

PROJECT PLANNING IN CONSTRUCTION 4.0: AI-DRIVEN CHATBOTS FOR PROJECT PLANNING CHALLENGES

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Abstract

From a promising idea and gadget, Artificial Intelligence (AI), is becoming a reliable tool in everyday business. Industries report a galloping adoption of AI across communications, optimization, planning, safety protocols, and monitoring. The construction industry, known for its slow adoption of new technologies, is sluggishly but surely reporting positive feedback and promising potential of the utilization of AI. This study has applied the most notable AI-driven chatbots, i.e., ChatGPT, Microsoft Copilot, Google Gemini, and DeepSeek, to solve standard project planning tasks. The results revealed that chatbots are surprisingly skilled at solving problems, but only when used by an experienced, professional user. Furthermore, the results showed the differences among the chatbots in solving the same types and scales of problems. Also, all analyzed chatbots can export data into documents compatible with standard project planning tools.

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- Overalllocation.

1 INTRODUCTION

Artificial Intelligence (AI) is rapidly emerging as a tool for solving various everyday social, economic, engineering, and personal tasks. After decades of hopes and expectations, AI has become a reality with the Fourth Industrial Revolution, also referred to as Industry 4.0 (Sawhney et al., 2020). The majority of AI-powered applications in daily life are taken for granted by the general public, e.g., from facial recognition algorithms to text editing and proofreading tools to AI-powered voice copying and video production systems.

In 2023, the U.S. Department of State issued a document

called Enterprise Artificial Intelligence, Strategy 2024-2025: Empowering Diplomacy Through Responsible AI (U.S. Department of State, 2023), to encourage the effective, ethical, and responsible use of AI globally. Almost simultaneously, the European Commission was iteratively developing a general-purpose AI Code of Practice (European Commission, 2024). Many AI systems in the EU are starting to use general-purpose AI (GPAI) models capable of a wide range of tasks. Due to their extensive utilization, they pose systemic hazards. Hence, the aforementioned code provides the guidelines for AI's safe and reliable development and usage by covering rules pertaining to copyright and transparency. In 2024, the

Australian Government noted that 35 % of Australian small and medium-sized enterprises were adopting AI; among these enterprises the health, education, and manufacturing sectors had the highest uptake at 45 %, while the construction industry had a 24 % of AI adoption rate (Australian Government, 2024). These documents and statistics clearly signal that AI is an interesting phenomenon, which is becoming an essential tool in everyday business.

Despite the promising results from Australia that almost a quarter of the construction industry is using AI, the construction industry has a globally acknowledged and common characteristic, i.e., its sluggishness in adopting new technologies and innovations. However, with Construction 4.0, as pushed by Industry 4.0, it is noted that the architecture, construction, and engineering (AEC) industries worldwide are embracing the main drivers of AI-empowered digital and computing technologies. There have been positive feedbacks reported in the literature that incorporate AI in the construction industry from developments of trustworthy and ethical construction robotics (Emaminejad and Akhavian, 2022; Liang et al., 2024; Abioye et al., 2021; Pradhananga et al., 2021); AI for optimized supply chains and procurement (Ogundipe et al., 2024); integration of AI in the optimization of construction materials' (Saad et al., 2024); to AI integration in construction safety (Rabbi and Jeelani, 2024).

From the strategic to the operational level, the utilization of AI in construction project management, is also documented in the literature. The integration of AI and BIM was elaborated on in the study (Pan and Zhang, 2023). The authors comprehensively reviewed the development and future direction of the BIM-AI integration in construction. Furthermore, (Pettinger and Nelson, 2024) highlighted the potential of AI technology for pre-job meetings through automated transcription, analysis, and coordination. The authors state that using AI for daily planning conversations could improve the culture, engagement, planning, and safety of construction.

Regarding Construction 4.0, AI is considered the driver with the most expectations and greatest potential (Begić and Galić, 2021). In a review presented by Bang and Olsson (2022), the use of AI in the construction industry was seen as having a wide scope, i.e., in the field of estimation and cost control, logistics, planning, scheduling, strategic planning, health and safety, project monitoring, risk management, sustainability, and material properties. Furthermore, (Holzmann and Lechiara, 2022) highlighted that AI most influences the estimation and control processes the scope of a project, and its schedule, costs, and risk management.

