Advances in Engineering Education

2025: VOLUME 13 ISSUE 2

Looking Ahead: Lego Construction Scheduling: A Serious Game for Construction Planning and Risk Management Education

HAMAD ALJASSMI
UAE University

BABITHA PHILIP
UAE University

MOHAMMAD ISSAM YOUNES
UAE University

ABSTRACT

Construction planning is vital to civil engineering projects, involving task coordination, resource estimation, and risk assessment. Traditional educational methods in Engineering management courses frequently lack real-world feedback, hindering understanding of students. To bridge this gap, this study aims to propose an educational approach called "Lego Construction Scheduling" activity. Students simulate planning decisions for a 'Lego' project, which they then execute in class. This technique replicates the entire learning cycle in real-world building projects, allowing students to evaluate their actions and learn from the results. The rules and procedures of the "Lego Construction Scheduling" game are outlined. This study is expected to improve the understanding and implementation of building planning ideas, closing the gap between theory and reality. The "Lego Construction Scheduling" game will be an innovative educational tool in Construction Management courses to develop essential planning skills and better understand construction project management.

Key words: Construction scheduling, Educational game, Lego project

INTRODUCTION

In the construction industry, problem-solving skills have a substantial impact on project outcomes and career paths. Students gain structured expertise and industry-specific competencies by handling practical challenges drawn from real-world projects (Zhang et al., 2019). Integrating theoretical knowledge with practical skills through course assignments and e-learning tools can significantly enhance learning effectiveness in construction project planning (Tseng, 2019). Students studying engineering project management usually lack opportunities to apply learned concepts practically. Conventional teaching approaches in construction management fail to adequately equip students with real-life problem-solving abilities (Al-Jibouri & Mawdesley, 2003). Construction planning involves defining work packages, estimating resources and durations, and identifying task interactions. In academia, students learn through practical projects and software, but lack real-world feedback, hindering their understanding of strengths and weaknesses.

Effective learning through practical experience involves completing projects and monitoring outcomes for feedback and reflection, which students typically achieve only after years in the construction field. Game-based learning in project management higher education enhances student engagement and knowledge retention through an impactful and memorable learning experience (Jääskä & Aaltonen, 2022). Hence, our approach is to introduce the "Lego Construction Scheduling Game" to close the learning feedback loop in Engineering Project Management education. The primary objective is to simulate construction planning and execution using Lego bricks, covering real-world scenarios and decision-making challenges. Participants plan, price, and bid on projects, focusing on informed risk management. This hands-on approach provides valuable experience and critical skills for navigating uncertainties in project management.

This study considers a construction activity involving repetitive tasks, designed to fit within a class environment and a limited timeframe, by conducting a LEGO project among undergraduate students. This would involve complex tasks such as project planning, risk management and cost estimation. Thus, this game is appropriate for upper-level undergraduate students with necessary background in engineering project management and construction principles to fully benefit from and engage with the game. The details of the methodology will be discussed in the following section.

METHODOLOGY

This study examines a LEGO prototype of the Brandenburg Gate. Figure 1 illustrates its various sections and Figure 2 displays the LEGO model of the structure developed using the Building Information Modeling (BIM) tool. Building Information Modeling (BIM) is a comprehensive digital methodology that combines policies, processes, and technologies to effectively manage critical building design and project data throughout the entire lifecycle of a construction project (Bryde

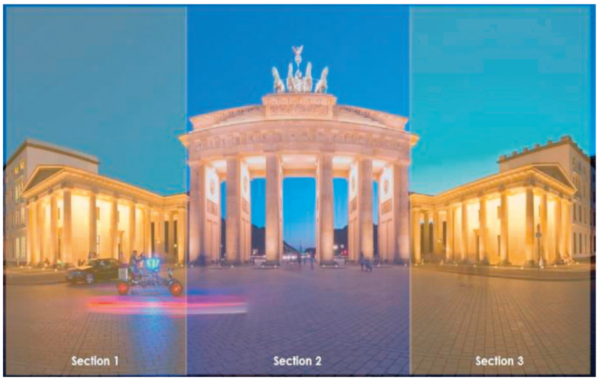

Figure 1. The different sections of Brandenburg gate considered in this study.

et al., 2013). Specifically, we aim to address the question of what constitutes an efficient plan for constructing the Doric columns and roofs of the structures.

