AN OVERVIEW, ANALYSIS, AND FACILIATION TIPS FOR SIMULATIONS THAT SUPPORT AND SIMULATE PULL PLANNING

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ABSTRACT

Pull Planning is an essential component of the Last Planner® System (LPS). It helps define how work will be handed off from one project performer (e.g., owners, designers, contractors, and suppliers) to the next. It illustrates how work is balanced between project performers to better support a project takt time, i.e., work completion rhythm. It encourages project performers to have conversations earlier about how to handle physical interfaces between components that may at first seem plausible in design but end up being much more challenging to accomplish in construction. Due to the importance of Pull Planning and the fact that it is a typical first step for lean implementation on Architecture-Engineering-Construction (AEC) projects, project teams that have limited Lean Construction experience can use a variety of simulations to ensure better participation during actual Pull Planning efforts. Thus, to help accelerate the rate of Pull Planning learning and successful implementation in the AEC industry, this paper will provide an overview of simulations that have proven to be effective in supporting and simulating Pull Planning. It will discuss how they prepare project teams for actual Pull Planning efforts and provide insight into facilitation techniques based on the authors' experience. It will address differences in teaching Pull Planning within an academic versus industry setting. In closing, we will provide a guide as to which simulations to prioritize when faced with limited time for educating students or training project teams.

KEYWORDS

Pull Planning, phase scheduling, simulation, facilitation

PULL PLANNING AND SIMULATIONS

Pull Planning is the second element of the LPS (Ballard 2000) that establishes a project's phase planning (Ballard and Howell 2004). It is a collaborative planning process where project performers work together to design the process to deliver a milestone. The term "Pull Planning" refers to the lean concept of "pull" as a request from downstream as opposed to the top-down "push" as applied in traditional practice. As Pull Planning is emerging as a popular first step for many companies that begin to implement lean on AEC projects (McGraw-Hill 2013), this paper will review the

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simulations that we have found to be most effective in preparing lean learners for actual Pull Planning efforts. Furthermore, this paper is intended to guide not only practitioners but academics as well to help accelerate the rate of lean adoption in the AEC industry.

Simulations are powerful tools for lean teachers to address diverse learning styles of lean learners [e.g., visual, auditory, or tactile learners (Hawk and Shaw 2007)]. By engaging lean learners in hands-on activities, lean teachers can use simulations to help illustrate key principles that support lean thinking during Pull Planning including: (1) Cooperation/Competition, (2) Production System Design, and (3) Dependency and Variation. Various simulations that illustrate these principles include:

- **Cooperation/Competition:** Win as Much as You Can, Build as Many Roads as You Can, Flip the Tarp, Magic Stick, Silent Squares, Marshmallow Game

- **Production System Design:** Lego® Hotel, LEAPCON™, Airplane Simulation, Dot Card, DPR Pull Planning Game

- **Dependency and Variation:** Beer Game, Parade of Trades

This paper will focus on providing an overview, analysis of Pull Planning-related objectives, and facilitation tips for the simulations that we have found to be most effective in preparing lean learners for Pull Planning – the Parade of Trades, the Airplane Simulation, Silent Squares, DPR Pull Planning Game, and Villego. We also will provide recommendations for Pull Planning session design using a combination of simulations, overview of the LPS, and actual Pull Planning efforts.

PULL PLANNING SEMANTICS

While the Pull Planning technique is critical during phase planning, it can also be used to do weekly work planning, or even minute-by-minute planning (e.g., to organize a process plant shutdown). Thus, although the AEC industry has used the terms "Pull Planning," "Phase Scheduling," "Reverse Phase Scheduling," and "Phase Planning" interchangeably, we advocate using the term "Pull Planning" to represent the basic technique and approach for establishing "*who* should be doing *what* work and *when*?" (Tsao and Tommelein 2004) to achieve end milestones.

In this paper, we will also use the term "Pull Planning session" to refer to a period of time set aside for lean learners to experience lean training and/or simulations to prepare them to be more effective during Pull Planning efforts. In addition, a session may or may not include the Pull Planning efforts for an actual project.

