Erazo-Rondinel, A. A., Melgar-Morales, M. A., Abregu-Gonzales, J. J., Napa-Almeyda, J. A. & Lipa-Mamani, D. S. (2024). Can ChatGPT help with the Last Planner System Implementation? An Expert Overview. In D. B. Costa, F. Drevland, & L. Florez-Perez (Eds.), *Proceedings of the 32nd Annual Conference of the International Group for Lean Construction* (IGLC32) (pp. 707–718). doi.org/10.24928/2024/0160

CAN CHATGPT HELP WITH THE LAST PLANNER® SYSTEM IMPLEMENTATION? AN EXPERT OVERVIEW

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ABSTRACT

In recent years, the construction sector has been influenced by different technologies, which has given way to construction 4.0. One of the elements of Construction 4.0 is the use of artificial intelligence, and in recent years, chatbots have become popular in different industries, including construction. However, the literature on how chatbots can help in construction projects is limited. In this sense, the following article aims to study the degree of reliability presented by a chatbot (ChatGPT) to improve the implementation of the Last Planner® System (LPS). This article begins with a literary review of LPS barriers. From this, 13 main barriers are validated with the help of 10 expert judgments. After that, ChatGPT 3.5 is interacted with to provide possible solutions to the barriers found, which are validated again with eight expert judgments. The results show that 68.27% of ChatGPT responses are "Totally agree" and "Somewhat agree." The following article will contribute to professionals in the construction sector so that they can evaluate the reliability of chatbots and explore their applications to solve LPS implementation problems and other problems in construction projects.

KEYWORDS

Last Planner, Artificial Intelligence, ChatGPT, construction 4.0, lean construction.

INTRODUCTION

The construction industry faces cost overruns, changes in execution, delays, and low productivity, and one of the main factors for these is the slow technological adoption of the construction industry (Hui et al., 2019). In this sense, Industry 4.0 can transform construction into a technological industry (Kozlovska et al., 2021). Given this, there are efforts to combine Industry 4.0 technologies in construction, which has given rise to Construction 4.0, where technologies such as BIM, virtual reality, mixed reality (Hossain & Nadeem, 2019) and artificial intelligence (AI) are used (Forcael et al., 2020).

One of the elements of Construction 4.0, AI, which is defined as a powerful management tool that provides superior analysis operated by humans, allows time savings in automating

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processes and forecasting results (Ayoubi et al., 2023). Its applications occur in intelligent manufacturing and predicting phenomena related to building design, construction, and operation, identification of elements on a construction site, and developing patterns to follow workers' performance (Forcael et al., 2020). The use of artificial intelligence in construction is increasing due to the large amount of data produced by digital transformation, the capacity for data management, and the improvement in computational quality (Baduge et al., 2022).

AI has been explored to generate synergies with the lean philosophy. For instance, Cisterna et al. (2022) explain how AI can leverage the data generated by Lean. In addition to this, in recent years, AI chatbots such as ChatGPT have been developed, which, due to an immense amount of data, training models, adaptability, and learning, are capable of maintaining conversations, understanding the context, and presenting solutions (Yan et al., 2023). This is how its implementation has expanded in different areas, and lean construction has not been the exception. Therefore, interactions between Lean Construction and Chat GPT have a promising future (Hatoum & Nassereddine, 2023). For example, Etges and Fireman (2023) generated a conversation with ChatGPT about the dimensions of lean construction concepts, tools and people and validated them with 14 experts, finding that 77% of ChatGPT responses are "good" or "very good".

In this way, construction 4.0 could support several Lean Construction objectives, such as LPS, Jidoka, and VSM. That is why Hamzeh (2021) mentions that together, these elements could give rise to what is known as Lean Construction 4.0, a new philosophy that uses emerging technologies to streamline processes and promote a culture of continuous improvement, elimination of waste, and respect for people. This new philosophy prioritizes the harmonious integration of people, processes, and technologies.

While there are studies on ChatGPT and lean construction, research on adopting Chatbots within Lean Construction still needs to be explored. Dumrak and Zarghami (2023) highlight that one of the most important gaps is understanding AI's potential in the Lean field and how it can aid in the application and concept practice. Schia et al. (2019) note that one of the benefits of using AI is its ability to automate repetitive processes, thereby reducing human errors and allowing people to focus on value-added tasks. This benefit aligns with the Lean principles of waste reduction and value generation. Despite this, as Cisterna et al. (2022) point out, there needs to be more research that analyzes the synergy between the fields of Lean construction and AI, indicating a significant untapped potential. This untapped potential underscores the importance and urgency of our research in this area.

