Simulation and Game-based Lean Training

Christoph Szedlak, Florian Baarsch, Bert Leyendecker
University of Applied Sciences Koblenz, Faculty of Operations Management
Konrad-Zuse-Str. 1, 56075 Koblenz, Germany
{Szedlak, Leyendecker}@hs-koblenz.de

Abstract

A popular form of participatory active training methods in the education of professionals and executives are simulations and game-based teaching methods. These approaches are ideal to teach Lean Management, focusing on knowledge transfer rather than studying plane theory. The application of Lean Management is much focused on practice, but not memory. Still a critical assessment of existing simulation and game-based Lean Training methods in this field has been lacking. Limited information is available on simulation and game-based Lean training of executive and professionals. Thus, a web-based search was conducted using a set of key words and logical relations among them and constraints on them. A total of 49 different simulations and games were identified and classified according to their emphasis on standalone lean tools or the overall lean philosophy, the area of application, the manifestation, number of iterations and the consideration of soft-skills. The majority lacks a stress on soft-skills and concentrate on single tools to be used in production. The number of findings concentrating on an application in offices resp. administration is dwindling. Only few are designed for online usage and most are fairly abstract, which requires the participants to be familiar with abstraction and the aspects of Lean tools. Authentic and realistic simulators and games are missing in professional and executive education. Future directions for the improvement of lean simulation design are proposed.

Keywords
Lean Management, Game-based Training, Executive Education

1. Introduction
Although Lean Management is becoming more and more popular with industrial organizations, its prevalence in academic education is rather modest. Less than one third of German higher education institutions included it to their syllabus (Pötters, Szedlak, & Leyendecker, 2019). Thus, the range of continuous education and profession trainings play a crucial role in transferring knowledge to the industry. Various consultancy companies and centres of continuous education offer Lean training courses. However, to successfully implement Lean Management transferred knowledge is crucial. The Ballés (2005) argue that in this context, studying plain theory is insufficient. Rather trainees must understand how the theory applies to industrial situations. Therefore, the application of Lean Management is much focused on practice, but not memory.

Based on the learning pyramid (Figure 1), developed by the United States National Training Laboratories, the learners recall associated with passive learning methods (lecture, reading, audio visual and demonstrations) is quite low. Although the learning pyramid lacks empirical evidence according to Letrud (2012) and empirical test would cause major methodological problems, it represents the amount of theory people remember for each teaching methods. Thus, participatory teaching methods, involving trainees in group discussions as well as practice oriented simulations and games, are the preferred methods in Lean training. Still the learning outcome is not equal to the faculty of memory (Yonglianga, Hua, Jiaob, Mingqianga, & Guanghuia, 2015). In addition, the application of tools and of the Lean Philosophy must be trained. Most vendors in executive and professional education choose simulation and game-based training methods as a form of participatory active teaching methods. This article provides a critical assessment of existing simulation and game-based lean trainings.

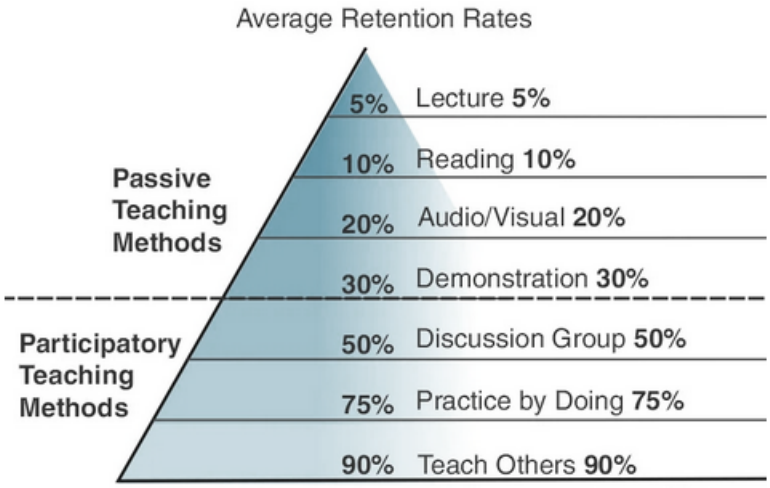

Figure 1. Learning Pyramid adapted from the National Training Laboratories. Bethel, Maine (Source: Stanley (2013))

2. Simulation and Game-based Lean Education and Training

2.1 Simulation and Games

Current literature has no real consensus on the term "games" (Crawford, 2003). A wide range of definition is proposed that can be characterized as follow:

- Games are typically enjoyable, mental or physical activities
- Games involve goals
- Participants try to achieve these goals by specific actions, so called "moves"
- Moves can be subject to constraints and rules
- Games are separate from real life

Like simulations, games can be played by individuals, pairs or in teams.
According to Crookall and Saunders (Crookall & Saunders, 1989) a simulation is a representation of a real world system focusing on specific aspects of reality. The representation can be phenotypical - in that case, it is a reflection of the process - or genotypical. The latter represents a subset of the systems and therefore is part of reality (Thavikulwat, 1999). While in simulations participants play a role in an abstracted and simplified real world systems, participants of games follow prescribed rules, that on purpose differ from real life situations (Heinrich, Molenda, Russel, & Smoldino, 1996; Crookall & Saunders, 1989). However, some authors bring both terms together defining simulation games as dynamic models that "mimic processes, networks, and structures of specific existing systems […and] incorporate players who assume specific roles" (Kriz, 2003).