RECOMMENDATIONS FOR PULL PLANNING FACILITATION

Building upon previous descriptions and discussions of Pull Planning (Ballard 1997; Ballard and Howell 2004), we provide the following additional recommendations regarding Pull Planning implementation based on our experience on AEC projects:

- Distribute an agenda preferably one week or more in advance to Pull Planning meeting attendees. It should identify the start and end milestones as well as initial ideas for breaking up the project into modules that support the planning of repetitive work. Make sure attendees understand that the modules may be reshaped or redefined throughout the Pull Planning meeting.

- For Pull Planning construction work, strongly urge trade superintendents and/or foremen to attend and participate in the Pull Planning meeting.

- To help attendees better prepare, ask them to consider in advance: (1) what work they need to do to support the end milestone, (2) what handoffs do they need from other companies to start work, (3) their preferred work paths, (4) durations for planned work, (5) crew size for planned work, (6) coordination required with other trades to enable completion of their scope, (7) any unresolved issues or roadblocks that may prevent work from happening, (8) planning assumptions, and (9) alternative approaches for executing their scope.

- Have project drawings, especially connection details, readily available for referral during the meeting either in paper or electronic format.

- If the actual Pull Planning session will be combined with lean training, limit the session to two hours since participants will start to lose steam during the third hour. If the actual Pull Planning session will occur on a different day, limit the session to three hours. If a session requires about four hours of effort, break it up into two 2-hour Pull Planning sessions.

- A single pull plan could cover approximately three months of work, and the session should take place at least a month if not two months in advance of when work needs to begin. This allows the project team sufficient time to make work ready to begin implementation as planned.

- Working backwards from an end milestone is challenging, especially for project teams that have not Pull Planned before. As a result, explain to attendees that the meeting will proceed in three phases: (1) the "backwards pass" will define any work required to support the end milestone, (2) the "forwards pass" will check the workflow logic and add any other activities that are required to support the end milestone, and (3) the "tightening pass" will strive to manage work in smaller batches and balancing work flow to enable a shorter overall duration. By clarifying this meeting agenda, attendees will become less resistant to working backwards because they have been assured that they will be allowed to work forwards during the next part of the meeting.

- Lean learning and Pull Planning is challenging and requires focus. Refreshments can help attendees get an energy boost in the midst of the meeting and become more productive, especially during Pull Planning. In meetings that do not provide refreshments, attendees consistently identify the lack of refreshments as a "delta" during Plus/Deltas. Considering the value of the attendees' time, refreshments are a small price to pay to ensure better outcomes, so we recommend the following catering arrangements for meetings:

  - 2 hours or shorter: Coffee/water and donuts/cookies/fruit

  - 2-3 hours: More substantial refreshments or even a full meal either at the start or middle of the meeting

  - 3-5 hours: At least one full meal and refreshments during breaks

  - 5+ hours: At least two meals (one of which is warm) and refreshments during breaks.

PARADE OF TRADES

SIMULATION OVERVIEW

In its current form, the Parade of Trades typically lasts 90 minutes and involves forming teams of seven who are responsible for processing 35 chips (representing, for example, hospital rooms or multi-residential units) and using blue, red, green, or black dice in play. During play, the dice and chips move in opposite directions.

If you want to get a company or project team into the Lean Construction game, we recommend starting with the Parade of Trades first because it (1) provides the conceptual foundation as to why Lean Construction works and (2) is straightforward in demonstrating the impact of variability on productivity. However, if your objective is to facilitate a Pull Planning session as soon as possible, we recommend starting with the DPR Pull Planning Game simulation first and then scheduling a separate lean training session featuring the Parade of Trades in addition to other simulations.

PULL PLANNING-RELATED LEARNING OBJECTIVES

The Parade of Trades demonstrates the concept of dependence and variation for serial processes. Understanding the impact of dependence and variation on project workflow is critical to comprehending the "why" that underlies the LPS.

- Reducing workflow variability (1) improves total system performance, (2) makes project outcomes more predictable, and (3) simplifies coordination.

- Point speed and productivity do not matter – throughput does.

- When workflow is unpredictable, specialists protect themselves by (1) adding contingency and (2) holding back labor to maintain higher utilization.

