Umstot, D., & Umstot, S. (2025). DUPLO® Simulation for Introduction of the Last Planner System®. In O. Seppänen, L. Koskela, & K. Murata (Eds.), *Proceedings of the 33rd Annual Conference of the International Group for Lean Construction* (IGLC33) (pp. 1440-1450). https://doi.org/10.24928/2025/0255

DUPLO® SIMULATION FOR INTRODUCTION OF THE LAST PLANNER SYSTEM®

David Umstot[1] and Summer Umstot[2]

ABSTRACT

Faced with the challenge to facilitate a 45-minute interactive session for a large group to introduce key concepts of the Last Planner System®, a new hands-on simulation has been developed using a design thinking approach. The simulation is designed for teams of nine participants using DUPLO® bricks. Gamification and serious game theory were integrated into lessons from earlier lean simulations to develop an experience that is engaging, informative, and educational. Key concepts to be introduced were identified including collaborative planning with those doing the work, visual planning and management, identification of key and interim milestones, pull (reverse) planning, identification of activities and hand-offs, forward pass of overall plan, working the plan, and reflection for continuous improvement. A first run study was conducted with 32 participants in August 2024 followed by a roll-out at scale for 80 participants at the 2024 Lean Construction Institute Congress in October. Subsequently, this simulation has been used successfully with project teams to introduce Last Planner System® principles.

KEYWORDS

Last Planner System®, gamification, simulation, lean learning, DUPLO®.

INTRODUCTION

Introducing the Last Planner System® (LPS) of Production Control to large groups has historically been challenging outside the context of an actual project. To address this, in February 2024, the Lean Construction Institute (LCI) Congress planning committee reached out with a request to develop a hands-on 45-minute simulation to introduce pull planning to a group of 200 at the 2024 annual Congress in San Diego, USA. Based on years of experience introducing the LPS to thousands of design and construction professionals including trade craft, this was a daunting task. The challenge was to design and deliver a simulation to introduce LPS concepts through hands-on participation for a large group in a very constrained time frame. This paper is organized to provide background on how the simulation was developed, the results, and recommendations for future facilitators. This includes discussion on how gamification stimulates learning neurologically, identification of key learning objectives and constraints for the simulation, testing of the simulation hypotheses via a first run study, making adjustments based on what was learned from the first run study to scale the learning to a larger group, and recommendations, based on feedback from participants, for how this simulation can be used to introduce LPS concepts to teams anywhere.

[1] President, Umstot Project and Facilities Solutions, LLC, La Mesa, California, USA, david.umstot@umstotsolutions.com
[2] Principal, Umstot Project and Facilities Solutions, LLC, La Mesa, California, USA, summer.umstot@umstotsolutions.com

A BRIEF REVIEW ON THE DESIGN OF EDUCATIONAL SIMULATIONS

Much research has been done with respect to designing for how people learn by understanding the gaps that must be overcome to bridge between current knowledge and future desired knowledge (Dirksen 2012). Simulations designed to introduce new concepts need to take this into account for successful learning outcomes. There are also lessons to be learned from what video games teach us about learning, particularly with respect to engaging participants, and the concept of an appreciative system where affect and cognition come together (Gee 2007). The potential application of gamification within the context of Lean construction training has recently been explored (Pütz et al 2021). The use of serious gaming in teaching and learning Lean concepts has also been well documented in a study of Lean Construction education at universities in the United States (Rybkowski et al 2020).

The LEGO® SERIOUS PLAY® Method was developed in the late 1990s as a result of the desire of Kjeld Kirk Kristiansen, owner and CEO of LEGO® at the time, to find an alternative means for strategic planning from traditional methods. Bart Victor and Johan Roos of IMD Business School were engaged to explore and develop the concept of using LEGO® bricks and storytelling to unlock a different approach to strategic planning. The process of the LEGO® SERIOUS PLAY® method is intended to create leaning in by participants, unlock new knowledge, and break habitual thinking (Kristiansen and Rasmussen 2014). One key element of LEGO® SERIOUS PLAY® is that when we construct or build something with LEGO® bricks (or other materials), learning is reinforced neurologically. This occurs through synaptic plasticity where repeated activation of neural pathways strengthens synaptic connections in the brain, making information recall easier. Additionally, the release of neurotransmitters like dopamine during learning enhances motivation and memory consolidation reinforcing behaviors and strengthening neural connections that help with memory and habit formation. Key takeaways from an overview of neuroscience and learning through play indicate that activities that contain joy, are meaningful, actively engaging, iterative and socially interactive stimulate interconnected neurological networks tied to learning (Liu et al 2017). Additional neuroscience research indicates that designing learning to include a think-pair-share approach reinforces long-term memory retention (Owens and Turner 2017).

