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Integrating AI Tools in Construction Project Planning Education: Impact on Schedule Acceleration

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In construction project planning courses, mastering effective schedule compression strategies is essential for preparing students for industry challenges. However, the role of AI tools in this educational context remains underexplored. This study examines the impact of AI-assisted tools, specifically ChatGPT, on enhancing schedule acceleration skills among Construction Management (CM) and Architecture students. The research investigates how using AI tools can improve students' ability to analyze construction schedules, identify optimal acceleration techniques, and implement effective approaches. Additionally, the study explores potential correlations between students' writing and mathematical skills and their effectiveness in utilizing ChatGPT for project scheduling. By comparing the performance of the two student groups, the research seeks to reveal how academic proficiency in math and writing influences their ability to optimize schedules using AI-driven methods. Most students demonstrated a solid understanding of using AI to identify schedule bottlenecks and accelerate projects, though engagement depth varied. Higher-scoring students critically evaluated suggestions, while lower-scoring students missed opportunities for deeper analysis. The findings provide insights into integrating AI tools in construction education, emphasizing the importance of cautious implementation to enhance students' readiness for real-world applications and ensure meaningful outcomes.

Key Words: Construction Planning, Scheduling, Project Acceleration, AI Tools

Introduction

Artificial Intelligence (AI) is revolutionizing the landscape of higher education, impacting various facets including teaching, learning, administration, and student support. AI's integration in higher education promises to enhance efficiency, improve personalized learning experiences, and foster innovation (Bozkurt et al., 2021; Chu et al., 2022; Laupichler et al., 2022), but it also raises ethical, social, and practical concerns that require attention development (Bearman et al., 2022; Zhang and Aslan, 2021). One of the primary areas where AI is making an impact is in pedagogical innovation. AI-powered systems such as Intelligent Tutoring Systems (ITS) and adaptive learning platforms enable personalized learning, allowing students to progress at their own pace while receiving real-time feedback. Research underscores AI's ability to boost student engagement, improve learning outcomes, and make education more accessible, particularly in distance learning and online education settings (Kuleto et al., 2021). For instance, AI tools can help create tailored learning environments that adapt to the needs of individual learners, thus improving both student satisfaction and academic performance (Kochmar et al., 2022). The integration of AI also extends to educators' professional development, where machine learning tools analyze student feedback to refine teaching strategies. AI can help educators adjust their teaching methods to better suit the learning styles of their students, thus improving the overall quality of instruction (Al-Zahrani and Alasmari, 2024). However, educators often require additional support and training to effectively utilize AI tools in their teaching, highlighting the need for ongoing professional development and the creation of AI literacy programs for instructors. The primary objective of this research is to examine the effectiveness of AI-assisted tools, like ChatGPT, in enhancing students' understanding of construction schedule analysis and project acceleration, while also exploring the correlation between students' writing and mathematical skills and their ability to optimize schedules using AI-driven techniques.

Background and Motivation

In construction projects, contractors often need to accelerate timelines to meet deadlines or adapt to changes without altering the overall scope of work. Schedule acceleration, or compression, involves reducing project duration while maintaining quality standards. Key questions include which acceleration method is most effective and how much acceleration is feasible. Common techniques, such as fast-tracking and crashing, have different impacts on cost and project dynamics, influencing both direct and indirect expenses (Yadollahi et al, 2020). Choosing the right method requires careful consideration of factors like cost, time, risks, and contractual obligations. Early planning and decision-making are crucial for optimal results. Integrating AI into construction project planning can aid students in identifying and selecting effective techniques (Uddin et. al, 2024). AI tools provide quick access to various strategies, allowing students to analyze scenarios and understand the effects of each approach. By offering insights based on project-specific factors, AI helps students make more informed decisions, improving the selection of tailored strategies (Nwankwo et. al, 2024).

