlation analysis had been conducted to identify significant influences. After the identification, major aspects of the nature of the influence have been discussed.

SAMPLE CHARACTERIZATION

Figure 1 displays an overview of the 12 survey answers regarding the participants' demographics and work-related information. These results offer insights into the gender distribution, ethnic composition, age demographics, trades represented, years of experience, positions within companies, and various aspects of companies' operations.

The initial graph highlights a male majority among respondents (92%), followed by a visualization indicating a dominance of Danish individuals (95%). Over 62% of respondents are aged 40 and above, signalling a lack of younger individuals in the industry. Carpenters lead the trades (26%), with varying experience levels: 21% having over 35 years in the field and 20% with 1-5 years of experience. Notably, 42% have spent 1-5 years in their current company, indicating a significant number of changes despite their considerable experience. Journeyman positions dominate. Companies mainly fall within the 10-49 employee range (34%), predominantly Danish-owned (96%). Regarding contracts and projects, most respondents' companies serve as contractors (39%) or subcontractors (37%). Project size remains uncertain for 31% of respondents, while 50% are engaged in building renovations.

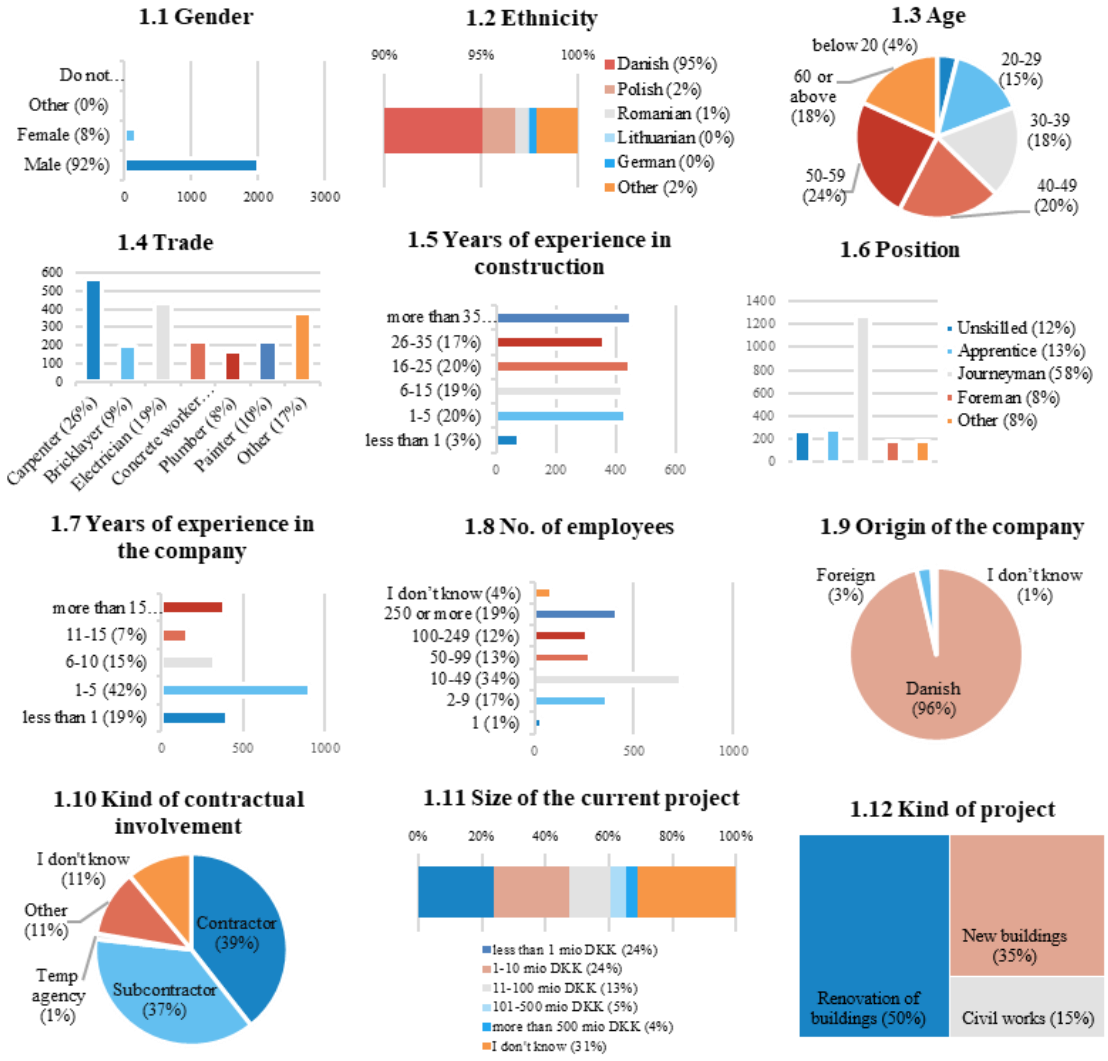


Figure 1: Demographic Profile of Respondents

RESULTS AND DISCUSSION

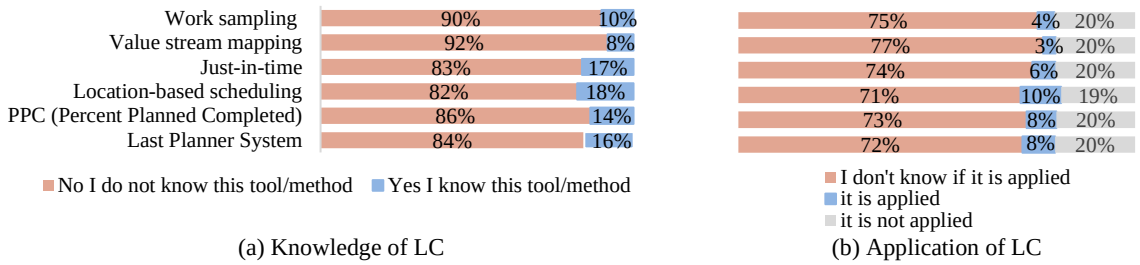
DESCRIPTIVE ANALYSIS OF THE KNOWLEDGE OF LC

The survey results revealed a substantial lack of familiarity among respondents regarding various LC tools, methods and concepts (Figure 2a). In addition to respondents' familiarity rates, the practical application of these Lean tools remained limited (Figure 2b). Uncertainty about their application ranged from 71% to 77% among