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Using the Villego® Simulation to Teach the Last Planner® System

Robert Warcup[1] and Edward Reeve, PhD[2]

Abstract

Research question: What type of learning and understanding can facilitators expect when teaching the Last Planner® System with the Villego® simulation?

Purpose: This paper studies the learning outcomes of teaching the Last Planner® System (LPS®) with the Villego® simulation.

Research method: Qualitative thematic analysis based on observations, surveys and interviews. Additionally, simulation scores are considered for each group of participants.

Findings: learning was influenced by the simulation to the extent that the simulation provided context rich experiences that helped participants understand lean concepts. Learning was also dependent on each participant's attitude and emotions, which emerged from interviews and direct observation.

Limitations: only two groups participated in the simulation study: a small group of college students enrolled in a construction management class and a group of construction professionals in the commercial sector during two separate training events. Additionally, the study is purely qualitative in nature, which includes only an evaluation of participants through observations and open-ended questioning.

Implications: findings will help teachers, trainers, and consultants feel confident that lean principles and the Last Planner® are adequately understood by participants through use of the Villego® simulation. Therefore, construction professionals, designers, and architects alike can benefit from the simulation.

Value for practitioners: findings will help Villego® facilitators prepare to deliver the simulation and provide insight into possible learning outcomes.

Keywords: Last Planner® System, Villego®, pull-planning, simulation

Paper type: case study

1 Assistant Professor of Construction Management at Utah Valley University, doctoral candidate at Utah State University, lean construction coach; robert.warcup@uvu.edu.

2 Professor of Technology and Engineering Education at Utah State University; 435 797-3642, ed.reeve@usu.edu.

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Introduction

Since the early 2000s, lean concepts and practices have continued to gain momentum in the global construction industry. As a production management-based project delivery approach, lean construction promotes value through the reliable release of work (Lean Construction Institute, n.d.). In lean construction, reliability occurs when the right work is completed by the right people at the right time. Lean recognizes that when subcontractors collaborate for the good of a project--pulling rather than pushing work into production--reliability increases. From design to supply and assembly, reliability in turn streamlines production while maximizing value and minimizing waste (Lean Construction Institute, n.d.).

The Last Planner® System (LPS®), developed by Glenn Ballard and Greg Howell, is a system that uses lean concepts and practices in construction project management. The LPS® is a collaborative, pull approach to planning in which the Last Planners, commonly trade contractor foremen, commit to complete the necessary tasks required on a project as the project team deems them necessary (Ballard, 2000). Reliability performance results indicate that projects which properly utilize the LPS® complete an average of 85 percent of all scheduled tasks, whereas traditional construction scheduling and project management complete an average of only 54 percent (Ballard & Howell, 2003). Alan Mossman of the UK shares additional benefits of the Last Planner® as "creat[ing] significant improvements in project and program safety, predictability, speed of delivery, profit and feelings of wellbeing among project staff" (2012).

These results have led companies to adopt and implement the LPS® with success (Ballard & Howell, 2003). However, because lean concepts often appear counterintuitive (AGC Lean Construction 101 Webinar, n.d.) compared to traditional project management--encouraging collaborative interdependence rather than siloed independence--it takes time and practice to understand the LPS®. Needless to say, many organizations are unwilling to put real construction projects at risk by using those projects to investigate the Last Planner®. Other organizations lack the funding to hire consultants that can guide them through the implementation process on real projects with high stakes.

Fortunately, LPS® teaching tools are emerging to help organizations learn and experiment with the system in a virtually risk-free environment. One such tool is Villego®. Developed by a lean construction consultancy team from The Netherlands, Villego® is a cost-effective, efficient, hands-on simulation that helps prepare teams to implement the LPS® on real construction projects by enabling them to first experience its concepts, processes, and practices in a simulated environment.