For this reason, the following article delves into how ChatGPT can help establish practical strategies to mitigate the barriers to Last Planner System implementation. To achieve this, the researchers collect and validate barriers associated with LPS through expert judgment. Then, using the categorized barriers, they ask ChatGPT for strategies to mitigate their impact. Finally, they validate the certainty of the obtained answers with expert judgment, thereby providing concrete insights and strategies for leveraging ChatGPT in Lean Construction, specifically in the context of Last Planner System implementation.

BACKGROUND

ARTIFICIAL INTELLIGENCE AND LEAN

Lean Construction is a construction management philosophy implemented on different continents (Engebo et al., 2017). Thus, in recent years, due to the technological revolution, various technological advances have been generating synergy with construction 4.0, giving rise to the concept of lean construction 4.0, which seeks to combine the technology of industry 4.0 with the people-process-technology lean triad (Hamzeh et al., 2021). Thus, one of the key elements of this synergy is the interaction of Lean Construction with artificial intelligence.

In that sense, Cisterna et al. (2022) mention that implementing AI and Lean together generates synergies that add value to what they would have when applied separately. Likewise, other authors have explored these synergies in different fields. Prieto et al. (2023) study the use of artificial intelligence for decision-making, thus avoiding people's subjective judgment that can lead to waste, such as unproductive actions that do not add value. Dumrak and Zarghami (2023) conducted a classification study on the different categories and AI tools to make an application in lean construction management (LCM) to support its principles.

Likewise, this synergy has extended to the interaction of chatbots such as ChatGPT with Lean Construction. Etges and Fireman (2023) conducted a conversation to obtain the definitions that ChatGPT can provide about the concepts, tools and behavior of people related to lean construction and then be evaluated by experts on the subject. Hatoum and Nassereddine (2023) focused on collecting and summarizing IGLC articles and identifying their trend in research that relates to lean construction and ChatGPT and their ability to educate and train on both theoretical and practical aspects of the application of lean construction.

CHAT GPT AND CONSTRUCTION INDUSTRY

ChatGPT is used in different industries, and the construction industry is no exception. Thus, ChatGPT promises to transform not only the way we build but also the way we imagine the infrastructure of tomorrow (Rane, 2023). ChatGPT can help carry out preliminary designs, structural analyses, and simulations, in addition to facilitating the optimization process and evaluation of the feasibility of each alternative (Aluga, 2023). In addition, it has been used in risk management (Aladağ, 2023) and in project planning, where it has promising results, especially for simple cases, but since it is not a tool designed for planning, it has limitations in the programming of real projects. (Prieto et al., 2023). ChatGPT also helps in the development of intelligent, sustainable, automated cities, BIM models, and choice of materials and technologies, showing that even with the challenges it presents, such as the need for specialized training and possible job changes, it seems clear that ChatGPT will have a central role in the development of the construction industry (Rane, 2023).

PROBLEMS IMPLEMENTING THE LAST PLANNER SYSTEM

The Last Planner System (LPS) tool, a Lean Construction tool, is used for production planning and monitoring to increase reliability and performance while establishing a predictable workflow (Hamzeh et al., 2009). It has been shown that its implementation brings benefits such as improved organizational control (Cerveró et al., 2013), a decrease in variability that translates into greater productivity, and a reduction in costs (Koskela et al., 2010), simplifying thus the production control and planning process (Aziz & Hafez, 2013). Despite these benefits, its successful implementation faces several barriers.

Liu et al. (2020) described the barrier of lack of knowledge about LPS, mentioning that one of the causes is the low effectiveness through which social dynamics are managed in construction organizations, which reduces both absorption and diffusion of LPS. These can be without a solution for a long time.

On the other hand, Venkatesh and Venkatesan (2021) explained that the barriers of "resistance to change" and "Lack of collaboration between project team members" have a relationship between the two because, in the construction industry, there is a late acceptance of the change and one of the main reasons for this is the low participation of various segments deployed in the project.

Lindhard and Wandahl (2015) focus mainly on two barriers: "Partial Implementation" and "Lack of Knowledge of the LPS execution process." In their research, they mentioned that a theoretical and practical study revealed that only parts of the LPS are implemented, and this

directly influences the process's reliability. In addition, a lack of knowledge of the implementation can cause reliability problems to go unnoticed.
Based on the literature review, 15 barriers to implementing the Last Planner system were detected, which are presented in Table 1.