respondents. VSM stands out as the least known methodology with 92% unfamiliarity. Among those evaluated concepts, LBS and JIT were the most two known concepts among the respondents, knowing by 18% and 14% of respondents respectively. However, the known adoption of those two concepts rates are 10% to 8% respectively.

Figure 3 provides a view of LC awareness and its distribution across trades, position, and project size. Across all trades (Figure 3a), the LC knowledge is uniformly low at 16%. There is a little difference with bricklayers displaying the highest awareness at 21%, while carpenters and bricklayers lag at 13%. The analysis also included positional variations (Figure 3b), which highlighted the influential role of leadership. The foreman exhibits the highest awareness at 36%, emphasizing the importance of leadership in LC implementation. On the other hand, the apprentices and unskilled show a low awareness, suggesting the need for targeted training

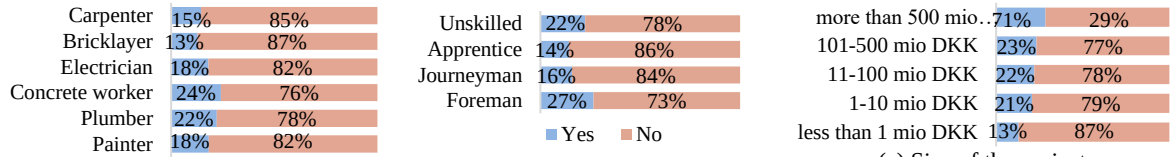
programs to foster the same comprehensive understanding. Considering the project size (Figure 3c), a positive relationship is noted between project cost and LC knowledge. Smaller projects demonstrate lower awareness (11%), while larger projects exhibit higher awareness (25%). This can be possible explained because the significance of resource allocation for training on smaller projects to ensure comprehensive LC implementation.

Figure 4 illustrates attendance for planning meetings in relation to different trades (Figure 4a) and positions (Figure 4b). For instance, plumbers and electricians exhibit a significant presence, with 22% and 20% reporting "always" and "very often" attendance. Similarly, in the position-based attendance chart, foreman position stands out predominantly, with 49% "always" and "very often" reporting attendance.



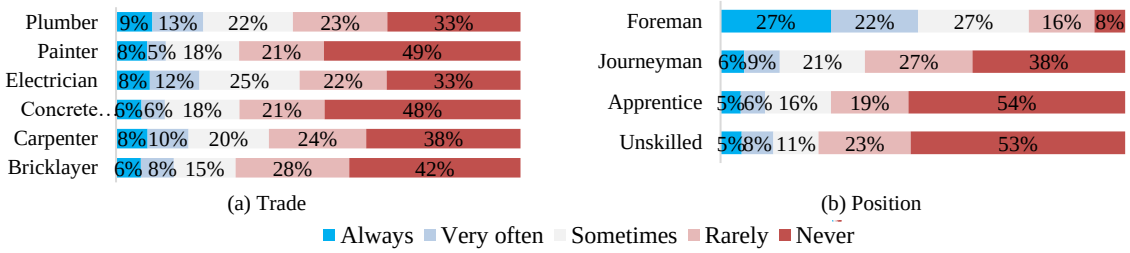
(a) Knowledge of LC (b) Application of LC