But is Villego® effective? Does understanding of collaboration and project flow increase as a result of the simulation? Do these qualitative improvements (collaboration and flow) lead to adequate knowledge of lean construction concepts? To answer these questions, researchers at Utah Valley University (UVU) put the simulation to the test, teaching Villego® to two disparate groups. At the conclusion of the simulations, researchers determined that the Villego® simulation can indeed be an effective means of teaching the LPS®. The researchers' methods, processes, and findings follow.

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Villego® at a glance

The Villego® simulation includes a minimum of two rounds of construction performed by teams of between six and 14 participants. In each round, a facilitator instructs the teams to construct a Lego structure, per plan, in the allotted time frame. Each 10-second interval represents one work day. In other words, each minute equates to one six-day work week. Between rounds, the facilitator introduces participants to the LPS®. The Villego® manual suggests that the training be spread out over a two day period with an introduction to lean on day one and the LPS® simulation occurring on day two. The simulation portion, which was the focus for this study, should last five to seven hours (2013).

In the first round, which generally takes one to two hours, participants use traditional push scheduling and management techniques. According to Villego® (2013), round one simulates the way participants currently deliver projects:

- Work is pushed into production as detailed by the critical path.
- Cooperation is not emphasized.
- Information is not shared.
- Costs are the primary focus.
- When problems occur, blame reigns as individuals focus on protecting themselves rather than advancing the project.

In the second round, which takes approximately two hours, participants utilize pull planning and other lean philosophies. According to Villego® (2013), round two simulates the way projects that use the LPS® are delivered. The LPS® techniques are characterized by the following:

- Work is pulled into production.
- Project management uses real time, in-process data and coaching.
- Continuous collaboration and cooperation are emphasized.
- Information is shared.
- Customer value is the primary focus.
- Teams focus on learning and continuous improvement.

Figure 1: Preparation for round one

Figure 2: Construction in round one

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During round two, planning sessions occur after each week (60-second interval) where the team identifies failures from the previous week and determines appropriate corrective measures to improve future performance. During the planning period, the team also collaboratively adjusts the project strategy going forward and precisely plans the work for the upcoming period. This process is repeated until the second structure is completed.

The two-round approach helps participants compare traditional management with lean management. Monetary bonuses for on-time completion, penalties for safety violations, fees for material delivery, and other considerations enhance the simulation. At the conclusion of both rounds, the facilitator compares scorecards and results for each round and helps participants identify specific experiences that emphasize lean principles. Below is a very basic summary of the Villego® simulation including the approximate time required for each phase:

- Round one (explanation, preparation, construction): two hours (typical)
- Introduction to the LPS® and lean construction: one hour (typ)
- Round two (explanation, preparation, planning, construction): two hours (typ)
- Recap, discussion, questions: half hour to one hour (typ)

Villego® test teams

Researchers selected two groups to participate in the Villego® simulation in two separate training sessions. The first group consisted of eight males and two females (n=10), nine of which were construction management students and one was a business management student at Utah Valley University (UVU). All were juniors and seniors with an average of 4.3 years of construction experience ranging from 0 to 20 years (the business management student was a general contractor with 20 years experience).

The simulation was part of an optional undergraduate research course, which focused on lean construction. The students had little knowledge of lean before the course began, but several of them had been minimally exposed to the LPS® and Integrated Project Delivery contracts at the Associated Schools of Construction student competitions. Their formal introduction to the Villego® simulation came after six weeks of studying lean construction in the course. Together, the ten students constituted one team for purposes of the Villego® simulation.

The second group of participants consisted of 21 male professionals (n=21) working for a small to mid-sized commercial construction company in Salt Lake City, Utah. Researchers selected this company because of a connection the researcher had with the company president as well as for the innovative perspective the firm has towards the industry. The Salt Lake City based company is a relatively new construction firm that is highly concerned with learning through formal study groups, trainings, and book clubs. The 21 professionals participating made up two teams for the simulation due to the number of participants.