Use of AI in Education and Construction Management

Researchers have explored AI's role in enhancing education and construction management. AI technologies, particularly in learning analytics, offer valuable insights by analyzing large sets of student data, helping educators identify at-risk students and provide personalized support (Holmes et al., 2021; Pardamean et al., 2022). AI can detect patterns in student behavior, allowing for timely interventions and improved academic outcomes (Singh and Hiran, 2022). AI-based tools assist in automated grading and provide feedback through Natural Language Processing systems, though concerns about fairness and reliability persist (McNulty, 2023). In construction management, AI technologies like Artificial Neural Networks address challenges such as cost estimation and safety management (Chen et al., 2021). Nwankwo et al. (2024) demonstrated AI's potential in optimizing project scheduling and risk management, leading to improved efficiency and savings. AI tools like ChatGPT have also been integrated into education for construction-related fields. Uddin et al. (2023) found a 25% improvement in students' hazard recognition skills after using ChatGPT, suggesting its potential to enhance practical safety knowledge. However, AI tools have limitations; biases in training datasets and risks of incorrect AI-generated information remain concerns (Aluga, 2023). Project scheduling involves coordinating tasks, resources, and timelines to achieve efficient construction within budget. While compressing schedules can reduce indirect costs by shortening project duration, direct costs often increase due to intensified resource use, requiring a balance to prevent cost overruns (Yadollahi et al., 2020). Techniques like crashing (adding resources) and fast-tracking (overlapping tasks) are commonly used, but their application requires careful analysis of project-specific factors like cost, risk, and resource availability. Poor implementation can lead to increased costs and risks, highlighting the need for strategic planning. This research builds on prior studies by assessing ChatGPT's role in improving schedule compression strategies in construction education. Architecture and CM students used AI-generated suggestions in Microsoft Project to optimize multi-phased project schedules, evaluating the impact on their learning and project management skills.

Research Objectives

The primary objectives of this research are to assess the effectiveness of AI-assisted tools in enhancing students' abilities to develop schedule acceleration strategies within a construction project planning course. Additionally, the study aims to compare the performance of Architecture and Construction Management students in optimizing project schedules using AI tools. A further objective is to explore the relationship between the improvements in students' schedule optimization skills and their academic performance in areas such as mathematics and writing. We are investigating the students' performance in three key math courses, Algebra, Trigonometry, and Calculus, and how these skills relate to their ability to solve scheduling problems using AI. Furthermore, we are exploring whether there is a connection between students' performance in Writing Studies and their ChatGPT proficiency. Students were asked to list their grades for other courses as part of the assignment. They were notified that this data would be used solely for research purposes, ensuring anonymity and confidentiality by processing the data blindly without mentioning their names.

Research Methodology

The study involved 22 students, including 7 from Architecture and 15 from Construction Management (CM), tasked with optimizing a construction project schedule using Microsoft Project and ChatGPT guidance. The project focused on key phases such as pre-construction, site preparation, structural work, and interior finishing. CM and Architecture students, primarily juniors and seniors with one to two years of industry internship experience, attended the course together in the same section. Assignments were conducted online via the MyLearning platform, powered by Desire2Learn Brightspace, and collected with set due dates. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS). A paired t-test evaluated whether improvements in schedule optimization after ChatGPT use were statistically significant by comparing pre- and post-optimization performance. This method treated each student as their own control, minimizing variability and isolating the AI's impact. Correlation analysis explored links between students' post-ChatGPT performance and academic backgrounds in subjects like math and writing. Pearson and Spearman correlations assessed whether stronger skills in these areas correlated with higher proficiency in applying AI for scheduling tasks. These methods provided a robust framework for analyzing the effectiveness of ChatGPT in improving student performance in construction project scheduling.

