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TRAINATHON LEAN SIMULATION GAME: DETERMINING PERCEPTIONS OF THE VALUE OF TRAINING AMONG CONSTRUCTION STAKEHOLDERS

Yamini Bhatt,[1] Zofia K. Rybkowski,[2] Negar Kalantar,[3] and José L. Fernández-Solís[4]

ABSTRACT

This research was prompted in part in response to a recent study by the Associated General Contractors (AGC) that there is a shortage of trained, skilled labor in the construction industry and this shortage is increasing. The QUESTION this paper seeks to address is: Why aren't construction stakeholders perceiving the value of training and development of employees? The PURPOSE of the research is to develop and test a simulation that will help identify the way building stakeholders view the impact of employee training on their long and short-term profit margins. The RESEARCH METHOD used was two phased: (a) a preliminary phase involving the iterative development and testing of a 50-minute table-top simulation using readily available materials; (b) a mature phase where results from a "perfected" version of the game were subjected to statistical analysis from a larger participant pool. The trials each team went through financially at each round were recorded and results recorded via cash flow diagrams. FINDINGS suggest that players tend to underestimate the importance of upfront training and its impact on long-term cash flows. LIMITATIONS of this research include a restricted sample size that was tested during this phase. IMPLICATIONS and VALUE for this work are potentially larger than that of pure research—i.e. as an opportunity to serve as a change agent as well since a number of respondents suggested that the simulation made them think about the long-term value of training, illustrating the first principle of *The Toyota Way*. This dual-role for simulations fits easily within the culture of lean construction which historically has used simulations both to understand impacts of certain types of stakeholder behavior as well as transfer comprehension of specific lean principles.

[1] Graduate Student, Department of Construction Science, Texas A&M University, College Station, TX,77843 USA, +1 669-226-1530, yam_karthik@tamu.edu

[2] Assistant Professor, Department of Construction Science, Texas A&M University, College Station, TX,77843, +1 979-845-4354, zrybkowski@gmail.com (corresponding author)

[3] Assistant Professor, Department of Architecture, Texas A&M University, College Station, TX, 77843, +1 979-845-7075, kalantar@tamu.edu

[4] Associate Professor, Department of Construction Science, Texas A&M University, College Station, TX,77843, +1 979-458-1058, jsolis@tamu.edu

KEYWORDS
Lean simulation; training; long-term value; skilled-labor shortage.

INTRODUCTION

This research was prompted in part in response to a recent study by the Associated General Contractors (AGC) highlighting a growing shortage of skilled labor in the construction industry. According to Loosemore et al. (2003) and Wild (2002) the construction industry exhibits a particularly dynamic and complex industrial environment. This creates a challenging situation for training and development (Loosemore et al. 2003; Raiden and Dainty 2006). The fast changing competitive environment requires effective development and management of human resources. Project Managers, executives and supervisors play a vital role in creating a positive impact by transferring knowledge to their employees (Jong et al. 1999). Nevertheless, literature about the construction industry indicates inadequate consideration is given to staff training practices (Tabassi et al. 2012).

DEFINING TRAINING

Training emerges from the realms of learning. "Training is an effectively outlined effort that develops knowledge, attitude, abilities and skills through learning experiences, helping people involved (trainees) to attain potent performance in an activity" (Garavan et al.1995; Reid et al. 1992). Training offers incremental adaptability and flexibility for employees and thus becomes essential for an organization to cultivate its proficiency (Tai 2006). Training and development practices must be recognized by companies as a vital means to enhance a company's level of achievement (Huemann 2010; Latagana et al. 2010; Raiden and Dainty 2006). It is critical for every construction organization to develop a learning environment for its employees (Raiden and Dainty 2006).