SIMULATION FACILITATION TIPS

From the start, emphasize that you are giving students dice with an average roll of "3.5." Then, ask them, "If I give you a die with an average roll of 3.5, *on average,* what week will the first trade finish processing 35 chips?" Once they answer "10," then ask, "If the second trade starts work in week two, what week will they finish processing 35 chips?" Help them walk through the logic so they can eventually predict that the seventh trade will finish *on average* at the end of week 16. With this insight established, ask the groups to predict what week they will finish processing 35 chips. Regardless of what week they predict, ask them to explain the logic behind their predictions – this will help students begin acknowledging the uncertain nature of work on projects and its impact on our ability to predict final outcomes.

Some Parade of Trades instructions describe seating groups around round tables. This may make it difficult to ensure that the dice and chips are moving in the correct directions. Cynthia Tsao recommends using rectangular tables instead with three students seated along the long edges and a single student seated at the end. With the single student representing the fourth trade, play would begin in a "U-fashion."

Furthermore, we recommend that one facilitator manages up to two groups so the facilitator can interact with the groups during play and ensure that play proceeds correctly. If a single facilitator manages three or more groups, it will be challenging to make sure all groups are moving dice and chips in the right direction. In those

situations, we recommend that the single facilitator direct all groups step-by-step through the first two weeks of play and score keeping. Furthermore, we recommend the old Lean Construction Institute (LCI) technique of printing the scoring sheets on both sides of the paper. Then, in case a group makes significant errors in play or score keeping, they can flip their sheets upside-down and start over. This is much easier to do than troubleshooting an errant group.

During play, we encourage facilitators to ask students to reflect on what they are experiencing. Some questions to ask include, "Who is the bottleneck holding everybody up? How does it feel to be the bottleneck?" If a student rolls a large number but has no chips to process, ask them, "This means you brought out enough workers to complete 6 rooms that week. You were not able to complete any rooms. Did you lose money that week? Do you experience this on your projects? If so, how does it feel when it happens?" These questions can help students recognize how closely this simulation can mimic actual project experiences.

If students discover that the dice are not "normal," quickly complement them on being so perceptive and ask them to focus instead on predicting the simulation results based on what they know. Otherwise, students may dwell on how deceptive you were as a facilitator, and this can slow down play. If you were consistent in stating that the dice have an average roll of 3.5, then you can claim that you were not being deceptive.

Finally, similar to the way LCI used acetate sheets in Parade of Trades play in 1997, facilitators can generate cumulative production charts using Microsoft Excel to illustrate the impact of variability on individual and group throughput (Figures 1 and 2). As generating these charts may add 20-30 minutes to a lean learning session, we recommend this activity primarily to facilitators working within an academic setting.
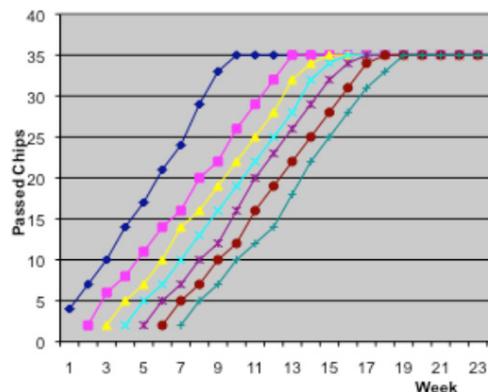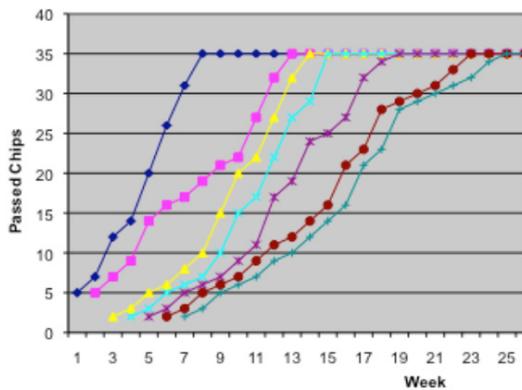

Figure 1: Cumulative blue die production   Figure 2: Cumulative red die production

AIRPLANE SIMULATION

SIMULATION OVERVIEW

The Airplane Simulation can last 1.5 to 2.0 hours and involves forming teams of five to six who are assigned different roles in fabricating Lego® airplanes during three rounds of six minutes each. Throughout each round, students adhere to rules that simulate real-life approaches to production (Visionary Products 2007).