Each of these professionals, with the exception of one, was considered to be a manager on various levels; project engineers, superintendents, and project managers. The professionals had an average of 12.2 years of construction experience ranging from 0 to 30 years. The one individual with zero years of construction experience was an office administrator for the firm and was therefore not assigned to manage any projects in this

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capacity. Only one of the managers had any knowledge of or experience in lean construction. This individual worked briefly for a large international construction company that had begun their lean journey a few years prior.

Five students from UVU, who had recently participated in the simulation, assisted with the facilitation of the simulation for the two professional teams. Researchers instructed the UVU student facilitators to coach the teams without providing any of the lean solutions they had previously learned from their own simulation. In other words, they allowed the two professional teams to struggle through the learning process just as they had previously done. They acted as true coaches.

Assessing Villego® Learning

Prior to beginning the first round of the simulation, participants from each group completed a short, four-question, open-ended questionnaire created by the researcher requesting their views on the strengths and weaknesses of current project management and scheduling techniques.

The pre- (and post-) simulation questions were:

- Describe the strengths of traditional scheduling methods.
- Describe the weaknesses of traditional scheduling methods.
- What is flow on construction projects?
- How can flow be created on construction projects?

After completion of the simulation, participants answered these same four questions along with several other questions, requesting an account of their experiences throughout the simulation. The remaining post-simulation questions were:

- What were your key "take-aways" from the simulation?
- What specific experiences demonstrated those "take-aways?"
- What will you implement right away?
- What was unclear or frustrating to you?
- What did you enjoy most about the experience?

The questions specifically probed into each participant's philosophy of scheduling and management before and after the simulation. Researchers designed each question after hypothesizing that the Villego® simulation would increase the level of collaborative planning between participants and the flow on a project. Therefore, the pre- and post-questionnaires recorded the change in participant's perceptions of scheduling and project management after the simulation. Specifically, the study identified changes in the idea of enhanced project level collaboration among project participants.

Researchers recorded and analyzed the qualitative responses using two different methods to triangulate the data. The first method summarized the open-ended responses and grouped them into similar categories to quantify the number of respondents holding similar views of the simulation content. This approach captured a change in the participant's understanding, pre- and post-simulation.

The second approach employed deeper qualitative analysis. Through observations, researchers recorded specific experiences, comments, reactions, and temperaments

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throughout the simulation. Documented observations emphasized participant experiences in which communication and collaboration were evident. Researchers recorded both evidence supporting enhanced collaboration as well as evidence supporting a lack of collaboration to establish the contrast between traditional management techniques and lean techniques.

Researchers also identified and recorded specific experiences in which lean learning was evident in participant's expressions, body language and words. Again, the intent was to illustrate how the simulation could offer unique experiences and teaching moments promoting the understanding of lean concepts. After observations were recorded, researchers organized frequently used words and key words (such as collaboration, teamwork, overproduction, etc.) into a qualitative domain analysis to identify the major themes of the simulation study. A taxonomic analysis was conducted to summarize any relationships among these themes. The themes were then compared and contrasted through the process of selective inquiry. Researchers explored these paradigms until several dominant findings emerged from the data.

Team experiences from round one

During the planning phase of round one, both the students and the professionals were instructed to prepare their materials for construction. Each team's approach to planning was different. Some participants chose to mark up their plans while others chose to organize and prepare their materials for construction. For the most part, project coordination and planning between subcontractor peers was lacking.

The role of the general contractor, assigned to an individual with real world project management experience, was to determine his strategy for construction and convey it to each subcontractor on the project. Most of the specialty contractor interaction was limited to coordination with the general contractor who was both attempting to learn his role in the simulation and to direct his team.

The researcher observed and documented reactions, expressions, and body language from all the teams that conveyed a sense of discomfort and apprehension prior to beginning construction. It was evident that they were uncomfortable because of the uncertainty of their role in the simulation. In contrast, there was also a feeling of excitement--a sense of enjoyment stemming from the uniqueness of the learning method.