Pull planning simulations have been evolving since the 1990s through the original leadership, experimentation and refinement of Greg Howell, Glenn Ballard and others (Tsao and Howell 2022). Overviews, respective key learning objectives, and recommendations for facilitation of four pull planning simulations (Parade of Trades®, Airplane Game, DPR Pull planning, and Villego®) that have been part of that evolution were explored in Tsao et al 2014. As part of this continuum of development, an experimental LPS LEGO® house game was developed for evaluation as a Lean teaching tool for students at the University of Auckland (González et al 2014).

The LPS and pull planning simulations we have seen used most frequently are the Make-A-Card Game, Parade of Trades®, and Villego®. Make-A-Card demonstrates the impacts on production flow of batch size, communication, bottlenecks, unevenness of workload, pull, continuous improvement, and tapping workers' creativity to solve issues where they are discovered. This simulation typically takes 90 minutes to 2 hours to complete in 3 rounds (Lean Construction Institute 2025). Parade of Trades® can be played in a single round with multiple teams or in multiple rounds to display variability's impact on production flow (Tommelein et al 2009). If played in multiple rounds this simulation typically takes about 90 minutes. Villego® is a simulation using LEGO® bricks conducted over two rounds: the first using traditional planning methods and the second using elements of LPS. Metrics tied to schedule, cost and profitability, quality, waste, and safety are measured in each round and used by participants to reflect on the differences LPS can make to improve production (Warcup and Reeve 2014). Villego® typically requires 4 hours to complete. Other LPS simulations that are less frequently used are the DPR Block Game (Nickerson 2020) and LEAPCON (Sacks et al 2007).

LEGO® bricks have been integral to many of the above-referenced simulations including the Airplane Game, Villego®, LEAPCON, and the LPS LEGO® house game. Others have also integrated LEGO® bricks into Lean simulations including the InFrame Lean game (Friblick et al 2007) and the Experience and Reflect (ER) game (Lidelöw 2017) both developed in Sweden.

METHODOLOGY TO DEVELOP THE LPS SIMULATION

In this section, we share how the simulation was developed based on the literature review, practitioner experience, and participant feedback. The existing body of knowledge on the principles of the LPS as discussed in the previous section is vast and well-documented in many references. Readers are referred to these two resources for the original research and current process benchmark (Ballard 2000, Ballard and Tommelein 2021). For the purposes of identifying key learning points for the simulation within the available time constraints the following LPS elements were identified:

1. Collaboratively planning with those doing the work
2. Visual planning and management of the work
3. Identification of key and interim milestones
4. Pull (reverse) planning
5. Identification of activities and hand-offs
6. Forward pass of overall plan (time permitting)
7. Working the plan
8. Reflection for continuous improvement

DESIGNING THE SIMULATION

A design thinking approach (Brown 2019) was used to develop the simulation with many "how might we?" questions with the desire to have participants be exposed to the eight elements identified above. The results of a subsequent brainstorming session yielded these three additional goals:

1. Keep it simple
2. Create aha moment(s)
3. Have fun!

Drawing on our experience using Villego® to train more than 100 teams and our experience with LEGO® SERIOUS PLAY®, we strategized to develop a simple simulation using DUPLO® bricks to demonstrate these principles. The simulation needed to be structured to allow collaboration of at least 8 participants so a model was designed with eight different color DUPLO® bricks to allow each participant to have a role. The number of bricks assigned to each color was purposefully selected to create an unbalanced work load to represent typical trade scope differences on a real construction project. We also needed to identify the means for participants to visually and collaboratively plan the work in a manner that all could access and see.