During play, students may claim that productivity gains in time to first batch are due primarily to the effects of a learning curve. In response, facilitators can clarify

that Rybkowski et al. (2012) found that about 70% of productivity gains can be attributed to lean principles whereas only 30% can be attributed to a learning curve.

PULL PLANNING-RELATED LEARNING OBJECTIVES

The Airplane Simulation illustrates several important lean concepts that are foundational to successful LPS implementation and Pull Planning in particular.

- Release work, materials, or information from one specialist or trade to the next by pull rather than push.
- Minimize batch sizes to reduce cycle time. One-piece flow is ideal.
- Balance the workload to create smooth workflow within the entire system.
- Encourage and enable specialists to collaborate with one another to sharpen their understanding of the conditions of satisfaction at handoffs – it matters *how* work is handed off from one specialist to the next.

SIMULATION FACILITATION TIPS

To allow more time for discussion, we advocate skipping Visionary Products' Round 2 (Visionary Products 2007). Then, after each round of play, ask students to propose changes for the next round and only accept those that match the rules for the next round. This forces them to develop techniques on their own to improve throughput.

We recommend that one facilitator manage one to three groups at most to ensure that play proceeds correctly. Similar to the Parade of Trades, we make this recommendation so that the facilitator may interact better with the groups during play. If a single facilitator manages four or more groups, it will be challenging to make sure all groups are adhering to the one-piece flow rule during the second and third rounds.

With regards to group size, we recommend that facilitators form groups of five so everyone can play with the Legos®. Then, the entire group can work together to fill out the score sheet at the end of each round. Otherwise, form groups of six only if you (1) do not have enough Legos® to form groups of five or (2) want to make sure each facilitator is managing a lower number of groups.

In terms of role assignment, make sure to scan your students to determine their dexterity at manipulating Legos®. A good question to ask at the start is, "Is anyone really good at playing Legos® or recently played Legos® with their kids?" Those that raise their hands should be assigned the fourth role that is responsible for attaching the 2x2 pieces. In contrast, assign the first role with 2x8 bricks to those that appear to be less dexterous or voluntarily admit that they are not very good with their hands.

Finally, Visionary Products (2007) recommends stopping production at the 4:00 mark during each round. We recommend doing this and counting the scrap only in the first round. Then, at the 4:00 mark in the second and third rounds, instruct teams to continue production but become aware of how much scrap would have been generated if they had stopped production (i.e., two to three pieces of scrap total).

SILENT SQUARES

SIMULATION OVERVIEW

Silent Squares typically lasts 30 minutes – that is, about 10 minutes spent on play and 20 minutes on group discussion. It involves giving envelopes containing puzzle

pieces to teams of five and instructing team members to form 15 cm (6") squares out of their puzzle pieces without speaking or stealing pieces from each other.

PULL PLANNING-RELATED LEARNING OBJECTIVES

Silent Squares clearly demonstrates that within a project environment, it is not about individuals but the group. At times, individuals may need to "break their square," that is, give something up to help out the group. However, the group will then work hard to make sure that individual is made "whole again." Silent Squares also:

- Illustrates that collaboration is not only okay but is often a requirement for success on AEC projects.
- Demonstrates that the sooner individuals work as a team, the sooner the team will reach a group solution to the problem.

SIMULATION FACILITATION TIPS

Since the silence during Silent Squares will enable the facilitator to quickly pinpoint those who are violating the rules, we believe that one facilitator can comfortably manage up to six Silent Squares groups.

Next, we recommend developing puzzle pieces that are blank on one side and colored on the other. Then, the facilitator can instruct players to form their squares using the color side up. This will help reduce confusion that may emerge by using squares that are the same color on both sides. Two-pocket laminated folders from the office supply store provide a good material to use in this regard.

We also recommend distributing different colored puzzles to each group, e.g., a blue puzzle to one group and a red puzzle to another. This enables a facilitator to easily detect if one group attempts to use the puzzle pieces from another table – either with or without the permission of the other group.