Table 1: Barriers associated with the implementation of the last planner system.

Barriers	References*
Lack of leadership and management commitment for the implementation of the Last Planner System (LPS).	1
Lack of Last Planner training to managers to manage the project.	2, 3
Management has a short-term vision in the implementation of LPS in their organization.	4
Lack of knowledge about the LPS System	1, 2, 5, 6, 7, 9
Lack of role definition in LPS implementation	3, 5
Lack of commitment of the team in the LPS implementation	2, 4
Lack of involvement of the last planners	5, 6
Lack of involvement of the members of the production chain (customer, suppliers, subcontractors)	2, 3, 5, 7
Resistance to change	1, 2, 3, 6
Lack of transparency and weak communication in the exchange of information in the weekly meetings	2, 3, 5, 7
Lack of commitment of the whole team in the implementation of LPS	6, 7
Failure to use a gradual process of LPS implementation	9
Lack of self-criticism to take improvement actions during LPS implementation	3, 7
Incorrect use of the information gathered during implementation to create a learning loop	1, 3, 5, 7
Lack of management support for LPS implementation	1

Note: *1. Murugaiyan et al. (2022), 2. Venkatesh and Venkatesan (2021), 3. Murguia (2019), 4. AlSehaimi et al., (2009), 5. Brady et al. (2011), 6. Liu et al. (2020), 7. Tayeh et al. (2018), 8. Lindhard and Wandahl (2015), 9. Perez and Ghosh (2018).

RESEARCH METHOD

Figure 1 shows the phases of the methodology of this research. In the first phase, a literary review of the barriers to the implementation of the last planner system is carried out by searching with the keywords "Last planner" and "barriers" in the IGLC and Scopus databases because IGLC contains the most significant amount of Lean Construction publications (Daniel et al., 2015) and Scopus has a greater range of construction publications than other databases (Mongeon & Paul, 2016). In the second phase, a survey was developed that allowed the main barriers of LPS to be categorized, and the survey was sent to 10 experts using the Likert scale. The surveys were used because they have been used in other lean construction studies, such as those of Murguia (2019).