THE SIMULATION

Figure 1 shows the materials required. For planning activities, color Post-It®s matching the color of the DUPLO® bricks are provided (Figure 2) and a plotted paper grid of 10 x 30 squares sized for the Post-It®s (Figure 3). The participants are provided images of the DUPLO®

structure to be constructed for their use in planning and production in elevation (Figure 4) and top and isometric views (Figure 5).

The instructions for participants are shown below:

- 9 people per table
- Work collaboratively (20 minutes to plan; 5 minutes to assemble)
- Self-select roles (1 CM, 8 DUPLO® trades by color)
- Establish your milestones
- Use your wall for planning
- Responsible for your own Post-It®s (don't move others' Post-It®s)
- Develop your plan from the finish backwards
- Make a forward pass of the plan if you have time
- You are responsible for your own DUPLO® blocks (organizing and placing)
- No pre-fabrication

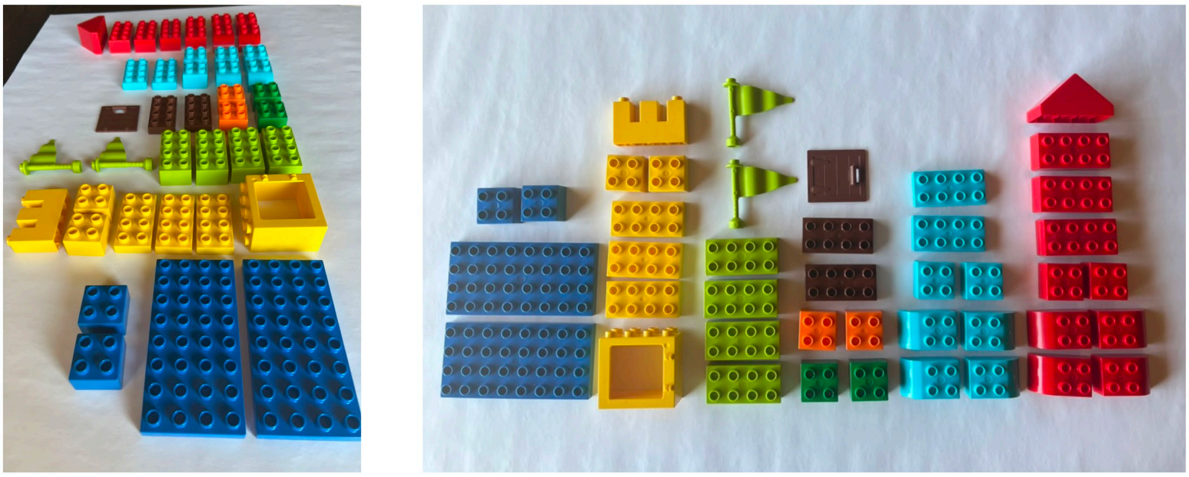

Figure 1: DUPLO® materials required for simulation (left image is oblique view to show brick thickness, right image is in plan view; 42 total bricks)

