

LEARNING LEAN THROUGH LEAN GAME – A CASE FROM THE INFRASTRUCTURE INDUSTRY

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ABSTRACT

Lean games can be a successful way to introduce Lean thinking but identifying and removing learning barriers in the games are important for successful quality learning that supports individual Lean thinking and behaviour after playing the game.

FIA– Renewing in the infrastructure industry, developed a Lean game for educating all their members in Lean production. The game was initially influenced by the Buckingham Lean Game and then adjusted to fit an infrastructure production process. Focus in the design process and when playing the game is on breaking barriers and making the learners, learn through reflection.

The game addresses basic Lean principles and tools such as; process design, eliminating waste concerning for example materials and space, push Vs pull, kanban card, kaizen and performance measurement. When this paper is written the Lean game InFrame has been played half a dozen times and so far no quantitative results can be presented. However, three levels of reflection can be distinguished.

Facing learning barriers when meeting practitioners in the construction industry is a critical issue for learning. However, games as a first introduction to Lean for practitioners is a rather undiscovered field of research and need more attention in the future. Further development and research need to focus on what do learners bring from playing Lean games and how can the learning environment for practitioners be improved.

KEY WORDS

Learning, Game development, Lean applied on infrastructure production, Process design, Continuous improvements.

AUTHENTIC LEARNING WHEN LEARNING LEAN

Playing Lean games, is one way of introducing Lean thinking to an organization that is about to implement Lean construction. A Lean game has thus a significant importance as an – more or less consciously chosen – first contact with Lean principles such as push and pull, kaizen and so forth, for people in an organisation implementing Lean.

The most important form of learning is that which enables us to see something in the world in a different way. It is characteristic of frontier research that it opens up new ways of seeing the world (Kuhn 1970). This could be said for Lean construction and thus the question of improving quality of learning when learning Lean is an important part of implementing Lean construction.

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Successful implementation of Lean construction means changing mindset among individuals in the implementing organisation. How to bring about Lean construction capabilities in people in one situation – for instance playing the Lean game - which they are supposed to make use of in other situations, that is their every day construction business environment. What the learner carries from the situation of playing the game to his or her normal business is recognized as the problem of transfer in the psychology of learning. But of course all knowledge must be transferred, Lean thinking is no exception. Anything that is learnt the learner must make use of in other situations; the player of a Lean game can never re-enter the situation that gave birth to learning (Smedslund 1953).

The pedagogical consequence is that the game leader is of great importance as supervisor to control the learning environment of the game. The game leader must first listen to the players, observe them and try to understand in what phase of learning Lean development they are, in order to find appropriate assignments and supervising in order to guide the players into their next level of development. That is the level that is closest to the level they already are on, as an individual or as a group (Miller 1988).

The question of transfer becomes a question of how the players of Lean games make use of what they have learnt. Without practical experience, the theory makes no sense; without theory one can not understand practical experiences. Learning situations – such as a lean game – should not only give real experience and visualisation, it should also make the learning players use to test their ideas and new settings in reality. The learners should meet a problem or complexity and feel an impulse, a lust to solve the problem in accordance with the dynamic learning (Dewey 1933)

OVERVIEW OF EXISTING LEAN GAMES

There are a number of Lean games to play in an educational purpose. Many described in articles and as playable versions on internet. Most of the games are typed for describing Lean principles within the manufacturing industry e.g.: Beer Game (Steerman 1987), Nima's Board Game (MacMillan 2007), Buckingham Lean Game (Bicheno 1995).

There are also games developed that adapt Lean philosophy at the construction industry, e.g.: LEAPCON (Sacks et al. 2005), and The Parade Game (Tommelein et al. 1998).