Once the clock started and the construction period began, the mood became much more intense as teams raced to complete the structure as fast as they could. At times, tension was apparent as participants struggled to "keep up" with the project. Both the students and the professionals became visibly frustrated when errors were made. Sometimes these errors went unnoticed during construction; on occasion, they were discovered. The pace of the simulation creates a mood of competition so that when one subcontractor struggled, the others became visibly agitated. Both groups had several strong, high-performing subcontractors but also a few weaker subcontractors. This dynamic heightened the mood of the simulation both positively and negatively.

At one point during the rush to build the Lego structure, one of the students misplaced a block on the building without knowing. The next student, representing a different subcontractor placed his Lego on top of the misplaced block, thus covering the error. The team of subcontractors proceeded building upon the error until they completed

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the structure. After identifying the mistake in the final quality check, the student subcontractor who covered the initial error exclaimed, "I saw [the mistake] but didn't say anything."

The experience caused the students to actually *feel* the impact of traditional management thinking. It wasn't simply the error and the subsequent penalty. Rather, each student felt the power of the social environment. This feeling caused other students to shout "you should have spoken up!" These comments reflect evidence supporting a lack of collaboration, but provided the perfect opportunity to contrast the ways that lean considers quality and teamwork against traditional management philosophy.

The experience led into a discussion of the underlying concepts of the LPS® -–where the project team relies on collaboration to determine and carry out the project plan. This experience points to the LPS® as a social marketing event in which the team works together to create a change in behavior amongst members (Andreasen, 1994). Despite being a negative example of lean, the experience provided a deeper understanding that is difficult to learn through discussion or reading alone.

As the clock continued to run during round one, and as more penalties were earned, the team of subcontractors became more and more desperate to finish on time. As was the case for both groups in this study, round one is expected to produce results that are over budget, late and having poor quality. Therefore, the simulation outcomes reported a calculated net loss for each project team (see results tables).

The first round is also intended to produce relationships common to the construction industry; subcontractors seeking to optimize their own work at the expense of others, a high focus on cost, and a lot of blaming others when things go wrong. This traditional approach is often reactive and adversarial. Many of the observations recorded by the researchers illustrate how the lack of lean application to a given problem can have a detrimental effect on the project. It is the very experience, in context, that produces a highly-positive learning experience. As the participants experience these situations, it prompts a meaningful discussion on the related lean philosophy--helping the concepts develop, and in some instances, solidify in the participants' minds.

Introduction to the Last Planner®

After round one, the facilitator has the opportunity to discuss the results and begin a presentation of the LPS® in preparation for round two. The half-hour to hour long discussion and presentation, originally provided by Villego®, but often expanded by the researcher, covers waste, flow, and other elements of the LPS® and lean construction. It is an excellent time to identify and contrast the differences between lean and traditional management, which the participants just experienced in round one.

It is very important that the facilitators have previous experience with the LPS® so that they are fully capable of answering questions and explaining the simulation to the participants. Each group in this study had several deep, interesting questions. The professional group had very practical questions, such that it was evident that they were truly attempting to transfer the information to their own projects. Some of the lean concepts are so new and different from traditional project management that they may require more time than the presentation allows.

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It is not uncommon for these concepts to initially appear as counterintuitive (AGC Lean Construction 101 Webinar, n.d.). A few of the professionals were somewhat skeptical, which is to be expected when learning anything that challenges their traditional paradigms. The majority, however, were very open to the new ideas. All the student participants were accepting of the concepts, possibly because they lacked real world management experience when compared to the professionals.