Course Context and Homework Design

The "Construction Project Planning" course focuses on developing advanced scheduling skills for managing multi-phase construction projects. Students learn to create and analyze detailed schedules using industry-standard software, emphasizing techniques like resource allocation, cost loading, and schedule crashing to optimize timelines. The course provides practical experience in scheduling, including tools like logic diagrams and bar charts. Students were tasked with optimizing a schedule for a given project. The project involved optimizing the schedule of a small, one-story commercial building to be constructed in Alfred on the site of an existing small-frame structure. The building was 30 by 60 feet in plan, with concrete block exterior and interior walls, a roof constructed of bar joists covered with a steel roof deck, rigid insulation, and built-up roofing. The ceiling consisted of suspended acoustical tile, and the floor was a concrete slab on grade with an asphalt tile finish. All the interior walls were finished with paint. The assignment aimed to enhance their understanding of schedule analysis and acceleration strategies through manual and AI-assisted approaches. The assignment assessed students' abilities to optimize and accelerate schedules, with performance evaluated before and after AI integration. Grades for each of the three sections (A, B, C) were compared using a paired t-test to analyze the effectiveness of AI tools like ChatGPT in improving schedule optimization skills. Table 1 shows the rubric implemented for grading the two parts of this assignment. The assignment was divided into two parts:

Table 1. Implemented rubrics for grading Part 1 and Part 2 of the homework assignments

Excellent (E)	Good (G)	Satisfactory (S)	Need Improvement (N)	Poor (P)
The analysis is thorough, demonstrating a deep understanding of the schedule. Observations are articulated, including the identification of the critical path, bottlenecks, and opportunities for acceleration.	The analysis shows a strong understanding of the schedule. Most key elements, such as the critical path and potential bottlenecks, are identified and discussed.	The analysis provides a basic understanding of the schedule. Some key elements are mentioned, but the discussion may lack depth or miss important aspects.	The analysis is superficial or incomplete, with few key observations. Important aspects of the schedule may be overlooked, and the discussion is not well-developed.	The analysis is minimal or incorrect, showing little to no understanding of the schedule. Key observations are missing or poorly explained.

Part 1 (Schedule analysis and acceleration strategy): Students were provided with the initial project schedule and required to:

- Section A: Review and analyze the schedule, identifying critical tasks, bottlenecks, and opportunities for schedule compression.
- Section B: Select and justify an appropriate acceleration technique based on their analysis of task dependencies, resource availability, and critical path.
- Section C: Apply the chosen acceleration method using MS Project, adjusting the schedule as needed, and evaluating the impact on project cost, time, resource allocation, and risk.

Part 2 (AI-assisted schedule optimization): Students revisited their original schedule and used ChatGPT to enhance their understanding of project acceleration techniques. They were asked to:

- Section A: Use ChatGPT to gain insights into their initial analysis, decision-making, and optimization strategies.
- Section B: Reflect on the lessons learned using AI-tool, comparing the results and insights with their initial, non-AI-driven approach.
- Section C: Provide a detailed analysis of how AI improved or altered their approach to schedule compression and discuss the impact on both cost and timeline in the final schedule.

Results and Analysis

The students were required to assess the critical path, identify potential bottlenecks, and suggest areas for improvement without the use of ChatGPT. Students analyzed the structure of the schedule and provided feedback on the sequencing of tasks, resource allocation, and potential risks that could delay the project. The results of grades for the two parts are presented in Figure 1.

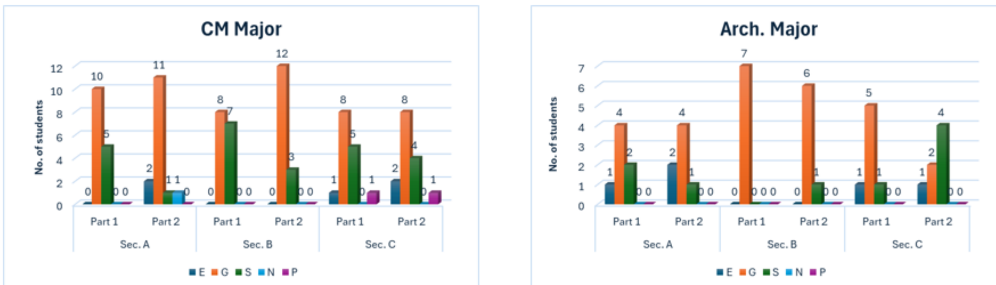

Figure 1. Assessment of results before (Part 1) and after (Part 2) integration of AI.