NEED FOR TRAINING

A survey conducted by the Associated General Contractors of America (AGC) involving more than 1,000 construction firms across the U.S. indicated that 83% of firms currently encounter a challenge finding craft workers (shown in **Figure 1**) and 61% of firms confirmed difficulty filling executive positions. This has increased from 74 % and 53%, respectively, as measured against the prior year (AGC 2014). Finding experienced workers in the industry is a primary concern for A/E (architecture and engineering) firms, GCs (general contractors) and specialty trade contractors. The literature on training and development in the construction industry offers a pessimistic view of investment in this area. In the construction industry, employee training and its benefits are undervalued, resulting in a lack of formal training practices (Kuykendall 2007).

RATIONALE FOR INVESTING IN TRAINING

According to a study by the Construction Industry Institute (CII 2007), a return of \$3.00 is expected for every \$1.30 invested on craft training; The US Department of Labor also confirms a productivity increase of 16% on ongoing trainings. Even though the return on investment is high, contractors remain averse to allocating time and money for worker training (Kuykendall 2007). Also according to research conducted by the Construction Industry Institute (2007), trained workers appear to have lower turnover and absenteeism rates than workers without training. The study reported that training appeared to be responsible for a 23%-27% decrease in rework and injuries. Moreover, a substantial decrease in absenteeism and turnover rates appears to lead to a 10% increase in productivity.

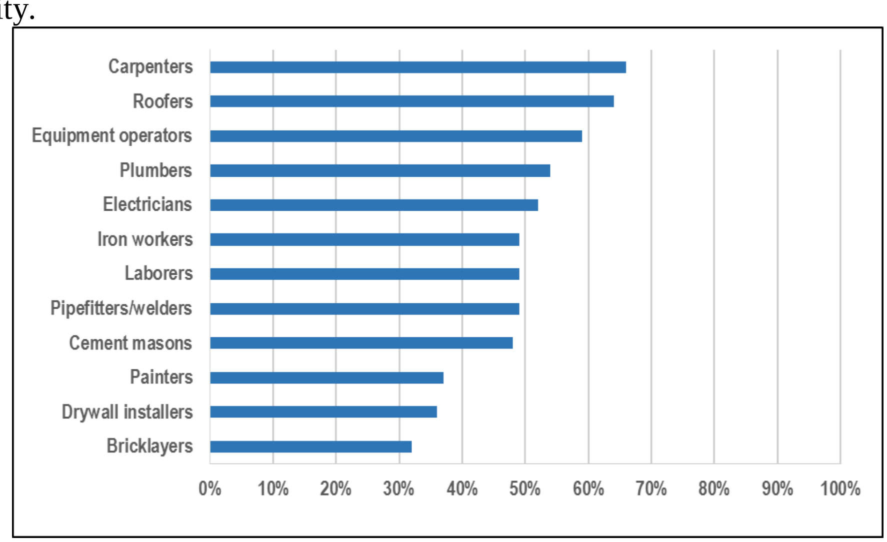

Figure 4: Craft workers shortage according to the survey conducted by AGC Adapted from Skilled labor Shortage (AGC 2014)

IMPORTANCE OF ON THE JOB TRAINING

An expansion of the construction industry during the last decade has led to the need for a workforce that is equipped with technical and managerial skills. McGraw-Hill Construction (2012) conducted a study on the use and importance of training by the A/E firms, General Contractors (GC) and specialty trade contractors. General contractors and specialty trade contractors rank on-the-job training as their top-most priority. Almost 64% of A/E firms and 67% of GC's indicated that on-the-job training is as important as a college education. A high score for on-the-job training reflects the importance the industry places on the value of practical, real-world experience. Also according to the McGraw-Hill (2012) report, the skilled labor shortage can be addressed by continuous education and training programs for workers to help sharpen their skills and update their familiarity with forms of innovative technology. According to Karen Holloway, Project Management Institute's Lead Instructional Designer, training boosts learning retention because when everyday work is combined with learning, the mind starts associating sights and sounds of the environment with skills under development (Gopanapalli 2014). Erina et al. (2015) argues there is a need to offer training to improve productivity on construction projects. Trainings should be designed to increase construction site productivity.