According to (Felicetti et al., 2024), AI is driving technological advancements that are changing cognitive activities and are beyond simply improving operational efficiency. Alongside promising examples of AI utilization in various project management tasks, Ng and Zhang (2025) highlight that there are still challenges in human-machine communications (HMC) regarding having trustworthy AI systems. While the focus is on developing AI chatbot algorithms, they note that humans have to adapt and learn how to

communicate with such systems. Within the HMC framework, an important issue is the user's psychological approach to the AI source. Findings presented in studies Lee et al. (2022) and Tandoc et al. (2020) highlight that people are often "cognitive misers", meaning they may not be sufficiently mindful of a source as long as the information provided appears useful. The potential threat is the user's cognitive shortcut based upon the assumption that the machine's output is undoubtedly objective or accurate. The authors (Sourav et al., 2026), present an in-depth analysis of HMC and indicate that successful human-AI cooperation depends on the algorithm's sophisticated approach to assessing the human operator, through direct observation and cognitive modeling that support the human decision-making process, which means that algorithms will probably more efficiently adapt to human expressions than vice versa. In line with this perspective, a project management AI source (PMI Infinity 2024) was developed by the PMI organization, which is trained and focused on solving project management-oriented problems more efficiently.

Another threat that LLM algorithms pose is hallucinations (Ji, et al., 2023; Bang, et al., 2025). Hallucinations are categorized as either intrinsic (contradicting user input) or extrinsic (deviating from pre-training data), both of which present significant risks. Effective mitigation involves iterative self-reflection loops to refine the factuality of the answers and to improve a model's ability to abstain from responding when it reaches its known knowledge boundaries.

An AI chatbot application for solving project planning problems was presented in the study (Hajdu, 2023). The author used an AI chatbot, i.e., ChatGPT v1, to determine the project's duration by calculating early starts (ES) and early finishes (EF). The results showed iterative issues during the test because the algorithm was not ready for this task. The problems and results presented by the author above and the lack of other research on the implementation of AI for solving standard project planning issues were the motivation for the study presented in this paper. The motivation behind this study was to determine the extent to which chatbots can autonomously solve small-scale but relevant and everyday project planning tasks. The results show a promising future for AI-driven chatbots for solving standard project planning tasks; however, challenges must be overcome for fully autonomous, trustworthy solutions to be gained by AI algorithms.

The literature review revealed a research gap, which was structured into four research questions as follows:

RQ1: Can AI-driven chatbots solve standard project scheduling tasks, i.e., determine the project's duration, time slacks, and critical path?

RQ2: Can AI-driven chatbots solve standard project cost planning tasks, i.e., determine the cost-significant activities?

RQ3: Can AI-driven chatbots solve standard project resource planning tasks, i.e., determine overallocated resources and solve any allocation problems?

RQ4: Are there differences among the AI-driven chatbots applied in terms of the quality of their solutions, responsiveness, and iterations?

The remainder of the paper is structured as follows: after this introduction, the second section introduces the methods applied in the study. In section three, the authors present the results and a discussion that reveals the performance of the AI chatbots in solving the given tasks. In the fourth section, the conclusions are given, along with directions for further research.

2 METHODOLOGY

This study is structured in five consecutive steps, as shown in Figure 1, i.e., definition of the research questions, choice of literature-based examples, definition of the planning tasks, choice of chatbots, and data export from the chatbots to standard project scheduling (PS) software.