Figure 2: Color Post-It®s matching DUPLO® brick colors

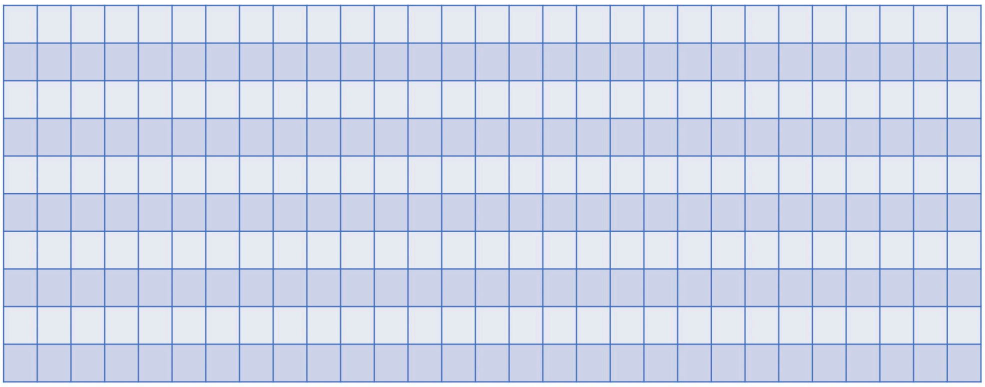

Figure 3: 10x30 Square Grid for Activity Post-It®s

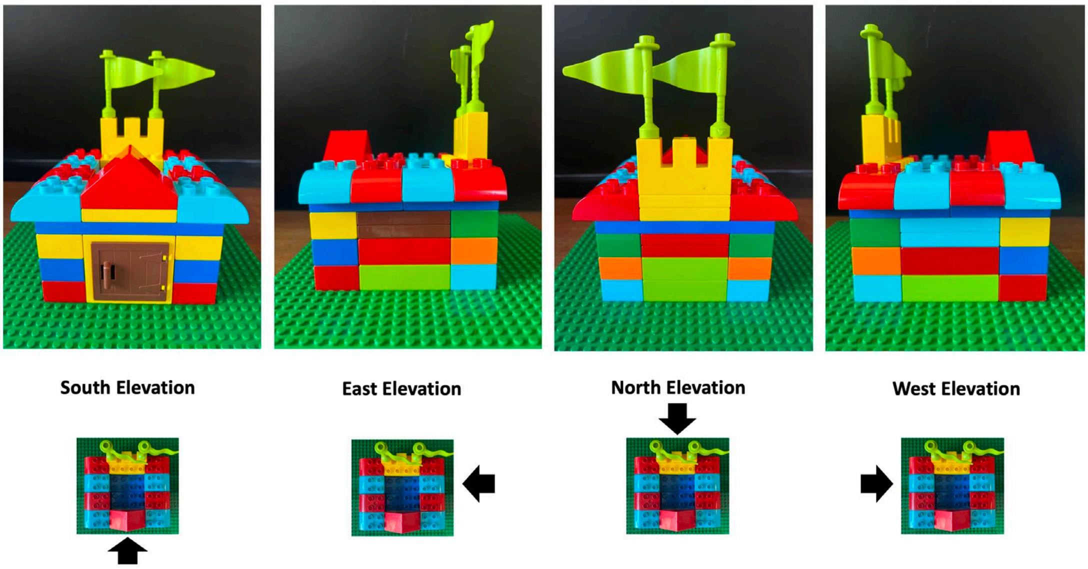

Figure 4: Elevation views of DUPLO® model to be constructed

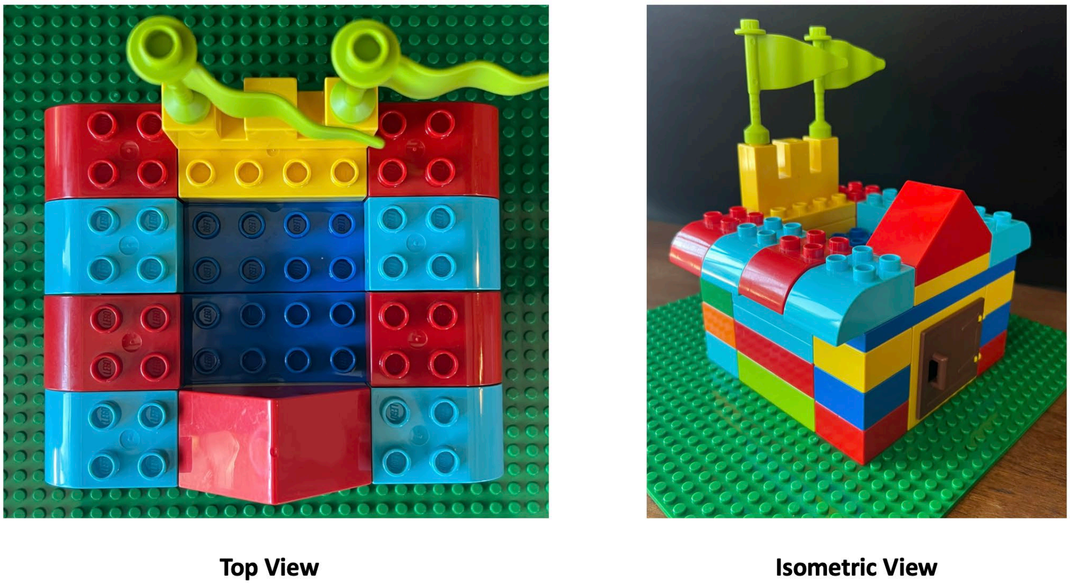

Figure 5: Top view and isometric view of DUPLO® model to be constructed

DEPLOYING THE SIMULATION FOR INTRODUCTION OF LPS

This section describes how the simulation was tested through a first run study, modified, then deployed with a larger group, and then launched with project teams.