Evaluation of Project Analysis (Section A, Before Using ChatGPT)

The results from this section revealed varying levels of proficiency. About 73% of the students showed a good understanding of the project's critical path, identifying key tasks such as foundation work, roof construction, and MEP systems as critical areas where delays could significantly impact the timeline. These students highlighted bottlenecks and dependencies but missed more detailed acceleration strategies. About 27% of the students provided satisfactory analyses, recognizing the basic structure of the project but lacking depth in identifying opportunities for schedule optimization.

Evaluation of Acceleration Technique Selection (Section B, Before Using ChatGPT)

In Section B of the homework, students selected schedule acceleration techniques based on their project schedule analysis. Nearly half (45%) opted for fast-tracking, focusing on overlapping non-dependent tasks, such as interior finishing and systems installation, to shorten timelines without significant resource increases. Another 30% chose crashing, emphasizing additional resources for critical tasks like site preparation and foundation work. While this approach reduced durations for labor-intensive tasks, some students overlooked potential quality and safety impacts of increased labor. The remaining 25% proposed mixed strategies, combining fast-tracking and crashing by overlapping tasks in certain phases and increasing labor in others. However, their rationale often lacked depth, with limited explanations of how the methods would complement each other. Some students missed discussing trade-offs, such as increased costs or coordination challenges. Overall, the exercise highlighted varying levels of understanding in applying schedule acceleration techniques effectively.

Application of Acceleration Technique (Section C, Before Using ChatGPT)

In Section C of the homework, students applied their chosen acceleration technique to a project schedule using Microsoft Project. They adjusted tasks, dependencies, and resources, then analyzed the effects on the timeline, costs, and risks. The goal was to evaluate how effectively their technique shortened the project duration. About 40% of students successfully applied their techniques, such as fast-tracking or crashing, and showed a clear understanding of how these changes impacted cost and schedule. They managed to shorten the timeline by an average of 5–7 days, acknowledging trade-offs like potential quality issues or coordination challenges. Their analyses were well-rounded, weighing risks and benefits. Another 35% achieved moderate success, reducing the timeline but with less precise adjustments. Some failed to thoroughly analyze costs or consider risks, leading to less refined outcomes. Lastly, 25% struggled to implement their techniques effectively, resulting in minimal impact or unrealistic adjustments. Their analyses lacked depth, often overlooking critical cost implications and resource dependencies. Overall, while most students managed to make reasonable schedule adjustments, many did not fully explore the cost and risk implications, with only a few providing a detailed approach to mitigating potential risks associated with fast-tracking or crashing.

Effectiveness of AI Tools in Enhancing Students' Schedule Compression Skills

After utilizing ChatGPT to analyze the project schedules, students gained new perspectives and deeper insights into the critical components of the projects. Many students found that ChatGPT was effective in highlighting key phases and tasks, such as pre-construction, structural work, and interior finishing. The AI provided detailed overviews that helped students identify bottlenecks they had previously overlooked, such as delays in MEP installation, overlapping resource needs, and potential issues with task dependencies. A recurring observation was how ChatGPT emphasized the importance of resource optimization and task prioritization, leading to better-informed decisions regarding acceleration techniques. While most students appreciated the AI’s ability to refine their understanding, a few found its suggestions simplistic or not sufficiently tailored to the project context.

Section A: Analysis Summary

A small group of students, comprising 15%, demonstrated an excellent understanding of how AI enhanced their analysis. They provided insightful comparisons between their original assessments and the AI-generated insights, effectively highlighting new learnings and showing how these contributed to refining their understanding of the project. Most of the students, accounting for 70%, successfully used AI to identify key insights and improvements. Their reflections were clear and logical, though some lacked depth or missed a few details that could have made their analysis more comprehensive. Around 10% of the students demonstrated a satisfactory use of AI, which led to some improvements. While their reflections were present, they often lacked detail or a thorough exploration of how AI insights changed their perspective. A smaller portion, 5%, showed a need for improvement in engaging with AI insights. Their comparisons were superficial, and the explanations lacked depth and clarity, reflecting minimal new learning.