Fig. 1 Process flow of the presented study

Tab. 1 Example 1 (E1) input parameters

Activity A_i	Duration D_i [days]	Preceding Activity	Type of Connection
A_1	5	--	--
A_2	5	$A_1; A_5$	FS(0); FS(0)
A_3	3	A_2	FS(0)
A_4	6	A_3	FS(0)
A_5	4	A_1	FS(0)
A_6	3	$A_5; A_9$	FS(0); FS(0)
A_7	5	$A_6; A_4$	FS(0); FS(0)
A_8	6	A_1	FS(0)
A_9	3	A_8	FS(0)
A_{10}	4	A_9	FS(0)
A_{11}	0	$A_7; A_{10}$	FS(0); FS(0)

Tab. 2 Example 2 (E2) input parameters

Activity A_i	Duration D_i [days]	Preceding Activity	Type of Connection	ES_i [cons. day]	Costs C_i [€]	Workers W_i
A_1	10	--	--	N/A	8.000,00	$W_1; W_2; W_3$
A_2	6	A_1	SS(7)	N/A	5.000,00	$W_1; W_2$
A_3	8	A_1	FF(4)	N/A	12.000,00	$W_3; W_4; W_5; W_6$
A_4	4	$A_2; A_3$	FS(0); FS(0)	20	6.500,00	$W_2; W_6$
A_5	12	A_1	FS(0)	N/A	15.000,00	$W_7; W_8; W_9$
A_6	15	A_5	SS(2)	N/A	13.250,00	$W_8; W_{10}$
A_7	7	$A_4; A_6$	FS(0); FS(0)	N/A	7.750,00	$W_1; W_2; W_3$

To ensure comparability of the results and performances of the chatbots, the terminology of the task was uniquely structured and presented to the chatbots in the same form and order.

2.1 Research examples

The second step was to choose examples from the relevant literature for testing the chatbots. The first example (E1), with eleven generic activities sequentially connected with finish-start (FS) connections, with no resource limitations, and without any time lags among the activities (see Table 1), was initially presented in the literature (Hajdu, 2023). While the author in that study had sought the project’s duration, the authors in this study have presented more tasks to the chatbots and compared the results.

The second example (E2) has seven generic activities, with the connections among the activities as finish-start (FS), start-start (SS), and finish-finish (FF) with delays, given the early start of one activity, given the costs of all the activities, and given a pool of ten workers assigned to each activity (see Table 2) was initially presented in the literature (Radujković et al., 2012).

2.2 Planning tasks

In order to answer the research questions according to the examples, ten standard project planning tasks were put in front of chatbots:

- T1 - calculation of the durations of projects E1 and E2;
- T2 - solving problem E1 with sequenced activities;
- T3 - solving problem E2 with parallel connections;
- T4 - calculation of the activities' free (FS_i) and total slacks (TS_i) for E1 and E2;
- T5 - determine the critical paths of projects E1 and E2;
- T6 - determine project's E2 cost significant activities;
- T7 - determine whether there was an overallocation of workers in project E2;
- T8 - providing the solution of the overallocation problem by extending project E2's deadline;
- T9 - providing the solution of the overallocation problem by adding workers to project E2;
- T10 - creation of a PS software-compatible document.

2.3 AI driven chatbots

Based on the findings in the previous studies and research questions, the AI-driven chatbots were chosen. Upon the findings and results presented in the literature (Gupta et al., 2023; Abu-Haifa, et al., 2024; Lee and Huang, 2024; Chen, 2024) four chatbots were selected to be tested in this study, as presented in Table 3:

Tab. 3 Chatbot versions and model names included in the study

Chatbot	Chatbot Version / Model Name	Access Mode	Reference
ChatGPT	GPT-4o (default)	web; free with usage limit	(OpenAI, 2024)
Microsoft Copilot	GPT-4o Think Deeper (OpenAI o1 reasoning model)	web; Microsoft account required; free with unlimited use of advanced features after Feb 25	(Microsoft, 2025)
Google Gemini	Gemini 2.0 Flash (default)	web; free with file uploads and integration of Google services	(Google, 2025)
DeepSeek	DeepSeek-R1 (reasoning model)	web; login account, no paid tier existed	(DeepSeek AI, 2025)

The chatbots selected are categorized as Large Language Models (LLMs). These models use advanced transformer architectures to process and generate human-like text based on extensive datasets. It is important to note that all the chatbots selected were in non-charged and educational versions with the authors' registrations. Both experiments were conducted in February 2025, using the same educational account on a standard PC Intel(R) Core(TM) i7-8700 CPU @ 3.20GHz.