All these Lean Games are stable simulations that show the impact of Lean principles as: Kaizen, Heijunka, Kanban, JIT, 5S and so forth. The Lean principles are also shown trough computer simulations: Beer Game (Steerman 1987) (Nienhaus 2002), The Parade Game (Choo Tommelein 1999) (Alarcón, Ashley, 1999) and LEAPCON (Esquenazi Sacks 2006). The accurateness of these game models are well mapped in the extensive computer aided simulations.

In the framework presented about Lean Games focus is on showing different principles and not the players' context. There is not much written in the articles about the learning environment and the pedagogy carrying games out with practitioners in the construction industry. Also quite less is written about what reflections the players do when playing and when changes are made.

CASE: FIA, RENEWING IN THE INFRASTRUCTURE INDUSTRY

FIA, Renewing in the infrastructure industry, is a Swedish non-profit organisation gathering members of the infrastructure industry regarding that change and renewal is

necessary. FIA's goal is to renew the industry within 2010; higher efficiency, more quality, lower costs and increased profitability.

FIA focus on three fields:

- better teamwork between the participants of the infrastructure industry
- better incentive for research and education
- more efficient spread of the knowledge and experiences that exist

One of their actions is to inspire and educate the industry in Lean. Out of earlier experiences of distributing education packages and a deep knowledge of member companies, FIA identified the need for overcoming teaching barriers to not loose any members saying "this cannot be adopted here".

Actions were taken and FIA decided that first an education package about Lean with a game as base should be developed then all members of FIA should participate in workshops and play the game.

Lean Forum Bygg, Lean Construction Sweden, was engaged to develop a Lean game for FIA's members. Lean Forum Bygg is the leading inspirer in Lean thinking within the Swedish civil engineering sector. Lean Forum Bygg distributes knowledge of successful Lean practice, methods and tools to Swedish companies. Lean forum Bygg identifies needs of development, host seminars, workshops, conferences and trainings in Lean Construction.

PUTTING TOGETHER THE DESIGN TEAM

A design team from Lean Forum Bygg, with practical experience from working in construction projects and with education within the civil engineering sector, was put together. The authors, also members of the design team are experienced game leaders for various Lean games in university environment and in the environment of practitioners in the construction industry. Together the design team has played over fifty Lean Game rounds and given seminars to a few hundred students at university level and to practitioners in the civil engineering sector.

LEAN DESIGN OF A LEAN GAME

Initially the game design process was addressed. Important was to design a game that maximize potential learning for the learners and minimize waste during the design. When considering the design process a clear customer perspective was taken. Important was to identify a design process that support designing a game that give potential for true learning. Designing a game that gives no potential for true learning was considered as waste. One part is delivering a product with no or low value for the customer but also if playing the game in educational purpose; time spent on education activities with no true learning was considered as waste.

The design process identified, *figure 1*, starts in evaluating experiences and grasping design fundamentals. To understand the environment were, the customer, the learners are at reference groups and site visits were used.

The future development of the game will be an iterative process of continuous improvements. Experiences are continuously put back to improve the game as a tool for learning. After every game the players reflections and actions will be evaluated. As action teaching notes and game plan will continuously be updated after every session.

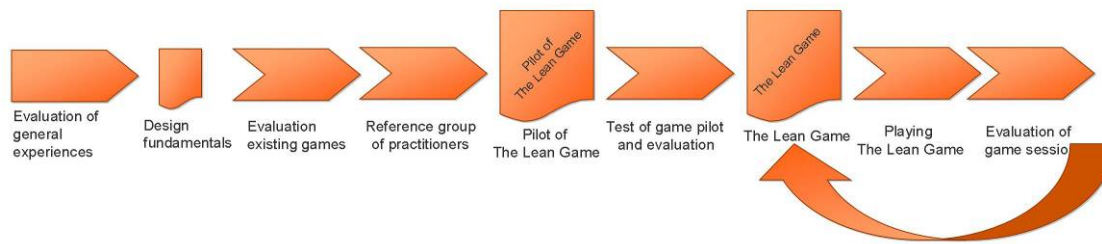


Figure 1: The Lean Game design process

GRASPING DESIGN FUNDAMENTALS

Starting point in the design process was evaluation of earlier experiences from education sessions with practitioners. Important in this work was identifying obstacles for learning and how to avoid them. Obstacles for learning were identified out of FIA's earlier experience and out the design team's earlier experiences. For designing a game that gives prospect for true learning, six design fundamentals were identified:

- Make the participants feel confident and relaxed in the education situation.
- Give the participants sufficient time to reflect on how rather abstract philosophy can affect an ordinary day in their business.
- Make the game and the discussion very tangible; problems occurred in a common day for the practitioners are very hands-on.
- Make the game as real as possible and show lean principles in an infrastructure context; practitioners tend to, more than university students, get confused with vocabulary and on game examples that describe an adjacent industry.
- Design the game with free boundaries; the players should be able to, through own reflections, take their own way trough the game.
- Make the game design process Lean.

EVALUATION OF PRESENT GAMES

The framework presented earlier gives a wide platform of how Lean principles can be simulated in classroom games. However, many of the games were considered to not emphasise the nature of the infrastructure industry. Playing a lean game that describes the reality of another, or even an adjacent, industry was through experience considered to be an obstacle for learning.

In the Buckingham Lean Game (Bicheno 1995) some characteristics were found that made the game suitable for further adaptation. The game has stability in the same time as flexibility, the processes could be translated to processes from the infrastructure industry and the game leaders were more comfortable with this game than others.

DEVELOPING THE LEAN GAME PILOT

To ensure that the nature of infrastructure construction would be understood by the design team, a focus reference group of practitioners in infrastructure construction was interviewed. Time was also spent at sites to better understand the problems that are faced on everyday basis, and to get the terminology right.

Taking the practitioners references in to count, The Buckingham Lean Game was chosen to be suited for further development. The example chosen in the Lean Game describes the process of manufacturing and delivering lining elements for tunnel coating and the game starts in a state that is recognised by participants from infrastructure construction.

EVALUATING THE LEAN GAME PILOT

The Lean Game pilot was played with a reference group consisting 12 national representatives from different backgrounds. All members of the board were interviewed about strengths, weaknesses and possible game improvements. Focuses were on: game tempo, vocabulary and associations, Lean Construction presentation, photos used, and possible misunderstandings.

During test run three explicit inconveniences were addressed and adjusted:

- Vocabulary
- The importance of giving learners time to reflect and discuss Lean principles
- The importance of understanding the players' daily environment to make tangible examples.

The design team also made improvements in the presentation of Lean principles and added more photos and realistic sound from a construction site.

The game also got acknowledgement during the test; *“Finally the construction industry got the same heavy education package used in the car manufacturing industry for decades”*. All members of the reference group were positive or neutral to the game example. The game design team interpreted the neutral reflections as positive in the sense that no barrier of knowledge transfer is present.

With the board's comments in mind, extensive teaching notes were developed and a new version was launched, called InFrame

PLAYING THE LEAN GAME, INFRAME

The game session starts with a theory seminar. Lean Construction principles are explained for example Ohno's Wastes and 5s (Bicheno, 1998), how deep and how widely depends on what level of knowledge the learners are at. The game leader emphasize that these methods can be useful during the game.

Stories and photos from learners' environment are used to lower barriers of knowledge transfer. This is an important part to make practitioners feel that Lean Construction is for them and can be used by them.

The Lean principles are then used to improve processes in the game and at the end more is made with less. The games clearly shows what could be considered as waste in manufacturing, push – pull, kaizen, kanban, 5s and importance of communication. Performance is measured in the game to illustrate the effect of Lean principles.

During the game slides are shown to the players, accompanied by a sound track with authentic sound from construction production environment. The purpose is to establish confidence among the playing practitioners that the game leader has a genuine interest and a deep knowledge of the environment where the players are to implement the Lean knowledge from the game situation.