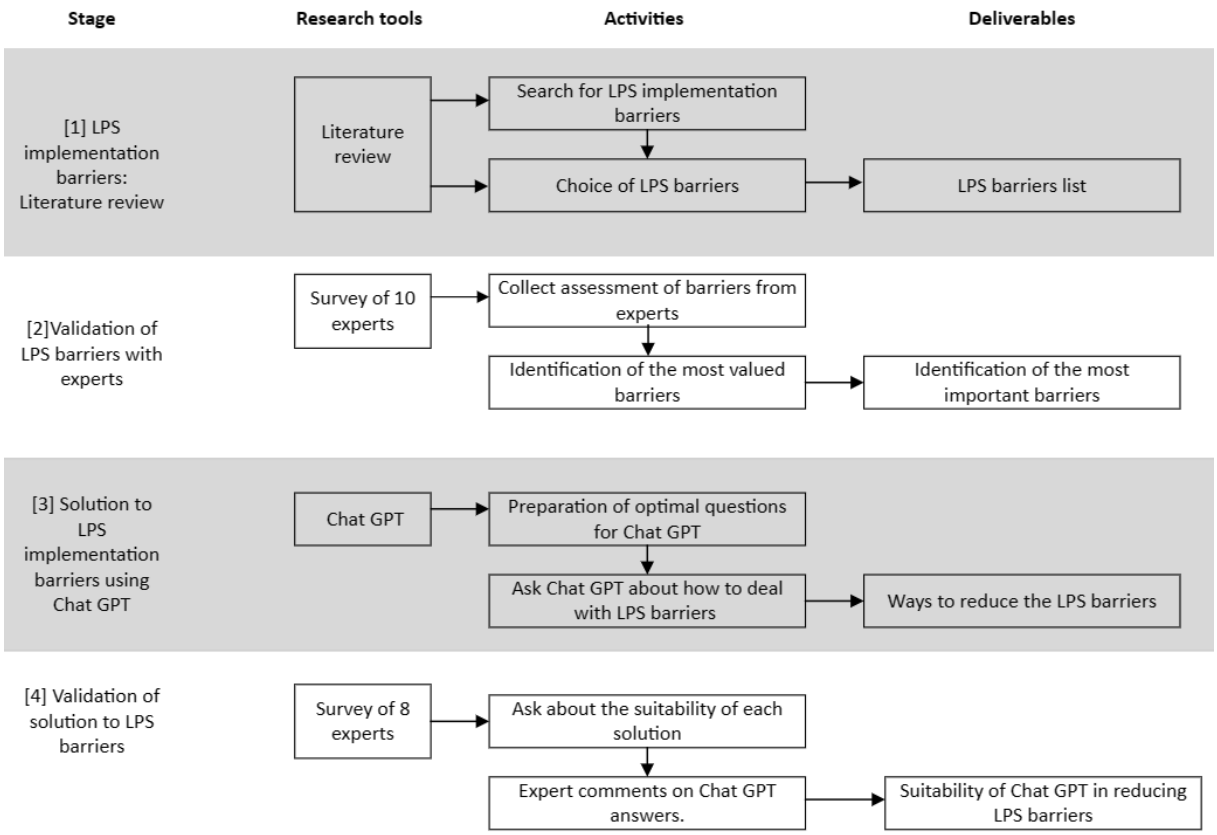

Figure 1: Structure of the Paper.

The selected experts had to be civil engineers with more than five years of experience in lean construction. Table 2 shows their profiles.

Table 2: Profile of the experts who validated the LPS barriers.

Number	Experience	Experience in Lean Construction	Industry/Academic	Business /Interest Area
Expert 1	10-20 years	10-20 years	Industry Participant	Project management
Expert 2	5-10 years	5-10 years	Industry Participant	Construction
Expert 3	>20 years	>20 years	Academic	Research, development and innovation
Expert 4	10-20 years	10-20 years	Industry Participant	Construction
Expert 5	5-10 years	5-10 years	Industry Participant	Construcción
Expert 6	10-20 years	10-20 years	Industry Participant	Project management
Expert 7	10-20 years	10-20 years	Industry Participant	Construction
Expert 8	5-10 years	5-10 years	Industry Participant	Project management
Expert 9	5-10 years	5-10 years	Industry Participant	Construction
Expert 10	10-20 years	10-20 years	Industry Participant	Project management

In the third phase, ChatGPT was used to ask how it would resolve the barriers with an average greater than 4, of which there were 13 and were considered the most important. In the last phase, the answers were sent in a new questionnaire to experts, with the same requirements as the previous validation. They were evaluated using a Likert scale to evaluate how much they agreed with the content and quality of the answers and to write a comment with their opinion. Table 3 presents the characteristics of the experts.

Table 3: Profile of the experts who validated the set of CHAT GPT's answers.

Number	Experience	Experience in Lean Construction	Industry/Academic	Business /Interest Area
Expert 1	10-20 years	<5 years	Industry Participant	Construction
Expert 2	10-20 years	10-20 years	Industry Participant	Construction
Expert 3	5-10 years	<5 years	Industry Participant	Project management
Expert 4	5-10 years	5-10 years	Industry Participant	Construction
Expert 5	10-20 years	10-20 years	Industry Participant	Construction
Expert 6	10-20 years	10-20 years	Industry Participant	Research, development and innovation
Expert 7	10-20 years	10-20 years	Industry Participant	Project management
Expert 8	5-10 years	5-10 years	Industry Participant	Construction

RESULTS AND DISCUSSION

LAST PLANNER BARRIERS

From the surveys with the experts, 13 barriers were obtained, shown in Table 4.

The most important barrier is barrier B1, with an average of 4.6. This shows that a key factor in the successful implementation of LPS is management's support and commitment to it. For this same reason, the B3 barrier does not allow us to achieve the expected results.

It is argued that barriers B2, B4, and B5 exist because the LPS is a tool that requires a good understanding of the principles and their composition to put them into practice and obtain results. Furthermore, barriers B6, B7, B8, B10, and B11 exist because the LPS is a tool that requires collaboration from the entire team (Daniel et al., 2015), so if it is not available, it can lead to problems in implementing this tool. On the other hand, barrier B9 is typical of lean approaches such as LPS despite the benefits it may bring (Pedrosa et al., 2023).

Table 4: Most important Barriers of LPS.