The game is structured to accommodate groups of three students who compete to develop the best plans. The best plan is determined by its accuracy in estimating task durations, effective risk management, and cost minimization. The competition comprises several phases, each conducted during a 2-hour session, as detailed in the subsequent sections.

Phase 1: Quantity and Productivity Rate Estimation

The first phase involves quantity and productivity estimation. In this session, the consumption rates for each task in the model are estimated. Consumption rates is basically the amount of time or resources required to complete a specific task. Hence, in this game consumption rates are

Figure 2. The Lego model developed using BIM.

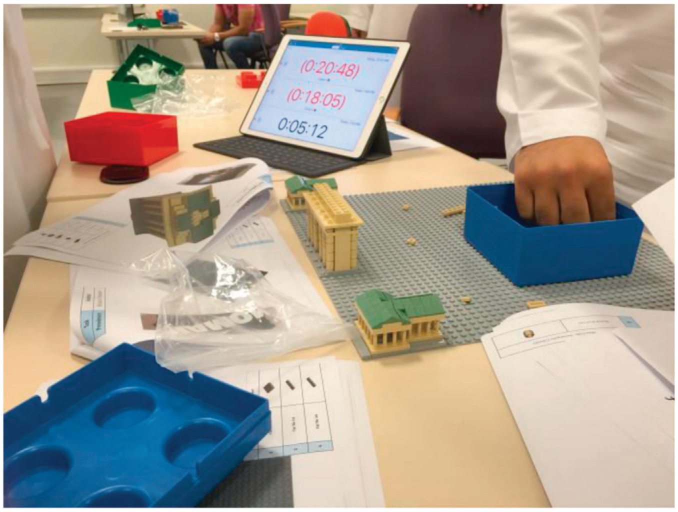

Figure 3. Productivity rate estimation.

measured in seconds per LEGO piece for each task as shown in Figure 3. The model is physically erected in class by the students, and their progress is recorded using a stopwatch application. This physical erection allows students to gain hands-on experience and practical feedback, helping them to better understand the actual time and effort required for each task. While constructing the full LEGO model within the allotted time is beneficial, the primary goal is not necessarily to complete the model but to use the activity as a learning tool for planning and risk management. For each attempt the fastest time (optimistic), the slowest time (pessimistic), and the average time required to complete each task is recorded and inserted into an Excel spreadsheet provided by the course instructor.

Phase 2: Planning and Bidding stage

In this session, information regarding brick quantities, consumption rates, and uncertainties collected from Phase 1 is utilized to formulate a plan for the LEGO project. This plan is developed using the commercial “Vico Schedule Planner” software by entering all the data. It details how three players will work in coordination to complete the project, as depicted in Figure 4.

Students must determine the level of risk they are willing to undertake and subsequently bid on the project. The bidding information includes:

- Exact planned start and end times (in seconds) for each player at the LEGO construction site. A rule stipulates that each player can only be on site once; once they leave, re-entry is not permitted.
- Players cannot arrive earlier than the scheduled time.

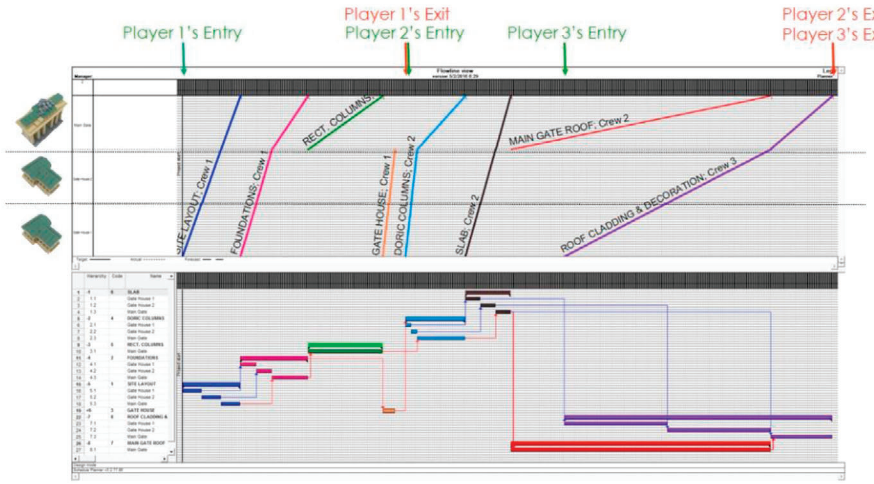

Figure 4. An example for Lego Construction Scheduling Plan.