LEAN GAMES AND ITS IMPACT

The Lean Construction Institute (LCI) uses simulations to teach lean concepts (Rybkowski et al. 2012; Verma 2003). Simulations have played a crucial role in Lean construction (LC) by successfully demonstrating the practical implications of lean principles. According to Canizares (1997) and Walters et al. (1997), the simulated game environment helps participants to comprehend real world scenarios, enabling students to understand more easily lean concepts and their application to construction industry processes. For example, simulations such as the Lego® Airplane Game (Visionary Products 2008) and Parade of Trades simulation (Tommelein and Howell 1999) are regularly played by the Lean Construction community to educate participants about the impacts of pull, batching, and variability.

This simulation is an effort to help the participants understand how a company's decisions, if based on a long-term philosophy with respect to employee development, might prove costly initially but can benefit the company in the long-term by increasing its productivity. The simulation is also an opportunity for the authors to better understand the behavior of players confronted with weighing the short-term cost demands of upfront training against long-term benefits associated with that training.

RESEARCH METHOD

The purpose of this research is to develop and test a simulation that will help identify the way building stakeholders view the impact of employee training on their long and short-term profit margins. Trainathon lean simulation is a "perfected" version of a preliminary simulation concept that was developed in a Lean Construction class at Texas A&M University during the spring semester of 2015. Those involved in the development of the simulation's preliminary version included Krupal Bhatt, Yamini Bhatt, Sai Anirudh Challa, Rajath Padmaraj, Sachin Singh, Abhishek Shete, and Geethika Yarlagadda. The simulation was administered to graduate and undergraduate students in the Department of Construction Science between December 4, 2015 and February 10, 2016. The simulation was iteratively modified during successive trials. A total of 201 students was selected to participate in testing the mature version of the simulation.

To play the simulation, the following items were needed:

- Paper with 3 x 3 puzzle template
- Tokens with numbers written on them for each round
- Financial score cards (to record the cumulative cash flows and time taken in each round by the Project Manager; one per team)
- Pencil or Pen
- Stop watch
- Paper Tutorial (training to help solve the puzzle; one for each team)

The facilitator asked participants to form teams consisting of one Project Manager (PM) and two employees. The facilitator announced the objective of the game was to complete a given mathematical puzzle in the least possible time. The puzzle consisted of a 9 square (3 x 3) grid where each horizontal and vertical row must tally to a specified sum using individually pre-numbered wooden tokens (although paper tokens are also acceptable). The maximum permitted time in play per round was two minutes. The simulation was conducted in three rounds. The teams were able to earn profits and increase their net worth by solving their puzzles on time. The facilitator consulted a stopwatch to restrict the time limit to two minutes. At the beginning of each round the Project Managers were offered the opportunity to train their teams. The training was a tutorial that revealed how to solve the puzzle. The Project Managers were given financial score cards; they were responsible for requesting training for their employees and completing the financial score cards. For each successful attempt, the teams earned $1000. The initial amount given to every team at the start of Round 1 was $2000. Training cost $1000 per team and represented a onetime cost. The cost of labor per team per round was $500. The profit for each successful attempt was $1000. During each round, the tokens and sums were refreshed, but the mathematical strategy was the same and could be learned if teams had opted for training. The trials and tribulations each team went through financially during each round was recorded by the Project Manager. An assumption made for this study that undergraduate and graduate students in the Department of Construction Science at the university accurately represent future stakeholders of the construction industry. Their mindset is assumed to reflect the mindset of the industry.

RESULTS

The data collected for Trainathon lean simulation were evaluated using the financial score cards completed by each team. The financial score cards provided information about the cost and the time taken in each round to finish the project. Based on the financial trials of each team per round and the tendency of participants to request training upfront, 14 different scenarios were observed. **Table 1** shows the 14 observed scenarios. These were further evaluated using cash flow diagrams and bar graphs. The acronyms appearing in **Table 1** stand for the following: **NT** (No Training); **T** (Training); **NS** (No Success); and **S** (Success). Additional factors such as gender ratios, age, and participant experience were also recorded. The numbers of teams opting for each scenario are tabulated in **Table 2**.