When starting the simulation, it is important to be consistent in the instructions each time – for instance, "No talking, no stealing, no scissors or knives, and the goal is to get a 15 cm (6") square in front of each of you." John Draper and Hal Macomber discovered that the third rule was necessary as some trade foremen regularly carry pocketknives and are tempted to alter their pieces. Greg Howell also instructs players, "No talking, writing notes, shrugging, pointing, touching, sign language, etc."

Once play begins, a facilitator should covertly track the group times when (1) members start exchanging their puzzle pieces and (2) finish forming their 15 cm (6") squares. Then, the facilitator can use this data as points for discussion. For example, "Why did your group take so long to start exchanging puzzle pieces?" can start the discussion of the natural "I've got mine" tendency of individuals to protect their own interests first before considering the interests of the group.

During play, it is common to observe one group successfully form their squares and then wait for the other groups to finish on their own. The facilitator might ask, "Why did you not help the other groups once you figured out the solution?" This helps explore the tendency of groups to become clan-like on projects – that is, once they overcame the "I've got mine" tendency, they will fall into the "We've got ours" mindset. This helps the facilitator explore with the group the extent to which the "I've got mine" and "We've got ours" mentalities exist on AEC projects.

Likewise, the facilitator might ask a group that was struggling to complete their squares after other groups have finished why they did not get up to look at the other

groups' solutions. This discussion can help lean learners consider how long individuals attempt to solve a problem independently before seeking help and when it is appropriate for individuals to begin seeking help from others on AEC projects.

DPR PULL PLANNING GAME

SIMULATION OVERVIEW

Released in the early 2010s, the DPR Pull Planning Game challenges teams to plan and build a tower out of building blocks (King 2011). The facilitator will help teams start planning by identifying the end milestone (i.e., the last step of building the tower) and role model the next few steps of making a pull plan for building the tower. Then, the groups need to work backwards to develop their plan for building the tower. Once all groups have finished developing their plan, the facilitator will remove the pictures and drawings of the tower and challenge the groups to build their towers only by following their sticky note plan and as quickly as possible without any errors.

PULL PLANNING-RELATED LEARNING OBJECTIVES

The DPR Pull Planning Game provides a simple simulation of the Pull Planning technique. It illustrates the following key concepts of Pull Planning:

- The importance of managing the "I Get / I Give" concept during Pull Planning sessions and how sticky notes embody that concept.

- The understanding that each person performs dual roles in the LPS – that is, they can be a supplier in some situations and a customer in others.

- The difference between push versus pull planning.

SIMULATION FACILITATION TIPS

Lean learners often have difficulty starting with the end milestone and planning backwards. As a result, we recommend forming groups of five for the DPR Pull Planning Game. Four players will be responsible for planning and installing blocks of a certain color and the fifth player will make sure the team starts with the last activity, works backwards in their planning, and fills out their "I Get / I Give" sticky notes correctly. Then, a facilitator can manage four to six teams. Otherwise, if teams have only four players, we recommend that one facilitator manage at most three teams because the facilitator will take care of the fifth player's responsibilities for all teams.

To encourage a truly competitive spirit, we recommend offering a prize to the team that builds a defect-free tower in the shortest amount of time. For example, Hal Macomber awards copies of *Poke the Box* (Godin 2011) to winning team members.

We also recommend using tables that seat five people comfortably and limiting one team to each table. While seating two teams to a table allows lean learners to observe other teams' planning efforts, the dual conversations may prove distracting.

For a large group of 80 lean learners, based on the LCI New England Community of Practice's July 2013 experience, we recommend facilitators: (1) spend 20 minutes to explain the rules to the large group, (2) split into groups of 4 teams for further instruction clarification with a designated facilitator for 20 minutes, (3) allow 20 minutes for planning, (4) spend 5-10 minutes for building, and (4) allow for 10-20

minutes to debrief as a large group. In contrast, if a single facilitator manages two to three teams, the simulation can finish in approximately 45-60 minutes.