- The exact project completion time (in seconds).
- Based on the planned total time that players will spend on site and the projected total project duration, the organizing committee will calculate the bidding price.

The students physically erect the Lego model and an organizing panel consisting of three to five faculty members having expertise in construction planning and project management, uses stopwatches to record the time of execution. The organizing panel needs to be provided necessary training on the rules and procedures of the "Lego Construction Scheduling" game. Points are calculated based on Table 1.

Table 1. Lego construction cost items and explanations.

Cost Item	Calculation Method*	Explanation
Overbidding Penalty	Cost on top of lowest bid	Envelopes are opened, revealing bidding prices. The team with the lowest bid incurs no overbidding penalty, while higher bids incur penalties.
Delay Penalty	20 AED / Sec.	If the project exceeds the planned duration, each second of delay costs 20 Dirhams.
Consumption of Crews	10 AED / Sec.	The organizing panel charges for a player's presence on the Lego construction site as per the plan, regardless of task readiness.
Overheads	5 AED / Sec.	Overheads are based on the actual project duration
Total Cost		***Lowest Total Cost wins.***

* An AED (United Arab Emirates Dirham) is the currency used in the United Arab Emirates, with 1 AED roughly equivalent to 0.27 USD.

PRELIMINARY RESULTS

In the preliminary analysis, four groups of students from two sections of an advanced "Special Topics in Construction Management" undergraduate elective course participated in the game over one semester. The results of each group are given below in Table 2.

Table 2. Preliminary results of the LEGO game.

Cost Item	Group 1	Group 2	Group 3	Group 4
Planned Duration (min.)	21.5	23.1	19.5	26.9
Proposed Overheads (AED)	6455	6950	5865	8065
Actual Duration (min.)	21.7	21.9	24	31.9
Actual Overheads (AED)	6515	6575	7200	9565
Overbidding Penalty (AED)	590	1085	0	1985
Delay Penalty	240	0	5529	6000
Consumption of Crews	16110	18860	13990	34320
Total (AED)	23455	26520	26710	51870

Group 1 emerged as the winning team, displaying remarkable accuracy in their planning. Their planned duration was 21.5 minutes, with the actual duration closely aligning at 21.7 minutes. Despite a minor deviation of 0.2 minutes, which incurred a overbidding penalty of 590 dirhams, the performance of Group 1 remained remarkably accurate and efficient compared to other groups. Group 2 demonstrated accuracy in their planning as well, although they were slightly over pessimistic. Surprisingly, they completed the project ahead of schedule, avoiding any delay penalties. However, their cautious approach led to an overbidding penalty. On the other hand, the optimistic planning of Group 3 resulted in significant delays, leading to a substantial penalty. Conversely, the risk-averse strategy of Group 4 translated into the slowest plan and execution, resulting in both delay and overbidding penalties. Their performance lagged significantly behind other groups, showcasing the importance of balancing efficiency and accuracy in project planning and execution.

To expose students to risk management and real-world trade-off dilemmas, the game was designed to expose students to the implications of their decisions made at the planning and bidding stages, which are carried on to the execution stage. In a real-world scenario, over-bidding may lead to the loss of project award in a tendering process. In this hypothetical game, over-bidding was penalized as cost incurred on top of the actual execution cost. Overbidding penalty is calculated as the cost on top of the lowest bid (refer to Table 1). In this case for example, Group 3 made the lowest bid, and Group's 1 price was 590 dirhams higher than Group 3 (refer to Table 2).

The team's grade for the game assignment was influenced by their overall performance, with factors such as project accuracy, time management, and teamwork being assessed. While the winning team received recognition for their success in simulating a real-world project efficiently, all teams were graded based on their ability to meet the project objectives and demonstrate critical thinking throughout the game activity.