Table 1: Explaining the 14 case scenario generated through the Lean simulation

	Case No.	Round 1 (R1)	Round 2 (R2)	Round 3 (R3)
	Case 1	T:S	S	S
	Case 2	T:NS	NS	S
	Case 3	T:NS	S	S
	Case 4	T:NS	S	NS
→	Case 5	T:NS	NS	NS
→	Case 6	NT: NS	T: S	S
	Case 7	NT: S	NT: S	NT:NS
	Case 8	NT: NS	NT: NS	NT: NS
→	Case 9	NT: S	NT: NS	NT: NS
	Case 10	NT: NS	NT: NS	T: S
	Case 11	NT: NS	NT: NS	NT: S
→	Case 12	NT: S	NT: S	NT: S
	Case 13	NT: NS	NT: S	NT: S
	Case 14	NT: NS	NT: S	NT: NS

Based on the frequency of occurrence, four case scenarios (case 5, case 6, case 9 and case 12) were selected for further focused analysis. From **Table 2** it can be seen the four selected scenarios constituted a total of 46.25% of all scenarios. The results for the simulation were analyzed using cash flow diagrams (**Figure 2**). While field testing the simulation, three demonstration rounds were conducted. The data has been extrapolated for the cash flow analysis.

One observation made by studying the cash flow diagram is that teams that opted for training after R1 (Round 1) broke even in R3 (Round 3) after which they started making profits, visible by a uniform positive gradient. Teams that delayed the decision to train, suffered losses and recouped from the loss only after Round 5; their profit margins decreased by $1000 due to their delay in adopting training. **Figure 2** represents the case scenarios discussed below:

- **Case 5: *"The Worst case scenario"* (1.49 % of all scenarios)**: In this scenario, the teams invested in training and were still unsuccessful in completing the project. These teams suffered a negative cash flow which is represented by the uniform downward gradient in **Figure 2**. It was observed that the training concepts were either not well understood by the teams or they failed to collaborate.
- **Case 6: *"The pragmatic case scenario"* (34.32 % of all scenarios)**: The majority of participants followed this decision-making scenario. In this scenario, after an unsuccessful attempt in R1 (Round 1), the teams realized that they needed to undergo training. The PM requested to train the team. This led to a loss of $500 (seen as a dip in **Figure 2**). However, this also led to positive cash flows and an increase in their profit margins during subsequent rounds. By the end of the rounds the teams ended up with $5000. This is $1000 less than the ideal case scenario. **Case 9: *"No Training, no success"* (5.97 % of all scenarios)**: Three observations could be made about teams that found themselves in this scenario:

  a) PMs were ignorant about training and the profits they could earn;

  b) PMs thought that the employees could complete the project without any training; and

  c) They were willing to go through repetitive cycles of trial and error.

In this scenario, teams suffered a negative cash flow which is apparent by the uniform downward gradient in **Figure 2**. In this case, the PM chose not to train the employees even though they were continuously unsuccessful in their attempts. In some teams, the employees asked for training but the PM refused.

- **Case 12**: ***"The Ideal case scenario"* (4.47 % of all scenarios):** It was observed that despite the PM never choosing training for these teams, the teams continuously completed their puzzles successfully. In other words, this case required no investment in training by the company. It was observed that the graph was uniformly straight and the team continued to earn until successful project completion. By the end of Round 9, the teams earned $6000, as shown in **Figure 2**. This case is an outlier as only 4% teams fell under this category. This scenario is an unexpected outcome so should be explored with caution when making decisions about whether or not to train employees in actual practice. It is also worth mentioning that although these teams succeeded without training, training would have likely reduced their time to completion.