The InFrame lean game takes place in a pre-cast concrete unit factory. The processes are taken from an existing factory and consist of planning, formwork, reinforcement, casting, curing, quality control, transport, inventory and a customer.

Preferably the game is played by two teams, each consisting of eight to eleven participants and with their own line, competing for the best results. There are three types of units to produce consisting of one Duplo piece and five Lego pieces in different colours put together in different ways according to a blueprint.



Figure 3. The pre-cast lining elements in reality and in the game.

The game is played in multiple rounds, with the possibility of making changes between every round. All premises are set, according to the real factory, during the first round and are then subject for changes during the following rounds. Two to three changes are allowed between rounds. The participants are the one deciding what changes to do, although all changes have to be confirmed by the game-leader. For every change in the game the participants have to make parallels to the reality – Would you allow this change? Would you say it is one or two changes?

The first round is played with six or seven workstations placed in different rooms or at least far away from each other. The participants sit with their backs against each other and are told to concentrate on their work, they are only supposed to talk to the person taking care of the transports. There is a batch size of six units, a medium inventory, a medium seized curing chamber and a lot of materials. This round is supposed to and will be chaotic, the results will not be good and the participants dissatisfied. It is important that the game leader draw parallels to the real world, that this is often the reality today, but also that this is god – there is a lot of potential.

After every round a result is calculated. The result depends on how many units were produced, how many units were delivered on time, how many people worked on the line, how much space did the line use, difference between initial and present inventory and number of incorrect units. The results are also used to calculate delivery accuracy, costs per unit and productivity.

Changes that usually occur after the first rounds are layout changes, smaller batch size, redistribution of work load and setup times. After following rounds changes like smaller inventory, different mixture of units, more flexible curing chambers, kanban cards, less workstations, less people and elimination of bottlenecks are made. Often changes leads to a worse result because they are made to big. The teams then have to rethink and the game leader has an important role to not let them give up.

The last round is played with ideal premises. During previous rounds the game leader gives the groups clues so that they more or less by themselves got the ideal premises for the last round. If not, the game leader has to help the groups.

The last round is played calmly, on customer demand with only one workstation, half the materials and few people.

After the last round the game leader leads a discussion on the game results and why it went as it did; if any changes were unnecessary or made in the wrong order or combination. In discussions parallels are drawn between the game and the processes the participants work with. But also to everyday things as the garage or kitchen at home, how we organise our closets or tools sheds. This to make the participants think on their own and remember more than just Lego pieces.

RESULTS FROM GAME SESSIONS

The Lean game has been played half a dozen times and so far no quantitative evaluation has been made. This will be made when the game is launched nation wide. In general the game has been well accepted at game sessions. *“The game was excellent, and the example very well chosen”*. However, some reflections made by the participants indicate future field of research.

At the game sessions played three levels of reflection, *figure 2*, can be distinguished. The first level is when the player take distance and don't come to reflection of the own environment. *“This cannot be adopted were I work”* is a common quotation. For these participants the gap between the real life and a game simulation is wide. These participants seem to get stuck behind characteristics in the game that they don't recognize from their own environment. Guest participants from adjacent industries have been more likely to stay at this level. With no discussion and reflection of how lean principles affect daily routines most players tend to stay here.

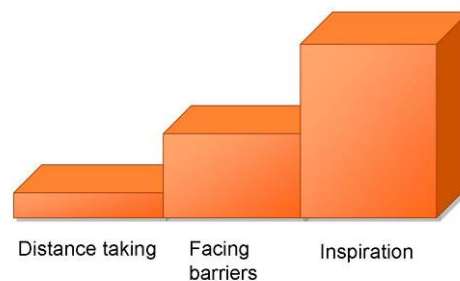


Figure 2: Levels of reflection

The second level is when the players make reflections of their own environment but come to barriers for implementing Lean. These players feel that they have no authority and power to affect the root of problems that occurs in their environment. This is most obvious when discussing purchasing activities and suppliers' behaviour. *“I can't address this problem”*. However, the reflection of the learners own environment indicates real learning.