2.4 Data export to PS software

The last step in the study was the data export of the E1 and E2 projects from the chatbots for further analysis in standard PS software, i.e., Microsoft Project version 2007 and 2021. It is important to note that the chatbots were not required to create a .mpp file but rather to create a document compatible with and open by Microsoft Project 2007 or 2021.

3 RESULTS AND DISCUSSION

The first task for the chatbots analyzed was to determine the duration of the projects. While ChatGPT, Copilot, and DeepSeek had no problems determining the durations of the projects for the sequenced activities in E1, Gemini had calculation errors that had to be corrected by the user. Regarding the parallel connections among the activities, ChatGPT and DeepSeek provided a correct solution without any interventions. At the same time, Copilot had an error, and the user had to remind it of the early start of activity A₄. As for the Gemini calculations of the duration of project E2, it only provided the correct duration after the user's corrections. The correct duration of the project for E1 is 28 days; the critical path is closed by the activities A₁→ A₅→ A₂→ A₃→ A₄→ A₇→A₁₁; other expected output parameters are given in Table 4:

Tab. 4 Example 1 (E1) expected output parameters

Activity A _i	ES _i [cons. day]	EF _i [cons. day]	LS _i [cons. day]	LF _i [cons. day]	TS _i [day]	FS _i [day]
A ₁	0	5	0	5	0	0
A ₂	9	14	9	14	0	0
A ₃	14	17	14	17	0	0
A ₄	17	23	17	23	0	0
A ₅	5	9	5	9	0	0
A ₆	14	17	20	23	6	6
A ₇	23	28	23	28	0	0
A ₈	5	11	11	17	6	0
A ₉	11	14	17	20	6	0
A ₁₀	14	18	24	28	10	10
A ₁₁	28	28	28	28	0	0

* ES denotes early start, EF early finish; LS late start; LF late finish; TS total slack; FS free slack.

The correct project duration for E2 is 34 days; the critical path is closed by the activities A1→ A5→ A6→ A7; the other expected output parameters are given in Table 5. In recognizing the critical paths for E1 and E2, Copilot and DeepSeek provided the correct solutions immediately, while Gemini and ChatGPT had to be corrected by the user in the case of E2.

Tab. 5 Example 2 (E2) expected output parameters

Activity A_i	TS_i [day]	FS_i [day]	Cost Significant Activity	Overallocated Workers
A_1	0	0	No	--
A_2	10	7	No	$A_1 \rightarrow W_1; W_2$
A_3	9	6	Yes	$A_1 \rightarrow W_3$
A_4	3	3	No	--
A_5	0	0	Yes	--
A_6	0	0	Yes	$A_5 \rightarrow W_8$
A_7	0	0	No	--

* TS denotes total slack; FS free slack.

ChatGPT had difficulties in determining the total and free slacks for project E2. Even though it correctly stated the difference between critical and non-critical activities and confirmed the given early start of activity A_4 on the 20th day of the project, it calculated the slacks with errors. Despite the user's corrections, it went into a loop of correcting one parameter and neglecting the given ES4, as shown in Table 6. By iteration 5, ChatGPT did not independently provide the correct calculation of the free and total slacks.

Tab. 6 Iterative solutions of the calculations of slacks for project E2 by ChatGPT

Activity A_i	Initial solution		1 st iteration		2 nd iteration		3 rd iteration		4 th iteration		5 th iteration	
	TS_i [day]	FS_i [day]	TS_i [day]	FS_i [day]	TS_i [day]	FS_i [day]	TS_i [day]	FS_i [day]	TS_i [day]	FS_i [day]	TS_i [day]	FS_i [day]
A_1	5	5	0	0	5	0	0	0	0	0	0	0
A_2	10	4	10	4	10	4	10	4	10	7	10	4
A_3	9	1	9	1	9	1	9	1	9	1	9	1
A_4	5	5	5	5	9	5	9	5	9	5	9	5
A_5	5	3	0	0	5	3	5	3	5	3	5	3
A_6	0	0	0	0	0	0	0	0	0	0	0	0
A_7	0	0	0	0	0	0	0	0	0	0	0	0

Gemini had similar problems, but with the slacks for E1, as shown in Table 7. By the 7th iteration, it could be concluded that Gemini could not independently provide us with the correct total slacks.