Code	BARRIERS	s.d.	Mean	Rank
B1	Lack of leadership and management commitment for the implementation of the Last Planner System (LPS).	0,70	4,6	1
B2	Lack of Last Planner training for managers to manage the project.	0,71	4,5	2
B3	Management has a short term vision in the implementation of LPS in their organization.	0,88	4,5	3
B4	Lack of knowledge about the LPS System	0,70	4,4	4
B5	Lack of role definition in LPS implementation	0,70	4,4	5
B6	Lack of commitment of the team in the LPS implementation	0,82	4,3	6
B7	Lack of involvement of the last planners	0,79	4,2	7
B8	Lack of involvement of the members of the production chain (customer, suppliers, subcontractors)	0,63	4,2	8
B9	Resistance to change	0,79	4,2	9
B10	Lack of transparency and weak communication in the exchange of information in the weekly meetings	0,67	4,1	10
B11	Lack of commitment of the whole team in the implementation of LPS	0,74	4,1	11
B12	Failure to use a gradual process of LPS implementation	0,67	4	12
B13	Lack of self-criticism to take improvement actions during LPS implementation	0,82	4	13

For reasons of space limitations, the responses provided by ChatGPT are not presented in this research, as this conversation occupied 31 pages of results. However, of the barriers identified in the previous stage, the questions asked to ChatGPT are presented in Table 5. The "act" prompt was used since this instruction guides the artificial intelligence to execute or reproduce a specific set of skills from a group of experts. This research scenario allowed the AI to provide us with solutions based on the answers previously uploaded by lean construction experts to its database. It is observed that the most critical barrier turns out to be barrier B1, with an average of 4.6, which shows that for a successful implementation of LPS, a key factor is the support of management and their commitment to the implementation. For this same reason, the B3 barrier does not allow us to achieve the expected results.

Furthermore, it is important to highlight that at the beginning of the conversation with ChatGPT, the pre-set question "What is lean construction?" was asked because it was observed that ChatGPT provided higher-quality answers by building connections with past answers (Etges and Fireman, 2023).

Table 5: Most important Barriers of LPS solved by ChatGPT.

Code	Questions to ChatGPT	Number of words
B1	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Lack of leadership and management commitment for the implementation of the Last Planner System (LPS)?	396
B2	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Lack of Last Planner training to managers to manage the project?	449
B3	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Management has a short term vision in the implementation of LPS in their organization?	473
B4	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Lack of knowledge about the LPS System?	449
B5	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Lack of role definition in LPS implementation?	460
B6	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Lack of commitment of the team in the LPS implementation?	472
B7	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Lack of involvement of the last planners?	485
B8	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Lack of involvement of the members of the production chain (customer, suppliers, subcontractors)?	495
B9	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Resistance to change?	504
B10	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: lack of transparency and weak communication in the exchange of information in the weekly meetings?	504
B11	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Lack of commitment of the whole team in the implementation of LPS?	504
B12	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Failure to use a gradual process of LPS implementation?	515
B13	Act as a professional in lean construction, how would you solve this barrier to implementing last planner system: Lack of self-criticism to take improvement actions during LPS implementation?	509

The experts' answers are in Figure 2. On average, 68.27% of the responses are in the range of "Totally agree" and "Somewhat agree," which is" close to the 77% obtained in the ChatGPT and lean construction study by Etges and Fireman (2023).

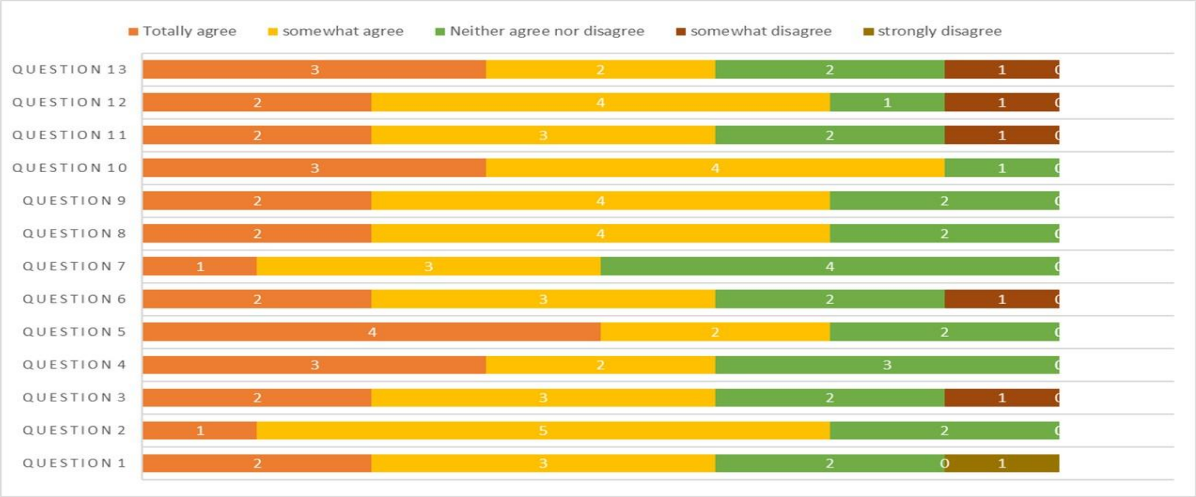

Figure 2: Chart of expert evaluation results on Chatgpt.