Both games and simulation have been used for educational and training purpose in a wide range of subjects, including business, engineering and Lean education and training.

2.2 Types of Simulators and Games in Lean Education and Training

A large number of simulators are used in practice for Lean education and training. These can mainly be assigned to four main groups:

- Paper-based Games
- Desktop Games
- Learning Factories
- (near) full scale simulators.

Paper-based games usually focus on a single or just a few aspects of Lean Management trying to convey the basic idea of these aspects. Simplicity is both, an advantage and a disadvantage. On the one hand, the presence of a trainer is not absolutely necessary. On the other hand, these games are fairly abstract, which requires the participants to be

familiar with abstraction and the aspects of Lean tools. For example, many trainees struggle to link variability in processes with the use of dices in specific games. Desktop games are also fairly abstract and are based on e.g. Lego. Typical for games they are very enjoyable for most participants but lack sufficient realism. Therefore these games are used to teach basic concepts only (Dukovska-Popovska, Hove-Madsen, & Nielsen, 2008).

Learning factories consist of real manufacturing equipment. They abstract and simplify subsets of the real world and are usually designed for the training of experienced machine operators due their high level of details. In addition they are restricted to a single type of production and a specific location (Tisch, et al., 2013). Near full scale simulators, in contrast, make use of near full-scale workstations to simulate entire production lines. Typically these are restricted to assembly line and are stationary. However, some combine the idea of desktop games with learning factories or full-scale simulators, offering an environment where also novices can learn basic concept in a more realistic subset of the environment.

2.3 Effectiveness of Game-based Lean Training

A very important aspect of the use of simulations and games in the area of Lean teaching is that the actual learning of theory slips into the background (Badurdeen, Marksberry, Hall, & Gregory, 2016). Rather, the participants are concerned with successfully applying the theory they have learned and solving a real problem. Thus, participants can put theory to action and observe direct result (Pasin & Giroux, 2010). This consolidates what has been learned and participants can better relate to practice. Once the learning outcomes are repeatedly applied in everyday situations, automatism sets in. The success of lean education and training is determined by the amount of knowledge that is ultimately applied in the real work environment. This is referred to as "training transfer" (De Vin, Jacobsson, & Odhe, 2018).

Consequently, a high level of training transfer depends on various variables. In particular, attention must be paid to the level of difficulty, that must be adapted to the participants previous lean experience level. If a simulation game is too simple, the participants tend to feel bored and underchallenged, while if the simulation is too complicated, the feeling of being overwhelmed is created. As a result, participants will not experience the desired level of training transfer (De Vin, Jacobsson, & Odhe, 2018; Adobor & Daneshfar, 2006). The level of abstraction adds to this. In particular, experienced workers tend to draw any learning outcomes from games with a very high level of abstraction. On the other hand, detailed simulations are rigid and inflexible not allowing for many variants. However, the absence of real risk allows participants to adapt techniques in a less stressful but still stimulating environment (Pasin & Giroux, 2011). Last but not least training transfer also depends on the group of participants. Participants are active throughout the learning process (Faria & Dickinson, 1994) and have to make sense of a complex decision process instead of applying simple rules, only (Zantow, Knowlton, & Sharp, 2005).There can be a huge difference in team interaction that heavily influence the learning outcomes. Consequently, participants and their teams are responsible for their own learning. Thus, participants should be divided into groups based on structured techniques with respect to their individual learning styles (De Vin, Jacobsson, & Odhe, 2018; Adobor & Daneshfar, 2006).

3. Methods

Currently lean education and training programs are mainly centered on higher education institutes, center for continuous education and consulting companies. However, limited information is available on simulation and game-based Lean training offered by most vendors of professional and executive training. Thus, a web-based search was conducted using a set of key words and logical relations among them and constraints on them. Google was selected as the search engine for this research, because it still appears to offer the largest database of web pages, documents and other data sources (Chris, 2021).