Tab. 7 Iterative solutions of calculations of total slacks TS_i [day] for project E1 by Gemini

Activity A_i	Initial solution	1 st iteration	2 nd iteration	3 rd iteration	4 th iteration	5 th iteration	6 th iteration	7 th iteration
A_1	0	0	0	0	0	0	0	0
A_2	4	4	4	4	0	0	0	0
A_3	4	4	4	4	0	0	0	0
A_4	4	4	4	4	0	0	0	0
A_5	0	0	0	0	0	0	0	0
A_6	3	3	3	3	3	0	0	5
A_7	4	4	4	0	0	0	0	0
A_8	1	1	1	1	1	5	5	5
A_9	1	1	1	1	1	5	5	5
A_{10}	1	1	1	1	1	5	5	5
A_{11}	4	4	0	0	0	0	0	0

All the chatbots analyzed provided correct feedback regarding the cost-significant activities, but only after the user additionally explained the cost significance as a cost equal to or higher than the average value of the total costs

in the project. This was the case of the HMC challenge that can be noted in this study. This confirms that HMC in project planning is not a discrete passive data exchange, but rather a dynamic and verification-based relationship. The chatbots are still prone to errors; hence, the communication process requires an experienced user to bridge the gap between the machine's rapid responses and the rigid, logical requirements of a construction schedule.

As shown in Table 5, this example generates an overallocation problem for workers: W1, W2, W3, and

W8 due to the parallel activities and 100 % of the workers' simultaneous engagement in those parallel activities. This problem can be solved by extending the project's overall duration while keeping the same number of workers and their assignments on the activities, whilst the increased duration of project E2 is 44 days (Figure 2), or by adding the required four workers to the activities with overallocated resources, i.e., A1 or A2, A1 or A3, A5 or A6, and keeping the original deadline of the project.

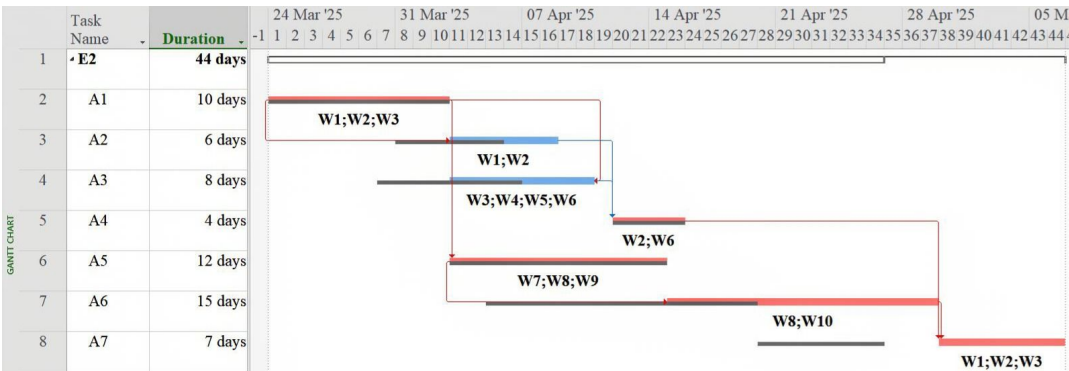


Fig. 2 Gant chart of E2 with levelled workers' allocation and extended deadline of the project

Microsoft Copilot had problems with solving the overallocation problem, despite the interventions by the users, had, as shown in Figure 3. It claims that it spots the

overallocated workers, but when asked to solve the problem by extending the project's duration or adding more workers, it claimed that there was no overallocation problem.