Section B: Selection of Acceleration Techniques

Among the students, 5% received an excellent rating, demonstrating a strong grasp of acceleration techniques with well-justified decisions and thoughtful rationales. The majority, representing 86%, effectively applied the suggestions using logical reasoning, though their analyses often lacked deeper exploration of trade-offs. About 9% showed a satisfactory understanding but missed opportunities to engage with the complexities of the techniques. A significant portion of students identified fast-tracking as a cost-effective method to shorten timelines while acknowledging potential coordination challenges. Some students revised their initial strategies, adopting a balanced approach that combined fast-tracking for non-critical tasks with crashing for critical ones. However, a few felt that the AI's recommendations were too generic, offering limited depth for addressing more complex scenarios.

Section C: Implementation and Adjustment of Techniques

A small group of students, accounting for 14%, demonstrated excellent application by making significant adjustments and providing thoughtful analyses of cost impacts, trade-offs, and risks. Another 36% used the inputs effectively to adjust their schedules, though their discussions lacked depth on potential risks. About 41% showed a satisfactory understanding, with limited reflections on the impacts and trade-offs of their adjustments. A smaller portion, 9%, struggled with implementation, resulting in unclear and disorganized explanations. Many students observed shortened timelines through strategies like starting MEP installations earlier or overlapping finishing tasks, achieving time savings without significant cost increases. Some encountered challenges when theoretical approaches clashed with real-world constraints, such as resource availability and task sequencing. While a few felt the recommendations were overly rigid, others appreciated minor adjustments, like reducing curing times, that delivered meaningful improvements.

Summary of Paired t-Test Results

In Table 2, the t-statistic measures the size of the difference relative to the variation in our sample data, and d_f, degrees of freedom, used to determine the critical value of the t-distribution for the test. If the p-value from the t-test (Sig 2-tailed) is less than 0.05, the difference between the two groups' means is statistically significant. For Pair 1 (A1 - A2), there was a slight decrease of 1.364 points, with a t-value of -1.821 and a p-value of 0.083. Since the p-value is above the significance threshold of 0.05, the change is not statistically significant, and the 95% confidence interval includes 0, indicating no strong evidence of a meaningful difference. Pair 2 (B1 - B2) showed a more pronounced decrease of 2.727 points, with a t-value of -2.324 and a p-value of 0.030, which is statistically significant. The confidence interval (-5.168 to -0.287) does not include 0, confirming that the decrease is meaningful. For Pair 3 (C1 - C2), there was no change, with a mean difference of 0.0, a t-value of 0.0, and a p-value of 1.0, showing no significance. The wide confidence interval (-5.299 to 5.299) further supports that there is no meaningful difference. These findings indicate that only Pair 2 showed a statistically significant change, suggesting that a real difference exists between B1 and B2, while Pairs 1 and 3 did not show strong evidence of meaningful differences.

Table 2. Paired sample t-test results comparing performance metrics before and after

		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	d_f	Sig. (2-taile
					Lower	Upper			
Pair 1	A1 - A2	-1.364	3.513	0.749	-2.921	0.194	-1.821	21	0.08
Pair 2	B1 - B2	-2.727	5.505	1.174	-5.168	-0.287	-2.324	21	0.03
Pair 3	C1 - C2	0.000	11.952	2.548	-5.299	5.299	0.000	21	1.00
Pair 4	Total 1 – Total 2	-3.636	16.197	3.453	-10.818	3.545	-1.053	21	0.30

Comparison of Architecture vs. Construction Management Students

The t-tests for Total 2, A2, B2, and C2 all indicate no significant differences between the groups, as their p-values exceed the 0.05 threshold (Table 3). Total 2 has a mean difference of -4.286, but the p-value of 0.551 suggests this difference is not statistically significant; indicating that any observed mean differences were not strong enough to suggest meaningful discrepancies between the groups.