Team experiences from round two

Round two begins with a planning phase just like round one. The Lego structure in round two is slightly different than that of the round one. Participants keep their same roles and are instructed to again organize their materials and begin planning for construction. The amount of planning time is usually similar to that of round one, but participants are encouraged to organize and cooperate more creatively. The major difference with round two is that after individual subcontractors plan on their own, the general contractor begins a collaborative pull-planning session. Facilitators provide specific instruction to assist him with the task. Because pull-planning is literally a backwards thinking exercise--from the end of a project to the beginning--it requires that the facilitator offers just the right amount of guidance and prompting. Part of the learning process includes learning by doing, even when it is uncomfortable.

Pull-planning in the Villego® simulation is accomplished in precisely the same manner as on real construction projects. Each subcontractor represents a different color (or trade) and provides input in to the sequence of the project. The sequence is represented by colored Post-it notes on a weekly calendar board. Starting at the end of the project, the final subcontractor promises to accomplish their work after agreeing on the terms of the hand-off with the subcontractor before him (the predecessor).

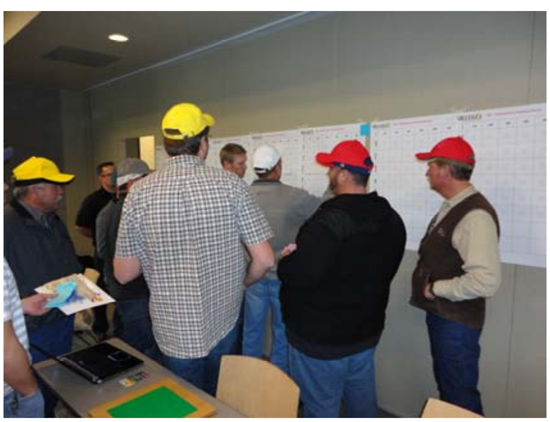

Figure 3: Collaborative pull-planning

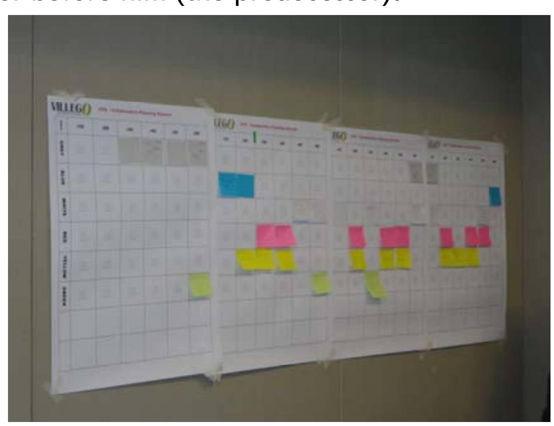

Figure 4: Completed pull-plan

A temporary phenomenon that each team had to overcome during round two was a trend the research team termed *pull-planning paralysis.* As the Last Planners endeavored to plan from back to front, they frequently got stuck after only a few tasks. They became frustrated with two items; the concept of pull and deciphering the reverse order of tasks.

As this temporary paralysis occurs, the facilitator should offer assistance without actually completing the task for the general contractor. It is critical that the general contractor maintains his/her leadership role. To help the teams understand the concept

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of pull, the Last Planner® (subcontractor) can be instructed to formally invite the next planner (predecessor subcontractor) up to the board to establish the terms of their hand-off. By doing this together at the board, the two planners formally agree to the terms of the task--determining when the predecessor will complete his task so the successor can begin his task. This format of formal invitations positively contributed to the simulation.

Agreeing upon a precise sequence to build the Lego structure is a simple challenge to overcome--but it is a concern that occurred with both groups. On real projects, the sequence of trades does not generally change much. In the Villego® simulation, however, the order in which the team chooses to place each block can vary greatly--as long as they are placed per plan. Specific block colors and sizes are placed according to the team's derived strategy--whatever that may be. This sequence flexibility contributes to the paralysis but can be overcome with proper coaching and encouragement. Facilitators should be aware that pull-planning paralysis was the most difficult obstacle to overcome during the simulation, however, once understood, the participants quickly embrace the new planning method and the session continues successfully.