By early 2014, Turner Construction implemented a number of adjustments to the DPR Pull Planning Game. First, instead of timing the teams, Turner introduced a new milestone tag that represents when teams finish building the first half of the tower. When a team reaches that mid-way milestone, the team will stop production, review their performance with a facilitator, and make suggestions for improvement. Second, Turner introduced two additional tower designs to vary up the work for larger groups of lean learners. Then, at the mid-way milestone, Turner will ask players installing the red blocks to exchange places with their peer from a team with a different tower design. This simulates how "people come and go on projects [and…] drives home the importance of clear conversations and sharing specific info on the [sticky notes]" to convey project requests, promises, and the conditions of satisfaction (Zettel 2014).

Turner also identifies the following learning objectives when facilitating the DPR Pull Planning Game: (1) Pull planning is one of the five key steps of the full LPS, (2) In every handoff of work between parties, there is a customer and a supplier, (3) Work can be planned when the customer makes a clear request to the supplier – the customer pulls what they need from the supplier, (4) The supplier then becomes a customer in order to meet the overall end customer's request, (5) Work is planned starting from the milestone activity working right to left, (6) As you get closer to the date the task will be performed, you may need to adjust your plan to improve process and that adjustment to the plan and adding detail to the plan is OK and is expected, and (7) Descriptions of the tasks on the tag come from clear, specific discussions between the customer and the supplier involved in the handoff.

In closing, we recommend that academic facilitators use the DPR Pull Planning Game as the first simulation to teach lean learners about Pull Planning basics. It is concise, easy to facilitate, and accessible to lean learners as they experience and begin to understand key Pull Planning concepts. Then, in a later class, academic facilitators may follow up with Villego which will be discussed in the next section. In contrast, we recommend that industry facilitators use the DPR Pull Planning Game if they have less than two hours to provide training to project teams that need to begin Pull Planning soon afterwards. If they have four or more hours to provide Pull Planning training, then we recommend that they use the time to facilitate Villego instead.

VILLEGO

SIMULATION OVERVIEW

En& - Systems thinking at work, BOB bv, and the Change Business Ltd developed Villego in December 2009 (Katan 2014). Requiring about four hours to play, Villego provides a comprehensive simulation of the LPS's Plan-Do-Check-Act (PDCA) qualities. In the first round, it challenges a team to plan and build a Lego® house with a Gantt schedule and drawings as guides. During the first round, the facilitator does not provide any guidance and allows the team to plan construction based on their own approach. After round one, Villego recommends providing an overview of the LPS (Villego 2013). In the second round, the facilitator will help the team use Pull Planning to determine the handoffs between subcontractors. Then, after each construction minute, the facilitator will help the team reflect on the results and replan.

PULL PLANNING-RELATED LEARNING OBJECTIVES

Villego clearly shows the value of a structured PDCA approach in project work, i.e. the LPS. In the second round, the facilitator shows the team the basic mechanics of Pull Planning and how it is an integral part of the planning phase. As a result, Villego helps lean learners understand that:

- The key is collaboration amongst the team members, and Pull Planning provides the framework to enable collaboration.
- Plans are models of the real world and consequently can never capture all of its detail and nuances.
- Since it is hard to perfectly predict how the future unfolds, they must be open to revising their plan after learning and when new details emerge.

SIMULATION FACILITATION TIPS

There are nuances to announcing key information at specific times of play. As a result, we and Arend Katan of BOB (Katan 2014) recommend that those who wish to facilitate Villego observe it twice before attempting facilitation. Furthermore, we recommend that a facilitator manage only one team at a time. While an experienced facilitator can manage two Villego teams, this would reduce the facilitator's ability to interact with the lean learners and foster deeper LPS learning. Ideally, we recommend a ratio of one facilitator and one assistant facilitator to each Villego team.

If facilitators have limited time for Pull Planning training, we suggest that they bypass the black and white drawings in the first round and begin using the color drawings instead. This eliminates the ability of lean learners to claim that some of the benefits from round two can be attributed to using only color drawings instead. In contrast, Arend Katan has found that using both the color and black and white drawings generates a valuable discussion regarding whether teams innately have the initiative to ask for more information from owners (ibid).

To save time, facilitators can also skip requiring subcontractors to fill in material order forms. Instead, they can use the laminated cards to determine the blocks that they need. However, Arend Katan has found that requiring subcontractors to fill in order forms adds a valuable extra dimension to play because it introduces the possibility of errors on the part of the subcontractors (ibid). This allows Villego to illustrate the impact of small procurement errors on the construction process.