Table 3. Paired sample t-test results comparing performance metrics between two groups

		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of th Difference**	
									Lower	**Upp**
Total2	Equal variances assumed	0.162	0.69	-0.61	20	0.551	-4.286	7.07	-19.03	10.4
	Equal variances not assumed			-0.68	16.04	0.504	-4.286	6.271	-17.58	9.00
	Equal variances not assumed			-1.45	17.82	0.164	-4.667	3.217	-11.43	2.09

Table 4. Correlation analysis between total scores and math and writing performance

Correlations				**Correlations**			
		Total2	Math			Total2	Writing
Total2	Pearson Correlation	1	0.219	Total2	Pearson Correlation	1	0.047
	Sig. (2-tailed)		0.416		Sig. (2-tailed)		0.879
	N	22	16		N	22	13
Math	Pearson Correlation	0.219	1	Writing	Pearson Correlation	0.047	1
	Sig. (2-tailed)	0.416			Sig. (2-tailed)	0.879	
	N	16	16		N	13	13

Correlation Between Student Performance and Academic Skills

For the correlation between Total 2 and Math (Table 4), the Pearson correlation coefficient is 0.219, indicating a weak positive relationship. However, the p-value of 0.416 suggests that this correlation is not statistically significant, meaning there is no strong evidence to confirm a meaningful association between Total 2 and Math. However, the correlation between Math and B2 shows a moderate positive relationship, with a Pearson correlation of 0.533. This correlation is statistically significant, as indicated by a p-value of 0.034, suggesting that higher Math scores are associated with higher B2 scores. Both variables have 16 paired observations, reinforcing the reliability of this result. Lastly, the correlation between Total 2 and Writing is extremely weak, with a coefficient of 0.047. The high p-value of 0.879 indicates no statistical significance, meaning there is no meaningful linear association between these two variables. The sample sizes for Total 2 and Writing are 22 and 13, respectively. Overall, only the correlation between Math and B2 is statistically significant, while the others do not show strong or meaningful relationships.

Conclusion, Limitations and Future Research Directions

The paired t-test analysis for Pair 4 indicates a mean decrease of 3.636 points, with a t-value of -1.053 and a p-value of 0.304. This suggests that the difference between the total scores before and after is relatively small and not statistically significant, as the p-value is above the 0.05 threshold. The 95% confidence interval for this pair also includes 0, further confirming that there is no meaningful difference. Among all the analyzed pairs, only Pair 2 showed a statistically significant decrease, indicating a meaningful change. The other pairs, including Pair 4, did not display statistically significant differences, suggesting no strong evidence of notable changes in those cases. In conclusion, while AI holds great promise for transforming higher education, its implementation must be approached with caution. Most students demonstrated a basic to good understanding of how AI could enhance their project analysis. They found value in using AI to identify schedule bottlenecks, accelerate tasks, and refine their approaches. However, there were areas where deeper engagement and more explanations would have led to stronger submissions. Particularly, students who scored higher provided insightful comparisons, and thoroughly discussed the pros and cons of applying AI suggestions. Those who scored lower tended to provide more superficial reflections, missing opportunities to dive into detailed analysis or failing to apply AI recommendations effectively.

This study offered valuable insights into schedule compression strategies and their impact on construction project timelines, but several limitations should be noted. The data was limited to projects within a specific region, affecting the generalizability of results, as practices may vary across different regions or sectors. The study relied on student assumptions during schedule optimization exercises, which may not fully capture real-world complexities like unforeseen site conditions, labor availability, and supply chain issues, potentially simplifying outcomes. Additionally, the focus on student performance did not fully account for external factors such as prior work experience and familiarity with construction software, which may have influenced the results. Ethical concerns about AI use in education are also highlighted, including data privacy, algorithmic bias, and the risk of exacerbating inequalities (Bearman et al., 2022; Zhang and Aslan, 2021). Furthermore, the study did not investigate how students' engagement with digital tools outside the classroom, including potential use of AI tools, might have influenced their ability to effectively use scheduling software during the assignment. This aspect could be a significant factor in understanding their overall performance and outcomes. Future research should continue to explore the full scope of AI's capabilities in project planning, particularly in areas such as higher-order thinking skills, collaboration, and communication. In addition, research could benefit from a broader dataset and more comprehensive inclusion of real-world variables, as well as a deeper exploration of the technological tools available for schedule acceleration.

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