Once the pull-planning session is complete and teams have collaborated, construction begins for round two. After the first 60 second period (representing one week), the clock stops allowing the participants to formally learn from their mistakes and to plan in detail for the upcoming week. It was common for the participants to feel uneasy about how to conduct the weekly planning sessions. One of the most important elements for the facilitators to teach the participants during the planning sessions was how to calculate PPC--Percent Planned Complete. This metric is calculated by dividing the percentage of completed tasks by the number of planned tasks during the previous week. Tracking PPC helps teams continuously improve as they identify root causes for performance failures from the previous week and subsequently put in place countermeasures to eliminate future errors.

The facilitator also helps the team "look ahead" to upcoming activities and to create weekly work plans for the upcoming week's tasks. These planning phases offer a greater depth of planning than traditional scheduling as the subcontracting teams "make ready" their work by preparing each task in great detail. After a few weekly planning sessions, the facilitator allows the team to run the remaining sessions with minimal input. By the end of round two, it is obvious to see that collaborative planning is critical to the project.

The results of round two commonly report improved results over round one; a positive net profit, on-time completion with minimal penalties. Construction duration will typically conclude well before the required project duration time expires. The improved results of round two helped the participants realize the power of the Last Planner® System and lean construction in general. See the results in tables 1-3 below.

Villego® team results

The data below indicates the improvements gained from round one to round two. Note the differences between rounds in construction time, productivity, and profit (or loss).

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Table 1: UVU Construction Management student results

	Round 1	Round 2
Construction time	11:31	5:33
Productivity (elements/minute)	8.86	18.38
# Subcontractors on site	96	50
Delivery penalties	8	0
Safety penalties	2	0
Damaged material re-use penalties	6	5
Waste penalties (# Lego studs)	0	0
Profit or loss	($117,922.12)	$84,023.24

Table 2: Construction professionals - team 1

	Round 1	Round 2
Construction time	12:27	4.37
Productivity (elements/minute)	8.19	22.09
# Subcontractors on site	75	30
Delivery penalties	5	3
Safety penalties	1	1
Damaged material re-use penalties	4	1
Waste penalties (# Lego studs)	44	34
Profit or loss	($78,285.64)	$119,586.76

Table 3: Construction professionals - team 2

	Round 1	Round 2
Construction time	12:05	4:55
Productivity (elements/minute)	8.44	20.75
# Subcontractors on site	99	39
Delivery penalties	4	5
Safety penalties	2	2
Damaged material re-use penalties	0	2
Waste penalties (# Lego studs)	16	172
Profit or loss	($93,721.40)	$13,034.20

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Simulation wrap-up

The power of the Villego® simulation is that facilitators and team members can discuss experiences from each round allowing the participants to relate the lean concepts to their own simulation experience. The facilitator deliberately prompts the participants to connect the process with the results. For example, participants identify that greater pre-planning, formal learning, as well as in-process planning all contribute greatly to the process. Experiencing the results offered a deeper understanding than simply learning about or reading about collaborative planning from a textbook.

In that regard, one of the most difficult lean concepts for construction industry participants to understand is the waste of overproduction. It is not uncommon for uncertainty to exist even after discussing the concept in a classroom or presentation setting. The commonly held paradigm is that it is always better to accomplish more work--even if it is not planned. The simulation allowed each team to experience overproduction and understand it first-hand in a non-threatening environment.

The students, for example, worked swiftly through the first few weeks of round two with minimal errors in production. However, during one particular week they noticed that they were approximately one to two "days" ahead of schedule, which means that there was no planned work for the remaining 10 to 20 seconds of the period. Several team members, fearing that the unused time would be wasted, shouted out to other team members to quickly proceed into the following week's tasks. Without having properly prepared, one eager student jumped in to use up the remaining time. He frantically placed his blocks just before the time expired for that week. He immediately recognized that he had placed several blocks in the wrong location. As he gasped in disappointment, the team spotted the error and instantly understood that they had all acted prematurely in encouraging him to continue construction without adequate planning. In a disgusted tone the student exclaimed, "So that is an example of overproduction, right?" Those few simple words verbalized the "aha moment" for the entire group.