FIRST RUN STUDY

To evaluate the simulation and assess if it achieved the desired learning objectives and to identify opportunities for improvements, a workshop was held with 32 participants on August 16, 2024 at the LCI San Diego Community of Practice. Specific data collected included:

- the time to complete planning,
- time to complete production,
- images and video,
- facilitator observations, and
- qualitative participant feedback via reflection discussion and plus/delta comments.

Four teams of eight members were established. One of the specific elements to be tested in addition to the learning objectives was determining the appropriate length of time for planning and production for the simulation based on the groups' performance. Team planning times ranged from 15 minutes to 25 minutes and production times from 1 to 4 minutes. Based on this preliminary data, the instructions for the simulation were modified to set 20 minutes for planning and 5 minutes to construct the model.

Feedback from participants (plus/delta) was captured and shown in Figure 6. One of the key recommendations was the value in having a construction manager or superintendent to manage the process rather than self-organizing as DUPLO® brick builders. This was added to the instructions allowing for the simulation group size to increase to a maximum of 9 participants. It is worth noting that if there are fewer participants than 9, facilitators can ask more than one DUPLO® brick color be assigned to specific team members similarly to assigning multiple scope packages to a single trade in construction. Other feedback that was incorporated was laminating all materials and relabeling of elevation views to north, south, east and west versus "front", "back" and "side".

Figure 6: Plus (left) / Delta (right) Feedback from Participants in First-Run Study

Roll-out of Simulation at Scale

The simulation was used in a workshop with 80 participants in nine separate teams at the 2024 LCI Congress in San Diego, California in October 2024. Figure 7 shows the pull planning activities by one of the teams starting from the completion milestone. Figure 8 shows two teams during the build phase of the simulation.

Figure 7: Planning during the simulation at LCI Congress October 2024

Figure 8: Build phase of simulation at LCI Congress October 2024.

After completion of the simulation each table was asked to reflect on their experience and share what had worked for them, challenges encountered, and opportunities to improve their planning and production activities. This reinforced the learning using the think/pair/share model (Owens and Tanner 2017). Three key summary takeaways from participants included:

1. identifying the benefit of communication,
2. gaining clarity and alignment in common understanding and vocabulary at the beginning, and
3. importance of the conversations in planning.

Plus/delta continuous improvement feedback was also captured. Many participants shared that they thought the simulation would be even better if it was extended beyond 45 minutes to a longer duration to assure that ample time was provided for each team to fully understand each introduced element of LPS. This is important for facilitators planning future use of the simulation.

Rollout with Project Teams

In December 2024, the simulation was used to introduce pull planning concepts to two Alliance project teams in British Columbia, Canada. The first was part of a greater team building effort with a focus on planning with a group of 32 in four separate teams. Figure 9 shows an example of one of the teams planning during the workshop. Figure 10 shows an example of a separate Alliance project team conducting a forward pass during the simulation. The construction phase of the simulation with one of the teams is illustrated in Figure 11.