NEXT STEPS

In this paper, we introduced a novel approach to teaching construction scheduling through the implementation of a LEGO-based game. While this initial study provided valuable insights into the potential impact of game, it represents only a preliminary investigation. Future research endeavors will focus on expanding the sample size, conducting further experiments, and refining the game mechanics (such as adjusting the rules and procedures for clarity and effectiveness, expanding the scope and complexity of the game to better reflect real-world construction scenarios) to optimize learning outcomes. Additionally, in the future studies, the effectiveness of the LEGO based game approach can be analyzed using the 4MAT model (McCarthy, 1990), which incorporates Kolb's learning style theory and has been widely used in engineering education. By categorizing students as innovative, analytic, common sense, or dynamic learners, the model enables educators to tailor instruction to diverse learning preferences, ensuring active student participation (Yanti et al., 2021). Insights from the 4MAT analysis can be applied to adjust teaching strategies, ensuring that the game accommodates different learning styles by integrating a variety of instructional methods. The 4MAT tool allows for an exploration of students' learning preferences, and by applying 4MAT analysis, we can better assess the extent to which game-based approaches enhance the understanding of key concepts.

REFERENCES

Al-Jibouri, S. H., & Mawdesley, M. J. (2003). A management game for evaluating the selection of project plans in construction. *ISARC2003 The Future Site*, 383.

Bryde, D., Broquetas, M., & Volm, J. M. (2013). The project benefits of Building Information Modelling (BIM). *International Journal of Project Management*, *31*(7), 971–980. https://doi.org/10.1016/j.ijproman.2012.12.001

Jääskä, E., & Aaltonen, K. (2022). Teachers' experiences of using game-based learning methods in project management higher education. *Project Leadership and Society*, *3*, 100041. https://doi.org/10.1016/j.plas.2022.100041

McCarthy, B. (1990). Using the 4MAT system to bring learning styles to schools. *Educational Leadership*, *48*(2), 31–37.

Tseng, H.-H. (2019). Use of e-learning and course assignments to improve learning effectiveness in construction project planning. *People: International Journal of Social Sciences*, *4*(3), 1361–1375. https://doi.org/10.20319/pijss.2019.43.13611375

Yanti, A. W., Budayasa, I. K., Sulaiman, R., Sutini, S., & Hasanah, A. (2021). Statistical reasoning ability analysis observed from 4MAT learning style system. *AIP Conference Proceedings*, *2330*(1).

Zhang, J., Xie, H., & Li, H. (2019). Improvement of students problem-solving skills through project execution planning in civil engineering and construction management education. *Engineering, Construction and Architectural Management*, *26*(7), 1437–1454. https://doi.org/10.1108/ECAM-08-2018-0321

AUTHORS

Hamad Aljassmi received the Ph.D. degree from the School of Civil and Environmental Engineering, University of New South Wales (UNSW). He is currently an Associate Professor of Civil Engineering and the Director of Emirates Center for Mobility Research at UAE University. He published more than 80 peer-reviewed articles, most which appeared in top ranked journals. He has more than 15 years industry experience in which he acted as Project Manager, Planner or Researcher at numerous high-profile consultancy projects related to life-cycle assessment of surface transport projects, mobility policy making, transportation planning and traffic safety. His research interests include expert systems and machine learning for the buildings and infrastructure sectors.

Babitha Philip is currently working as a Postdoctoral Fellow at UAE University. She completed her Ph.D. in Civil Engineering from UAE University, with research focused on pavement management. Research interests of Dr. Babitha include pavement management, asset management, transportation infrastructure, road maintenance, and sustainable construction practices. She is dedicated to advancing the field through innovative research and practical applications in improving the longevity and efficiency of pavement systems.

Mohammad Younes is a fourth-year Civil Engineering student at UAE University, minoring in Artificial Intelligence. His research focuses on integrating AI technologies in civil engineering, including projects on structural crack detection using AI drones and lab safety with AI cameras. Mohammad's interests also extend to the development of AI taxis and the impact of AI on mobility solutions. He has published two research papers and is dedicated to advancing sustainable infrastructure through innovative applications of technology.