One additional case is worth mentioning:

● **Case 10: *"Training in the second round"* (5.97% of all scenarios):** These teams opted for training after two unsuccessful attempts. Their double failure, declining cash flow and surrounding competition led the PM to ask for training for their teams. The teams in the end earned $4000, as shown in **Figure 2**, which was $2000 less than the ideal case scenario.

Table 2: The number of teams opting for each scenario

Experiment #	1	2	3	4	5	6	7	Totals
No. of teams	N = 10	N=11	N= 11	N=10	N=6	N= 8	N=11	N=67
Total participants	31	33	36	31	22	26	22	201
Cases	% Teams in each case							
1	20% *(N=2)*	9% *(N=1)*	8.3% *(N=3)*	10% *(N=1)*			9.09% *(N=2)*	13.43%
2	10% *(N=1)*	18.5% *(N=2)*	2.7% *(N=1)*					5.97%
3					4.54% *(N=1)*			1.49%
4				10% *(N=1)*				1.49%
→ 5		9% *(N=1)*						1.49%
→ 6	30% *(N=3)*	27.5% *(N=3)*	13.8% *(N=5)*	30% *(N=3)*	13.63% *(N=3)*	11.53% *(N=3)*	13.63% *(N=3)*	34.32%
7						7.69% *(N=2)*	9.09 *(N=2)*	5.97%
8	10% *(N=1)*			10% *(N=1)*	4.54% *(N=1)*	3.84% *(N=1)*	4.54% *(N=1)*	7.46%
→ 9		9% *(N=1)*		10% *(N=1)*	4.54% *(N=1)*		4.54% *(N=1)*	5.97%
10		9% *(N=1)*	2.7% *(N=1)*	10% *(N=1)*		3.84% *(N=1)*		5.97%
11	10% *(N=1)*						4.54% *(N=1)*	2.98%
→ 12		9% *(N=1)*		10% *(N=1)*			4.54% *(N=1)*	4.47%
13	20% *(N=2)*	9% *(N=1)*						4.47%
14			2.7% *(N=1)*	10% *(N=1)*		3.84% *(N=1)*		4.47%

The reasons stated by the teams for not asking for training were:

a) The PM estimated the project was easy and was not willing to pay for training. In certain cases, this attitude led to discord between the PM and the team.

b) The team members were challenged by the puzzle and wanted to try it on their own.

c) Few teams focused on the upfront cost of training and ignored potential long term profits.

The ones who took training in R1 were the most profitable teams in the end. The majority of people who took training after R2 were almost $2000 behind the ideal case scenario.

The ones with no training experienced a uniform downfall in gradient. **Table 3** illustrates the substantial difference in time taken by teams during each round. The teams who decided to train in R1 finished faster than the ones who took training in R3. The 95th percentile for the team taking training in R1 was 1.04 min., which is 0.23 seconds less than the team taking training in R3. This clearly indicates an increase in productivity for a trained employee. In other words, data from the Trainathon lean simulation trials suggests there is likely a substantial difference in the productivity of employees who take training in comparison to employees without training.