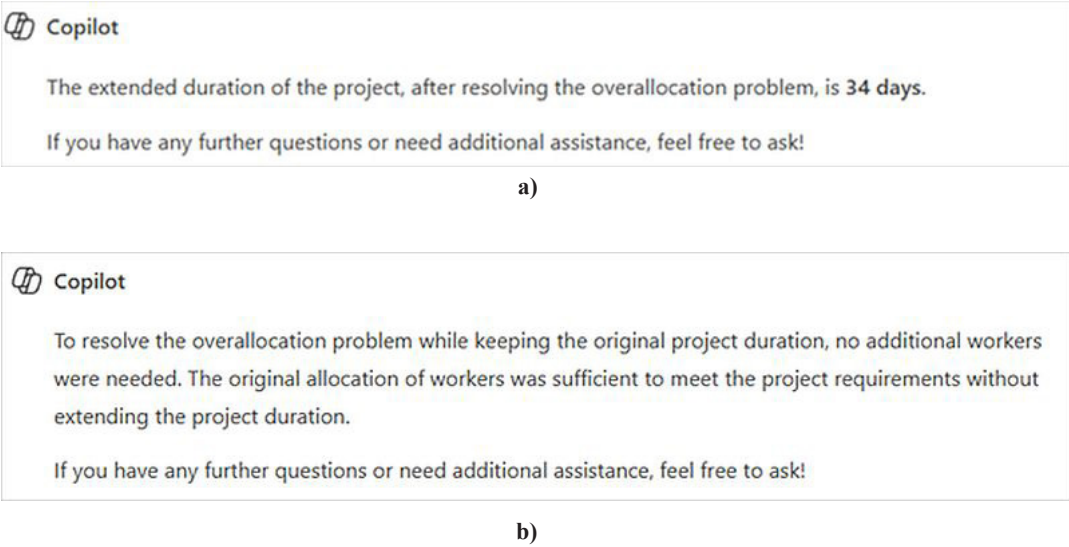


Fig. 3 Copilot's answers for solving the overallocation problems for E2: a) answer for solving problem by extending the project's duration; b) answer for solving the problem by adding more workers

The other three chatbots, i.e., ChatGPT, Gemini, and DeepSeek, solved the overallocation problem by utilizing both scenarios, i.e., extending the project's duration and adding the required four workers but keeping the project's deadline. As for task T10, it is noteworthy to state that ChatGPT provided a file in the .xlsx format, which is compatible with Microsoft

Project; Copilot created a .xlsx file; Gemini created a Microsoft 365 Table document; and DeepSeek provided files in .csv format, which is compatible with Microsoft Project. The overall performances in solving the planning tasks are given in Table 8.

Tab. 8 Comparison of the results gained by the chatbots analyzed

#	Planning Task	ChatGPT	Copilot	Gemini	DeepSeek
T1	Duration of the Project	✓	✓	✓	✓
T2	Solving Problem with Sequenced Activities	✓	✓	✓	✓
T3	Solving Problem with Parallel Connections	✓	✓	✓	✓
T4	Activity Free and Total Slack	✗	✓	✗	✓
T5	Project Critical Path	✓	✓	✓	✓
T6	Cost Significant Activities	✓	✓	✓	✓
T7	Determination of Overallocation	✓	✓	✓	✓
T8	Solution to Overallocation by Extending Deadline	✓	✗	✓	✓
T9	Solution to Overallocation by Adding Workers	✓	✗	✓	✓
T10	Creation of PS Tools Compatible Document	✓	✓	✓	✓
Legend					
✓	correct solution gained without any necessary interventions by the user				
✓	correct solution gained with a necessary additional explanation by the user				
✓	correct solution gained with necessary corrections by the user				
✗	incorrect solution despite necessary interventions and corrections by the user				

While this study utilized small-scale literature-based examples with 7 to 11 activities, scaling these tasks to real-world, large-scale construction projects introduces significant complexities. The HMC 'unwariness of errors' observed and the tendency for chatbots to enter 'error loops' when correcting slacks suggest that in a project with thousands of activities, logical inconsistencies could propagate undetected, leading to critical scheduling failures. Furthermore, the current reliance on user experience and the need to manually audit and verify every AI-generated output may become a bottleneck as the complexity of project increases, which could potentially negate the efficiency gains of AI automation. Future research should evaluate whether the full versions of these chatbots can maintain logical integrity when managing high-density, dynamic data exchanges and the complex constraints inherent in real-world scheduling problems, such as time-cost trade-offs or time-cost-resource trade-offs.