Figure 2: LC responses: (a) knowledge; and (b) application



(a) Trade (b) Position (c) Size of the project

Figure 3: Knowledge of LC regarding: (a) trade; (b) position; and (c) project size



(a) Trade (b) Position

Figure 4: Meeting participation on site regarding: (a) trade; and (b) position

IMPACT OF LEAN KNOWLEDGE ON JOB SATISFACTION

Two of the five factors asked in question 3.1 were selected to understand the impact of declaring knowing Lean on job satisfaction. Figure 5 represents the effect of knowing the Lean concept of JIT and the Lean Technique of WS within the level of satisfaction regarding "work monitoring" and "management-worker relationship". As per the Figure 5a, job satisfaction of workers who declared knew JIT ('Yes' bar in Figure 5a) in employee work monitoring was marginally higher than workers who did not know ('No' bar in Figure 5a). It was 41% and 38% respectively. However, as per Figure 5b; workers who did not know JIT had barely more job satisfaction (52%) than rest (51%) in "manager -worker relationship". As per Figure 5c and Figure 5d, knowing WS has a slight edge out, than whoever else in job satisfaction on both selected aspects. Statistically, workers knew WS has shown 10% and 3% improvement in job satisfaction under "work monitoring" and "manager-worker relationship" respectively. Hence, these representations implies that the impact of declaring knowing some Lean

tools/concepts/method is not significant for affecting job satisfaction. Hence, to examine the impact of LC application on job satisfaction, the next approach was adapted.

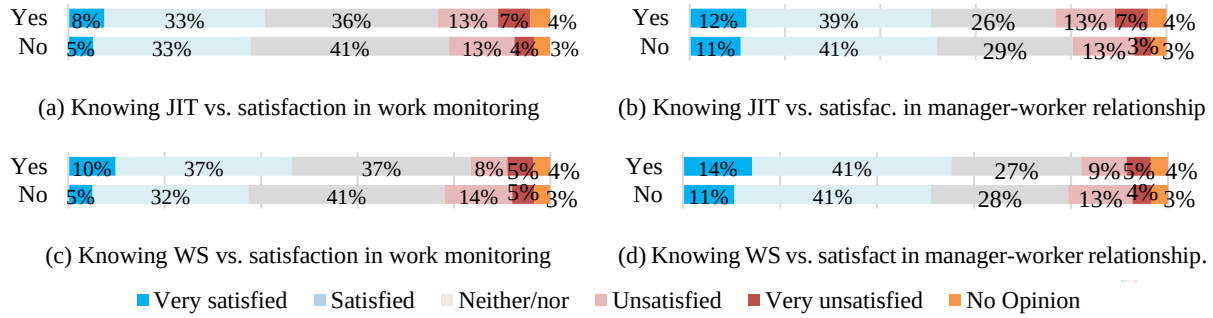


Figure 5: Impact of Lean knowledge of JIT and WS in satisfaction: (a & c) work monitoring, (b & d) manager-worker relationship.

IMPACT OF LEAN OPERATION ON JOB SATISFACTION

For understanding the impact of applying Lean on workers satisfaction, the authors selected how the "attendance in meetings" impact the satisfaction regarding "the workflow of the project" and the satisfaction regarding the "manager-worker relationship".

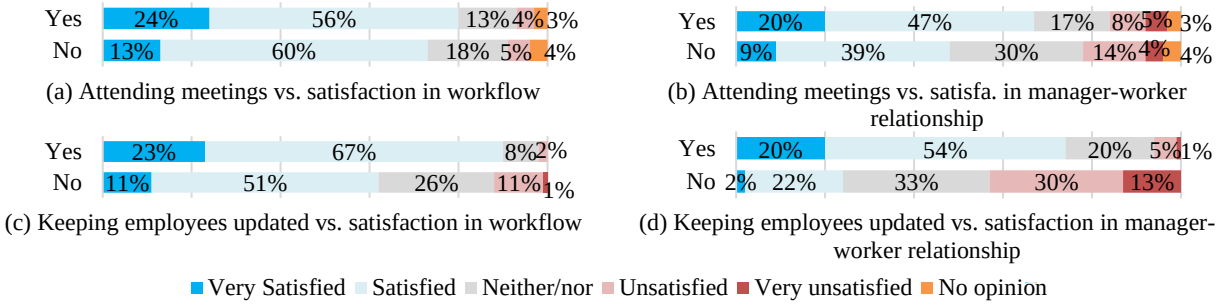


Figure 6: Impact of "attending planning meetings" (a & b), and "keeping workers informed" (c & d) on job satisfaction in "workflow" and "manager-worker relationship"