Figure 9: Alliance team planning during simulation

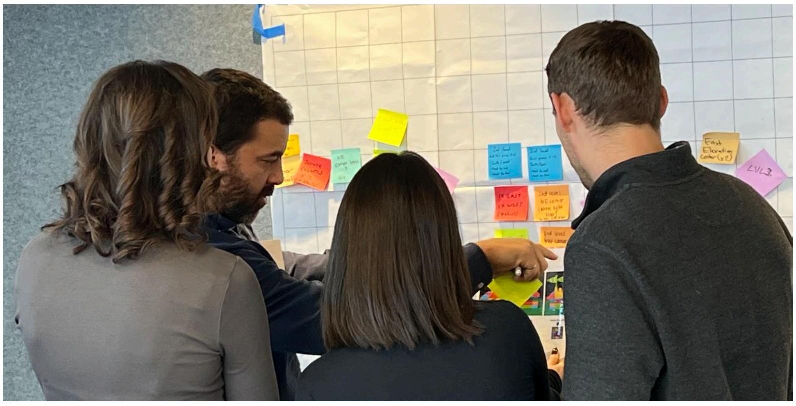

Figure 10: Alliance team conducting forward pass during planning

Figure 11: Alliance team during build phase of simulation

The workshops were successful in introducing the concepts of the Last Planner System® to the Alliance teams and one team spring-boarded immediately into a follow-on session to conduct a phase pull plan to the submittal of their Project Alliance Agreement.

INSTRUCTIONS FOR FACILITATION

Based on the available time, the simulation can be done in as quickly as 45 minutes or expanded to 90 minutes if deeper learning and discussion is desired. A general timeline for facilitator's use is presented in Table 1.

Table 1: Facilitator's Timeline

Activity	Time Recommended
Set up of room with materials at each table for groups of 9 (this includes LEGO® bricks, laminated instructions, color Post-It®s, Sharpie pens); tape planning square grid (figure 3) to wall – not recommended for horizontal use	30 to 45 minutes
Welcome and Introductions	5 minutes
Introductory slide deck with overview of the Last Planner System® with instructions to teams	10 minutes
Teams plan their build using LPS® principles	20 minutes (consider adding 5 minutes if teams have not completed a forward pass)
Teams execute their build plan; facilitator capture completion times for each time	5 minutes
Ask each table to debrief among themselves (What went well? What didn't? How could it be improved?	5 minutes
Group debriefings (all tables report out); facilitator shares any observations	10 minutes (maybe longer if a larger group or facilitator wants to walk through each of the LPS elements introduced and experienced)
Plus/Delta (continuous improvement feedback)	5 minutes (alternatively have each participant complete a Post-It® with a plus and a separate one with a delta; provide a board or easel to capture these)

CONCLUSIONS

This simulation was successful in introducing the milestone aspects, collaboration, sequence, handoffs, and visual management integral to successful use of LPS. One element of the LPS is Pull Planning - a fundamental planning method to identify the critical work that releases work through engaging project team members and the conversations that follow. Essential ingredients are collaboration and hand-offs. A good, simple pull plan simulation gives participants the experience of collaboration so that they are inspired to try it on their next project with more confidence or bring the tool back to share it with others. Creating familiarity with LPS concepts and seeing how they can benefit the user can help overcome resistance to trying something different. This simulation helps participants realize the importance of taking the time to plan and how that improves production flow. By making the simulation fun, learning was reinforced.

As shared by LCI Congress participants' feedback, this simulation can be expanded for a longer duration of time to allow participants to dive more deeply into the pull reverse planning and forward pass review. Discussion tied to material supply chain, staging, and pre-fabrication opportunities can also be woven into the post-simulation debriefing and reflection.

REFERENCES

Ballard, H.G. (2000). *The Last Planner System of Production Control* [Ph.D. Dissertation, School of Civil Engineering, University of Birmingham, UK]. 192 p. https://www.researchgate.net/publication/239062242_The_Last_Planner_System_of_Production_Control\

Ballard, H.G. and Tommelein, I. (2021). *2020 Current Process Benchmark – The Last Planner® System of Project Planning and Control*. 126 p. https://escholarship.org/uc/item/5t90q8q9

Brown, T. (2019). *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation*. HarperCollins Publishers: New York. 294 p.

Dirksen, J. (2012). *Design for How People Learn*. New Riders: Berkeley, CA, USA. 259 p.

Friblick, F., Åkesson, A. and Leigard, A. (2007). Learning Lean Through Lean Game – A Case from the Infrastructure Industry. In: *Proc. 15th Annual Conference of the International Group for Lean Construction (IGLC).* Michigan, USA. https://iglc.net/Papers/Details/487

Gee, J.P. (2007). *What Video Games Have to Teach Us About Learning and Literacy*. Palgrave MacMillan: New York. 249 p.