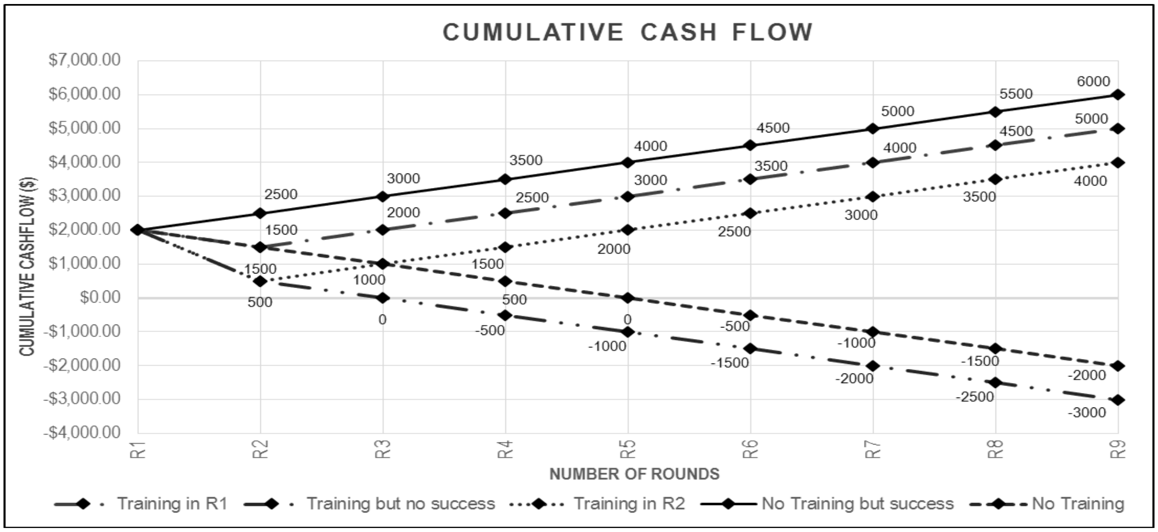

Figure 5: Displays the cash flow of each team at every round.

Table 3: The time taken on percentile basis

	Training in R1	Training in R2	Training in R3
P50	0.41	0.88	1.13
P90	1.05	1.15	1.47
P95	1.04	1.17	1.27

P_{50} stands for time taken by the 50th percentile of the participants;
P_{90} stands for time taken by the 90th percentile of the participants; and
P_{95} stands for time taken by the 95th percentile of the participants.

DISCUSSION

During the live playing of Trainathon several behavioral characteristics of participants emerged and these characteristics could be classified into "scenarios." Two are of special interest when applied to practice:

"The Ideal case scenario" This scenario was played out by participants who believed in themselves and felt convinced they could complete the project without training. Some teams did, in fact, manage to complete the project successfully without training. This population represented only 4% of the total sample size. This situation is found when employers seek the best graduates from premier educational institutions or among experienced professionals who do not require additional training.

"The Worst case scenario": These participants were forced to bear the decision made by their team leader to never purchase training. Team members in this scenario expressed feeling demotivated as they were never successful. Participants of teams in this scenario became increasingly demoralized as their competitors began performing with increased efficiency. For teams that found themselves in this scenario, there was a visible friction in the dynamics between the project managers and the team members. This mirrors actual scenarios where poor team dynamics can lead to productivity losses (Santorella 2011).

Overall feedback from the participants suggested, *"The simulation was challenging"*. It made them think about the "*long-term value of training."* Participants felt demotivated in cases where the PM did not train them. One respondent who did not receive training wrote, *"It was infuriating when the PM denied training as the people who trained finished their project faster while we struggled."* The simulation reinforces the notion that teams in the construction industry are varied and each team member exhibits personal strengths and weaknesses. Project Managers would do well to identify the abilities of each team member and consider offering training to supply specific skillsets that each individual requires for the task at hand.

CONCLUSION

As Trainathon teams postponed decisions to train, they lost $1000 repeatedly and this loss over time was recorded in cash flow diagrams. In the "real world," postponing a decision to train employees who do not already possess a critical skill can lead to a loss of millions of dollars on a construction project. Additionally, "trained" teams took 20% less time to complete a round, on average, than non-trained teams. It was observed that the majority of teams understood the concept of investing in training only after they failed once**.** After playing Trainathon, participants indicated they understood the lean principle associated with the simulation. The intent of this research was to develop and test a simulation to effectively highlight the value of training and its associated long-term benefits, thus helping to motivate increased productivity in the construction industry. According to Rybkowski et al. (2008), lean games create a "eureka moment" that enlightens participants about the effectiveness of a concept in a way that traditional presentations sometimes fail to do; This simulation was developed to create such a moment for stakeholders. But it was also developed to help researchers better understand the behavior of individuals confronted with options for upfront training. Student participants in this study were potential stakeholders in the construction industry and it would be worthwhile for a future longitudinal research project to investigate whether their understanding endures or is transformed as the student participants pursue careers following graduation.

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