From Figure 6a and 6b, it can be seen that "participating in planning meetings" have a slight, but a noticeable impact on the job satisfaction criteria selected. When the workers did not attend the planning meetings job satisfaction in both the workflow and the "manager-worker relationship" was respectively 73% and 48%. However, workers who participate in the planning meetings show 80% and 67% satisfaction in the same criteria (Figure 6a and b). Although the relationship was weaker compared to other variables, it shows a 7% and a 19% (respectively) increase in job satisfaction. "Keeping workers updated" shows a relatively remarkable influence (Figure 6c and d). The impact on job satisfaction under "manager-worker relationship" has improved from 24% to 74% which is nearly three times of the percentage of the "workers who was not kept informed about the things mattered". Noteworthy, the influence of Lean operations is more apparent when compared to Lean knowledge.

Another noticeable observation was, how participation in planning meetings affected PM aspects. As illustrated in Figure 7, workers who participate always and very often in planning meetings ("Yes" in Figure 7) have better chance of finishing their work on time (Figure 7a), know better about their tasks according to the plan (Figure 7b), know better of their tasks ahead of one week (Figure 7c) and one month (Figure 7d). In essence, this indicates how regular engagement in planning meetings contributes to improved project management outcomes.

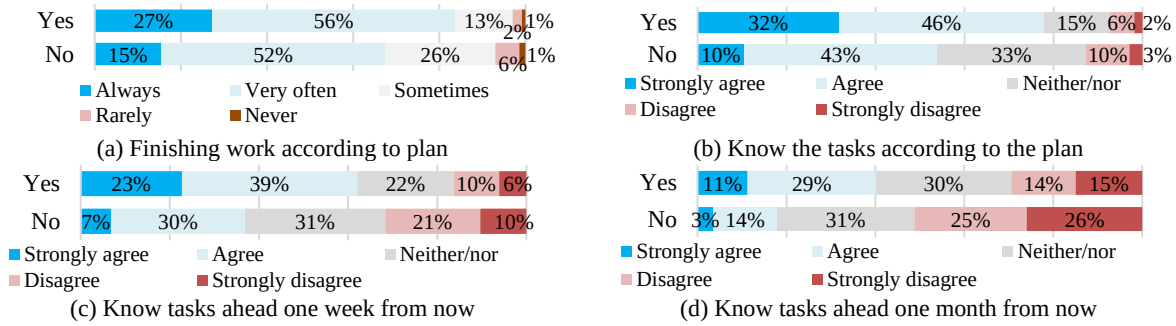


Figure 7: Effects of attending planning meetings on PM

COMPARISON OF LEAN KNOWLEDGE AND LEAN OPERATIONS

The last analysis aimed to understand the impact of having Lean knowledge on the job satisfaction (selected five fields) using the correlation analysis. As per Figure 8a, knowing Lean showed a varied influence on the selected factors. The correlations observed were barely noticeable, indicating a weak association between the variables considered, which infer that there is no correlation between the variables at all. However, for the sake of further investigation, it was noted that the largest correlation factor was found to be between WS and the satisfaction in "workload of the workers" (R^2 value of R^2=0.067) and the least being between PPC and the job satisfaction in "relationship between managers and workers" (0.001). Another observation is that JIT shows a negative correlation to all the job satisfaction factors besides job satisfaction in "work monitoring". However, it can be assumed that these correlations do not imply causation due to their insignificant magnitude.