González, V.A., Senior, B., Orozco, F., Alarcón, L.P., Ingle, J. and Best, A. (2014). Simulating Lean Production Principles in Construction: A Last Planner-Driven Game. In: *Proc. 22nd Annual Conference of the International Group for Lean Construction (IGLC)*. Oslo, Norway. https://iglc.net/Papers/Details/1060

Kristiansen, P. and Rasmussen, R. (2014). *Building a Better Business Using the LEGO® SERIOUS PLAY® Method.* John Wiley & Sons: Hoboken, NJ, USA . 232 p.

Lean Construction Institute. (2025). *Make A Card Simulation*. Accessed 14 January 2025. https://leanconstruction.org/learning/simulations/

Lidelöw, H. (2017). The ER Design Simulation Game: Experience and Reflect. In: *Proc. 25th Annual Conference of the International Group for Lean Construction (IGLC)*. Heraklion, Greece. doi.org/10.24928/2017/0106

Liu, C., Solis, S.L., Jensen, H., Hopkins, E., Neale, D., Zosh, J., Hirsh-Pasek, K. and Whitebread, D. (2017). *Neuroscience and learning through play: a review of the evidence*. https://cde-lego-cms-prod.azureedge.net/media/zbcd21td/neuroscience-review_web.pdf

Nickerson, R. (2020). *The DPR Block Tower Game slide deck,* presented July 20, 2020. Retrieved January 14, 2025 from https://www.coursesidekick.com/english/3550647

Owens, M.T. and Tanner, K.D. (2017). Teaching as Brain Changing: Exploring Connections between Neuroscience and Innovative Teaching. *CBE Life Science Education June 1, 2017 Vol. 16, No. 2*. https://doi.org/10.1187/cbe.17-01-0005

Pütz, C., Lühr, G. J., Wenzel, M., and Helmus, M. (2021). Potential of gamification for lean construction training: An exploratory study. In: *Proc. 29th Annual Conference of the International Group for Lean Construction (IGLC).* Lima, Peru. 259–268. doi.org/10.24928/2021/0134

Rybkowski, Z.K., Forbes, L.H., and Tsao, C.C.Y. (2020). Chapter 19: The evolution of Lean Construction Education at U.S.-based universities. In: Tzortzopoulos, P., Kagioglou, and Koskela, L. Eds. *Lean Construction: Core Concepts and New Frontiers*. Routledge: New York, 387-407. https://www.taylorfrancis.com/chapters/edit/10.1201/9780429203732-19/evolution-lean-construction-education-us-based-universities-zofia-rybkowski-lincoln-forbes-cynthia-tsao

Sacks, R., Goldin, M., and Esquenazi, A. (2007). LEAPCON: Simulation of Lean Construction of High-rise Apartment Buildings. *ASCE Journal of Construction Engineering and Management, Vol. 133 No. 7*, 529-539. https://doi.org/10.1061/(ASCE)0733-9364(2007)133:7(529)

Tommelein, I. D., Riley, D., & Howell, G. A. (1999). Parade game: Impact of work flow variability on trade performance. *Journal of Construction Engineering and Management*, *125*(5), 304–310. doi.org/10.1061/(ASCE)0733-9364(1999)125:5(304)

Tsao, C., Draper, J. and Howell, G. (2014). An Overview, Analysis, and Facilitation Tips for Simulations that Support and Simulate Pull Planning. In: *Proc. 22nd Annual Conference of the International Group for Lean Construction (IGLC)*. Oslo, Norway. https://iglc.net/Papers/Details/977

Tsao, C. and Howell, G. (2022). Development of Simulations & Pull Planning for Lean Construction Learning and Implementation. In: *Proc. 30th Annual Conference of the International Group for Lean Construction (IGLC), Edmonton, Canada*. https://iglc.net/Papers/Details/2032

Warcup, R. and Reeve, E. (2014). Using the Villego® Simulation to Teach the Last Planner® System. *Lean Construction Journal*. 1-15. https://www.villego.com/wp-content/uploads/2016/12/Villego-paper.pdf