A discussion ensued that considered real world examples of overproduction and the reasons it is considered the worst of all the wastes; because it creates or contributes to the other wastes--in this case errors and rework (Liker & Meier, 2006). Prior to this point, the students had read about overproduction, answered questions about it, and had even discussed it in class. They did not fully understand it however, until they experienced it personally in the simulation. They were able to feel its effects through penalties and rework as they proceeded throughout the remainder of round two. The simulation became the very tool that solidified the concept in their minds.

Interpreting the results

An analysis of the data suggests that the participants recognized the value of collaborative planning after having participated in the Villego® simulation. Responses to the pre- and post-questionnaire are reported below. Of the 31 participants from the two groups, not all were willing to respond to every question.

- Prior to the simulation, only 15 of the 31 participants (48%) mentioned any form of collaboration or planning as being important on the pre-test. Their experience revealed that subcontractors seldomly buy-in to the project strategy proposed by the general contractor. The lack of agreement makes it

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difficult for managers to attempt anything new, such as the Last Planner® (All 31 participants responded to this question).

- After the simulation, nineteen of 25 respondents (76%) indicated that communication, collaboration, teamwork and commitment were their key "take-aways." (Six participants did not respond to this question).
- Seventeen of 24 participants (71%) stated that they would implement the LPS® in some form immediately, such as pull-planning, soliciting subcontractor buy-in when planning and scheduling, or increased collaboration. (Seven participants did not respond to this question).

This data suggests that the Villego® simulation appropriately emphasized the importance of collaboration, teamwork and buy-in through the LPS®. A typical classroom discussion does not produce such unreserved results. Rather, it is the hands-on experience that leaves an impression on the learner. It is important to note, however, that the participant's comments also indicated that additional learning would be necessary for them to fully understand the LPS® and have the ability to implement it properly on their own projects. Further guidance and consulting is recommended.

The qualitative, taxonomic analysis identified the following themes as critical components to the study; *learning*, specific lean *experiences*, *emotions*, and *attitudes*. Each of these major themes contributed to the success of a participant's learning and/or experiencing the LPS®. A participant's attitude contributes positively or negatively to the way they experience the new lean concepts. The experiences produce emotions. Together, one's experiences, emotions and attitude influence the learning that takes place during the simulation--for better or for worse.

Learning is the outcome that the Villego® facilitator is seeking for each participant. Learning occurs as incoming information is built upon or added to one's prior knowledge (Bransford, Brown, & Cocking, 2000; Cobb, 1994; Vygotsky, 1978). The safe learning environment of the Villego® simulation bridges the classroom with reality. It is a form of situated cognition allowing the learner to "construct meaning from their experiences through doing" (Brown, 2001).

Additionally, the expectation is that learners will change because of the newly acquired knowledge. Alexander, Schallert, and Reynolds suggest that learning is a process of change (2009). The Villego® simulation attempts to reconstruct management's paradigms by expanding their knowledge and their skills with the intent to change behavior.

Learning is a critical and formal component of the LPS®. Lean emphasizes learning from the past so that mistakes will not be repeated in the future. As previously stated, the Percent Planned Complete (PPC) metric is used to identify performance failures (Ballard, 2000, Ballard & Howell, 2003). Systematic learning by recording and reporting PPC results is a positive approach to managing the learning of a team. As participants compare their initial plans with their actual performance, the variances are addressed and discussed so that any problems encountered during the previous work period will not be repeated.