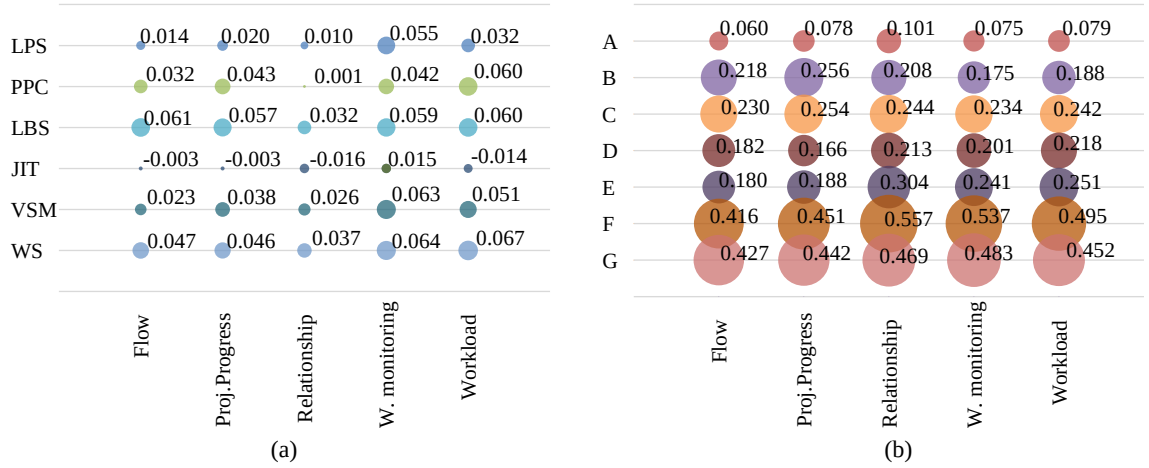


Figure 8: Correlations (R^2) of Job satisfaction: (a) Lean knowledge and (b) Lean operation

Within the designed analysis framework, correlations were explored for Lean operations (Figure 8b). The first observation was that the correlations were significantly higher than in Figure 8a, which suggests that Lean operations have a stronger influence on job satisfaction than Lean knowledge. Possessing Lean knowledge doesn't necessarily reflect whether that knowledge is actively implemented and practiced in a job site. However, it is the active practice of Lean that generates tangible results and could directly impact job satisfaction within the selected criteria. Further, when the attention is directed towards Lean operations, "3.3.1. organizations' attempt to keep workers informed about matters affecting them (Letter F in Figure 8b)" and "3.3.4. allowing the workers to evolve and improve (Letter G in Figure 8b)" have the greater influence on job satisfaction. R^2 value of R^2=0.557 is the strongest correlation factor of them, which is between "organization keeping workers informed" and satisfaction in "manager-worker relationship". This observation seems obvious, and it can be inferred that

effective and efficient communication between the organization and the workers is crucial. The least significant correlation (0.060) in the lot was with "3.1. Participation in planning meetings (Letter A in Figure 8b)". Even though "meeting participation" is expected to impact more on job satisfaction, the intended objective of planning meetings might not have been achieved. Frequently, meetings might be perceived as time-consuming, and workers may feel that extensive meeting participation takes away from their productive time. Nevertheless, operations related to RFP (F and G), has shown significant effect on task execution and planning awareness.

CONCLUSION

This study is part of an ongoing research project that aims to understand workers' job satisfaction in the construction industry. Data from 2176 responses were analysed using framework analysis, shorting the answers into three categories (Lean knowledge, application, and operation) to understand how the level of familiarity with LC impacts on job satisfaction.

The answers analysis has revealed a significant lack of awareness in various Lean approaches and their applications; meaning that most of the construction workers did not know LC and, they didn't even know whether they are practiced. Apart from that, "participation in planning meetings", which was classified as a Lean operation in this paper, was given closer attention as well. This unveiled that meeting attendance had a positive impact on PM where workers attending meetings had more tendency to finish work on time and knowing the project plan and their tasks 1- 4 weeks ahead.

The main contribution of this paper is understanding the influence of Lean knowledge and Lean operation on job satisfaction. The correlations between Lean knowledge and job satisfaction demonstrated a generally weak association, suggesting that the variables considered do not exhibit significant correlations. Shifting the focus to Lean operations, the strongest correlation was found between organizational communication practices and satisfaction in manager-worker relationships. Thus, Lean practices that lead or require RFP are the aspects that impact more on job satisfaction.

The study has some limitations that should be addressed in future research. Firstly, the results are limited to the Danish construction scenario. Thus, caution is necessary when extrapolating findings to other countries. For that, a broader data collection across various countries and regions could facilitate comparisons and offer insights into the impact in Lean in job satisfaction. To overcome that, the authors have been working with other researchers from other countries and the questionnaire is going to be applied in France, Lebanon, UK, Peru and Chile. Secondly, the assumption considered during the categorization into knowing Lean or not could have impacted in the results. The respondents were considered familiar with Lean when affirming knew at least three concepts. However, other assumptions could be considered for that categorization. For example, a Lean knowledge degree and/or a Lean implementation degree could be used. Thirdly, the impact of having Lean knowledge and Lean operation on job satisfaction was conducted only considering five selected factors; however, other factors asked in question 3.1 could be considered.

Despite the need for caution in applying the study's findings to different countries, they still offer valuable insights into the factors influencing job satisfaction in construction projects. Future research could focus on developing roadmaps based on these findings, tailored to meet specific local needs and contexts to promote RFP.

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