4 CONCLUSIONS

AI-driven chatbots are increasingly used in the construction sector to improve safety compliance, project management, and communications. Construction 4.0 drivers are pushing towards the integrated utilization of AI for automated construction processes. Hence, it is anticipated that the construction industry will soon embrace such technologies to solve everyday tasks. In this study, the authors tested frequently highlighted AI-driven chatbots for solving standard project planning tasks using small-scale literature-based examples. In general, the results showed positive outcomes for all the chatbots tested. Their performances were, in most cases, beyond expectations. The results were gained in seconds and were methodologically clear, with step-by-step calculations and recommendations or associations. However, some calculation difficulties and

HMC issues were noticed, and the user's explanations were required. The results reveal that, in project planning for Construction 4.0, HMC currently operates in a verification-based mode rather than a fully autonomous one. The primary challenge is the machine's lack of unawareness of errors, thereby requiring the human user to be experienced and capable of auditing every step of the calculations to ensure logical integrity. Communication hurdles can also manifest as semantic misalignment, where chatbots require explicit human intervention to define domain-specific technical parameters, as well as misinterpretations, where the AI prioritizes the literal completion of the task over the resource efficiency required in practice. Ultimately, these HMC issues demonstrate that while chatbots are responsive, their effectiveness is limited by a lack of independent reliability in the complex, multi-turn logical tasks, that are characterized by large construction projects. According to the results, the main research questions can be answered as follows:

Answer → RQ1: the chatbots analyzed can calculate and determine the duration of a project regardless of the connections among the activities. It was noted that the chatbots ChatGPT and Gemini had trouble with calculating free and total slacks, while Copilot and DeepSeek provided correct results only after the user's intervention. Since the chatbots had problems with calculating the slacks, the critical path was accurate only after the user's intervention for calculating the slacks.

Answer → RQ2: All the chatbots analyzed provided correct feedback regarding the cost-significant activities. It is important to note that an additional explanation about the definition of the cost significance was necessary.

Answer → RQ3: With one minor correction in the case of Copilot and Gemini, the chatbots determined the problem

of the overallocation of workers. However, while ChatGPT, Gemini, and DeepSeek resolved the overallocation problem by extending the project's duration, Copilot could not solve the problem by extending the deadline or by adding the required workers. ChatGPT provided a solution without any additional explanation or interventions by the user for either approach. In contrast, Gemini and DeepSeek provided initial solutions by adding more workers than minimally required to solve the problem, which could be characterized as an HMC misinterpreted issue.

Answer → RQ4: While all the chatbots tested showed high responsiveness and delivered results within seconds, their practical performance revealed differences in their reliability and logical consistency. DeepSeek demonstrated the highest overall reliability; it consistently provided accurate durations of projects and critical paths with minimal user intervention and successfully resolved resource overallocation issues. In contrast, Copilot demonstrated the most significant functional failures, i.e., an inability to solve resource-leveling problems. Despite initially identifying an overallocation, it paradoxically denied the problem's existence when asked to provide a solution. ChatGPT and Gemini occupied a middle tier of reliability, as both were prone to calculation errors regarding time slacks and often required iterative corrections or direct user intervention to achieve accurate results. Therefore, while the speed of the response was uniform, the differences in autonomous accuracy and logical integrity are substantial, which indicates that certain chatbots are currently far more dependable for construction project planning than others.

The autonomy of AI being able to solve planning tasks, even the small problems used in this study, has not yet been reached, but there are clear and positive signs that it might be in the near future. The development of new AI algorithms, their transformation into multimodal communication models, and the galloping sophistication of enhancements are yet to be seen in the full potential of utilization of the AI for solving project scheduling problems. Even though DeepSeek slightly outperformed other chatbots in this study, it cannot be considered the ultimate solution due to the aforementioned advances in AI algorithms. The development of scheduling-focused AI algorithms, such as PMI Infinity, which partially or even completely utilize one of the chatbots is a logical path towards a more efficient AI-powered tool. In future research, chatbots should be tested on real-scale planning and time-cost-trade-off problems with full versions of the chatbots tested. The enthusiastic anticipation that AI chatbots are “teachers”, seems distant at this point. In this context, chatbots

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