Question 10 is where the experts agreed the most, where no expert answered, "somewhat agree" or "strongly disagree." However, they would also propose an appropriate selection of the implementation team, making a better evaluation of the profile and performance of the participants.

Question 7 has the least approval, with 50% answering "Totally agree" and "Somewhat agree." Half of the respondents mentioned that more information was needed from Chat GPT and that, from the experts' experience in practice, they mention that this barrier is also influenced by factors external to those raised in the answer.

The only question with a "strongly disagree" answer was question 1. The expert who gave that rating commented that Chat GPT's answer fits the adoption of a general tool and not a tool with a philosophy of continuous improvement and lean transcendence, such as the LPS, which is consistent with what was mentioned by Etges and Fireman (2023). However, there were also responses in "Totally agree," arguing that good responses were given, such as highlighting the economic benefits to the company, as this will ensure a successful start to implementation and with high involvement of senior management.

In question 2, the experts mention the relevance of training operational managers and project supervisors but not so much that of "managers," pointing out that raising their awareness is enough to improve management with LPS. On the other hand, some criticisms were that knowledge management is more than the application of learning tools; rather, it is a process to ensure the learning achievements that are to be transmitted.

The experts highlight that question 4 is developed using the approach of barrier 2. However, both the question and the answers are more specific. It is also differentiated by the inclusion of "internal champions," who will be the defenders and mentors in the integration of LPS. There are unaware of LPS due to a generational issue, but not because they do not know of its existence.

In question 3, the experts mention that ChatGPT's answers were predictable in the sense of prioritizing that the LPS is oriented with the strategic plans and demonstrating the business benefit of implementing LPS.

Question 5 has the most answers in "Totally agree," and the experts mention that they provide accurate recommendations on role recognition in the implementation of the LPS, but they also mention that there should be more emphasis on the communications management part.

Most experts gave their opinions with a "Totally agree" rating for question 6, showing their interest in a relationship with communications management within the workplace.

In the comments on question 8, they mention that Chat GPT provides general answers to multiple factors, so it would be better to identify the flaws in a project personally and then ask Chat GPT what it would do to solve them.

Question 9 has a generally accepted answer. However, the experts mention that one must look beyond providing training and incentives and worry, for example, about generational change and how to generate change for senior professionals.

For question 11, it was recommended that this barrier can be avoided with better personnel selection and evaluation of profiles and performance of participants so that they are aligned with the work's objectives.

In question 12, the experts mention that adequate points were given in the answer but that the implementation process depends on each problem, so the answers are very general. In addition, they recommend getting more information to ask about a particular case.

Experts mostly agree with the answers provided by Chat GPT. However, some recommend that each problem for LPS adoption be first identified in addition to collecting data. So that Chat GPT has a greater context of the situation and generates better, more precise, and more understandable solutions. Results are consistent with the results found by Etges and Fireman (2023).

CONCLUSIONS

From this research, Chat GPT can be a good tool for providing responses related to mitigating the impact of the barriers associated with the Last Planner System since the specialists agreed with the different measures proposed by ChatGPT in 68.27% of cases.

The authors propose that future research try more interactions between lean construction and ChatGPT, increase the quality of the questions in the present study, and follow the recommendations of the experts to solve LPS implementation problems in a particular case study with ChatGPT so the answers can be more accurate.

The strong approval in question 10 indicates that experts recognize the importance of carefully choosing the implementation team. This finding suggests they value the need for trained and committed personnel to ensure success in applying the LPS. Furthermore, no expert selected "somewhat agree" or "strongly disagree" highlights a consensus on this topic.

The lower approval recorded for question 7 highlights a concern about the need for more information provided by Chat GPT in certain aspects. Experts suggest that a lack of clarity or detail in some areas could be an obstacle to the effective implementation of the LPS. This finding underscores that communication and the availability of complete information are critical elements for project success.

The experts' analysis shows that "Lack of leadership and management commitment for the implementation of the Last Planner System (LPS)" is the main barrier, which indicates the importance of management support and commitment.

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