The most valuable experiences from the Villego® simulation came not only through simulating the LPS® process but also through experiencing mistakes, errors, and the overall struggle. The overproduction "aha moment" experience mentioned previously was

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invaluable to all the participants. Not only did both groups have similar experiences with the waste of overproduction, but also with root cause analysis (5 Whys), the "go slow to go fast" concept, look-ahead planning, the weekly work plan, tracking non-conformances, and creating countermeasures, all of which are part of lean and/or the LPS® (Liker, 2006; Ballard & Howell, 2003). Even the pull-planning paralysis was an important phenomenon to experience and overcome. As the participant struggles through these uncomfortable situations, the learning deepens and solidifies within them.

The experience was accompanied by a wide degree of emotions as participants pushed through the uncomfortable feelings of making mistakes, becoming paralyzed with uncertainty, even feeling unprepared at times. It appeared that most experienced anxiety, tension, impatience, enthusiasm, and excitement. Each of these feelings are considered activity-related, achievement emotions that will contribute positively or negatively to learning and to performance (Pekrun, 2006). The benefit to the Villego® simulation is that the experience itself is quite enjoyable, which has a positive influence on the participants in most cases.

Much of learning lean is correlated with attitude. This assertion is based on additional experience of the researcher with several companies attempting to learn and implement lean concepts. In this study, those participants with a positive attitude asked questions, attempted to transfer the information to their current projects, and were positively competitive during the simulation. Additionally, they were very open to planning collaboratively during the simulation and were equally anxious to do the same afterwards on their own projects. However, in a few cases, when participants demonstrated an overly-critical attitude, they did not accept any new ideas that differed from their tightly held paradigms.

As a negative case analysis example, one of older superintendents from the professional group experienced this very phenomenon. During the presentation introducing the LPS®, this individual commented several times, objecting to the information presented. Later, during round two, it was evident by his body language and his diminished enthusiasm that he had mentally "checked out." His tightly held paradigms were too strong to break. Therefore, it appeared that his negative attitude did not allow any learning to take place during the experience. While this individual was the anomaly rather than the norm, this same situation has occurred on several other occasions when the simulation has been presented by the researcher to a general contracting company with seasoned managers. It seems that those few individuals who are "stuck in their ways" usually remain stuck.

However, a positive attitude influences emotions, which in turn contributes to greater acceptance of the new philosophies. Based on the comments and the expressions from both the students and the majority of the professionals after the training, each participant realized that they had just experienced something special. Not only were they able to cut their simulation build time in half because of the LPS®, they also realized that they were learning concepts considered to be on the forefront of the construction industry. Many participants from both groups commented that they were excited to test these tools on their own jobs.

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Conclusion

No participant can learn everything about the LPS® through one iteration of the Villego® simulation. Hours of additional study and practice are required to replicate the concepts on a real project. However, like other lean simulations, the Villego® simulation provides a focused experience in which participants learn the importance and logic behind the LPS® by experiencing and feeling the effects of the lean concepts in play (or the lack of lean concepts). The traditional paradigms each participant currently possesses can be altered or possibly completely changed through the simulation as long as their attitude and emotions are positive.

Because each group of future Villego® participants can vary greatly in their ability to learn and change, the results of this study may not be precisely generalized to all participant teams. However, in the spirit of qualitative research, there was no attempt by the authors to identify one single finding that supports all learning outcomes. Rather, the intent was to identify what each case could offer as potential obstacles to learning as well as recognize the positive learning outcomes from the participant's words and actions (Stake, 2013). The reader must then decide whether the results can be transferred to their own situations.

This study was intended to test the Villego® simulation as a means of teaching the LPS®. The research suggests that participants are more inclined to collaborate with others after the simulation as they consider planning their real world projects. The study confirmed that greater learning occurs when participants are able to experience lean concepts. However, the LPS® offers a beneficial introduction that creates understanding and buy-in prior to real world implementation. As instructors, consultants and facilitators prepare to teach the LPS® to construction professionals, designers, and students alike, the Villego® simulation should be considered a valuable option.

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