The third level is true inspiration. These players discussing Lean in a greater perspective than the last two levels. Discussions between these players regards: removing boundaries, reorganising construction activities, supporting supply chain activities and so forth. Participants from the main target group have been more likely to come further to the last two levels of reflection.

FOLLOWING UP WHAT LEARNERS BRING FROM PLAYING THE LEAN GAME

Starting this summer the game, InFrame, will be played with all FIA members in Sweden. On behalf of FIA, all participants will fill out a questioner, through an E-survey, on how they experienced the class. Also two deep interviews will be made in each group. The main purpose is to map what reflection the participants bring from class and how they go further in their Lean journey. FIA want to map if the project is worth the effort. For Lean Forum Bygg the main purpose of the evaluation is to get deeper knowledge of the relation between education and learning when addressing practitioners in the construction environment.

DISCUSSION

The Lean Game has been well recognised by players. One important part in the success is the design process. The Lean Games is developed through great consensus with practitioners in the infrastructure industry; practitioners made a game, by them selves, for them selves. Another great part of the success is that the learners want to learn. In this case FIA solely identified the need for innovation and renewal and the members are enthusiastic.

BREAKING BARRIERS

Experiences from the FIA case shows great results of trying to come closer to the learners and lowering barriers of knowledge transfer. That participants from adjacent industries were more likely to stay at distance taking reflection speak for the importance of meeting the learners in their own environment at their own conditions.

Developing and playing a game with this in mind has contributed to the learning environment when playing InFrame. Success factor has been to play a game where the learners feel confident and recognise them selves. The game is made neutral for the target group so the learners don't get hung up on irrelevancies.

Experiences from InFrame show that the game leader can have an open attitude to the game plan and let participants be in charge of changes even if they are not "right"; the participants will learn by doing wrong as well. The game leader stimulates reflection and enthusiasm through controlling boundaries of the game. However, the discussion and reflection about the change influence is important to not loose the idea of simulating Lean principles.

Open attitude and reflections about the learners daily environment requires more from the game leader. Holding game sessions will also always be reliant on pedagogic skills. However, a well developed and stable game with far-reaching teaching notes make the game session less vulnerable.

UNIQUENESS OF PRACTITIONERS

In the early design process great efforts were spent to address the common day issues for the practitioners. Still, the design team had to make changes because the reference group felt that vocabulary and organisation descriptions didn't catch their daily routines.

A repeating reflection is the uniqueness that the practitioners feel about their environment. The problem is that deeper customisation opens up for even more remarks from participators from adjacent industries.

CONCLUSIONS

It might be important that the game is played, but further more important is how a Lean game is played in order to support individual life-lasting lean construction knowledge. In general it should in most situations be reasonable to start learning from the experienced reality of the learning individual.

Teaching Lean Construction through games is not a quick fix, learning takes time. But conducted with understanding of Lean philosophy and the business where applied great impact on learning can be made. Experience from designing and playing InFrame shows the importance of giving the learner time to reflect and time to learn. Evaluation of the InFrame design process and game sessions show that only a game can not make an impression. The game has to link theory and practice. The game should be seen as one of many parts working together. Neglecting one part will affect others. A Lean game should be considered as a tool where learners can meet and through reflection in a playful environment open their eyes.

FUTURE FIELD OF RESEARCH

The field of research concerning learning through games as a way to break learning barriers meeting practitioners is rather undiscovered; especially regarding practitioners in the civil engineering sector. This field needs more attention in future research. Is games an effective way of teaching Lean principles and what do learners bring from the games?

An other field of future research is how to address the experienced feeling of uniqueness by practitioners; should the games be customized to perfection in a continuous improvement process or should the games not be customized at all?

The design team of the InFrame lean game will do further research and encourage others to contribute.

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