One last time saving measure determines if the team does not need to be convinced to use the LPS. Then, the facilitator can skip Round 1 completely and the team will just play Round 2 to learn about the LPS and its emphasis on PDCA.

If a team has not finished building the house by 20 minutes in the first round, Arend Katan advises to stop play and extrapolate the data to calculate the results (ibid). During the second round, we suggest that the facilitator assist the team with the first minute or two of Pull Planning before encouraging the general contractor to take over. Then, we recommend using arrow-shaped sticky notes to mark the end of each construction minute. The facilitator can then write the minute's Percent Planned Complete directly on the arrow sticky note to help the team replan the next minute.

Since catching reuse of waste is tricky, we recommend that the facilitator become personally responsible for tracking waste reuse if there is only one data collector. If

there are two data collectors, we recommend that one data collector tracks when subcontractors are on site and the other tracks safety violations as well as waste reuse.

As a matter of hygiene, we recommend that facilitators regularly spray the hats with disinfectant or wash them in a dishwasher. Then, at the start of play, they should check if anyone has a germ phobia and if so, allow that player to hold onto the hat in a pocket or their hand while on site. Alternatively, facilitators can purchase easier to wash colored hard hats to use with their local projects. Villego originally used hard hats but discontinued their use since they were bulky in transport (ibid).

Finally, Table 1 outlines average Villego results for nine teams. We provide this data to help other facilitators see how their teams compare in performance.

Table 1: Average Villego Results (n = 9)

Round 1 Profit/Loss	Round 2 Profit/Loss	Profit/Loss Difference	Round 1 Duration	Round 2 Duration	Duration Difference
– €380,000	€40,000	€420,000	21:45	6:22	15:23

DESIGN OF PULL PLANNING TRAINING SESSIONS

To address the problem that industry facilitators are often given limited time for Pull Planning training, we have developed the following recommendations for design of training sessions. Academic facilitators may also use these recommendations to determine how to break up Pull Planning learning amongst multiple class meetings.

Table 2 outlines our recommendations for the hours to allocate to each training activity based on the hours available. The top half of Table 2 assumes that the actual Pull Planning effort will take place on a separate day soon after Pull Planning training. The bottom half of Table 2 outlines our recommendations for a session that includes an actual Pull Planning effort. Since it involves training right before the actual Pull Planning effort, we recommend limiting the actual Pull Planning effort to two hours.

Table 2: Design for training session *with* or *without* an actual Pull Planning effort

Available Hours	LPS Overview	Lean / LPS History	LPS Details	Parade of Trades	Airplane Simulation	Silent Squares	DPR Pull Plan Game	Villego	Actual Pull Plan Effort
2.0	0.5					0.5	1.0		Future day
4.0								4.0	Future day
6.0	0.5			1.5				4.0	Future day
8.0	0.5			1.5	2.0			4.0	Future day
15.0	1.0	2.0	4.0	1.5	2.0	0.5		4.0	Future day
4.0	0.5					0.5	1.0		2.0
6.0								4.0	2.0
8.0	0.5			1.5				4.0	2.0
15.0	1.0		4.0	1.5	2.0	0.5		4.0	2.0

In contrast, if the actual Pull Planning effort will take place on a future day, then we recommend limiting the future Pull Planning effort to three hours. After three hours, the trades will run out of energy and focus to be truly effective in planning.

CONCLUSIONS

McGraw-Hill (2013) had a surprising insight – amongst 193 survey respondents, 36% reported implementing Pull Planning while only 30% reported implementing the LPS. Since Pull Planning makes up one of the five elements of the LPS, it is important for companies to understand all levels of the LPS to reveal more possibilities for value generation and waste reduction. Also, as mentioned earlier, Pull Planning is emerging as a popular first step for many companies that begin to implement lean on AEC projects (ibid). As a result, it is important that companies and projects share their best practices regarding Pull Planning training and implementation. Thus, we hope this paper will inspire others to share their insights about Pull Planning training to help accelerate the rate of lean learning and implementation in the AEC industry.

ACKNOWLEDGMENTS

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