3.1 Search Method

The data in this web-based search was collected through the internet via Google using the keyword ‘lean’ in combination with ‘training’, ‘certificate’, ‘certification’ and ‘qualification’. Logical operations were used. A large volume of work from diverse professional fields was retrieved using the following steps:

Step 1: The keywords and their relation structure are defined.
Step 2: The defined keywords and relation is fed to google’s advanced search page.
Step 3: Universities were excluded from the search by domain filtering (e.g. .ac, .edu)

Step 4: The search engines results were restricted to current hits (<1 year).
Step 5: Meta data was analyzed and relevant data was retrived
Step 6: Relevant hits were documented in a long list including manuals or detailed instructions on lean simulations and games, if applicable.

The searches were refined with the query string of 'simulation', 'games', 'executive education' and 'professional training'. Many vendors of professional and executive lean trainings use simulations and games developed by third parties. Thus, after applying the exclusion criteria to the long list, the web was searched for detailed instructions and manuals. These were compared with the detailed information of the initial search. Games and Simulation without the relevant information were eliminated. As a result a short list of 49 lean games and simulations used in professional training was obtained.

3.2 Selection Criteria

Before analyzing the data the following exclusion criteria were applied to the long list.

1. detailed information on the lean simulation and game is not accessible
2. detailed information is only available in a third language, but English or German
3. the game or simulation is not part of professional training
4. duplicates – entries with identical details

Any article not meeting the selection criteria was removed from the long list before refining the search. In addition, simulations and games that did not provide detailed descriptions, instructions or manuals and could not clearly be linked to an instruction or manual published by others, were eliminated from the reduced long list. The short list still contained duplicates and close variants of some games. After scanning the instructions and manuals all duplicates were removed. No value was placed on the vendor and therefore also not on the name to be retained. The application of the selection criteria had the effects shown in figure 2.

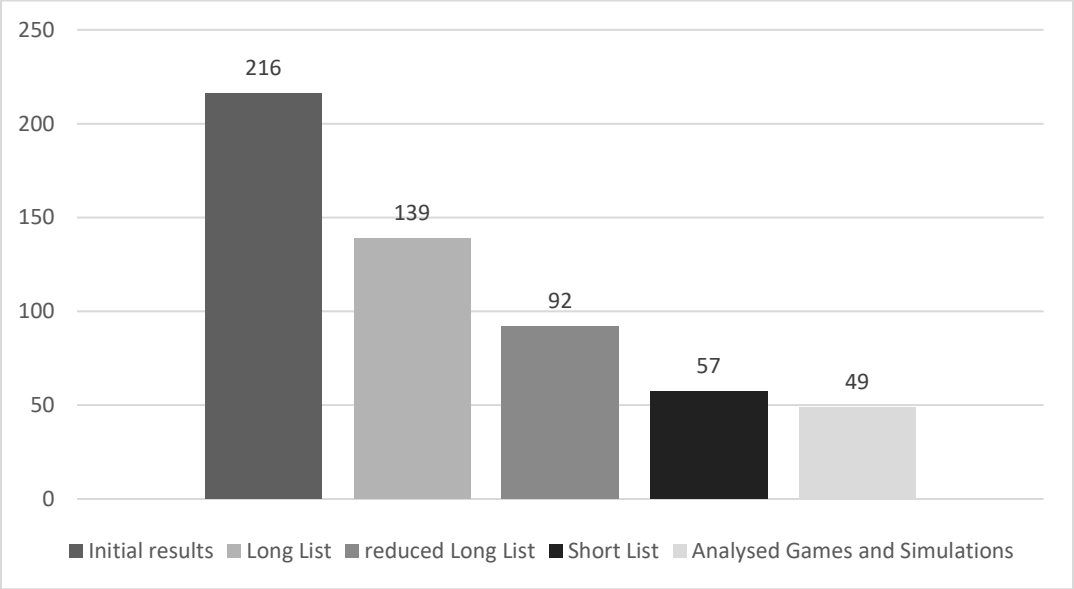

Figure 2 absolute results for the web-based search and application of selection criteria

4. Results

4.1 Emphasis of Simulations and Games Reviewed

The majority of games and simulations reviewed had a production line focus. Almost 70% emphasize the application of lean tools to improve the fabrication and assembly process. Only few consider other functional areas such as logistics or sales (e.g. No. 13). The focus predominately lies on the shop-floor operations focusing on large-scale discrete production. In particular, the administrative level (e.g. No.4) has been neglected so far. Although some of the paper-based and desktop games can also be used to teach the application of lean tools and techniques in an

administrative setting, none of the vendors has it on offer. Furthermore, result show that only few focus on the use of lean to the supply chain. Downstream operations or multiple suppliers along the supply chain (e.g. No.15) are usually neglected. Figure 3 illustrates the focus of the lean tools and techniques.

The reviewed games and simulations cover a wide variety of lean tools and techniques. 34 cover lean systems, which in this context defines the application of several lean tools, such as cell layout, kanban, visual control or visual stream mapping, to transform traditional systems to a pull system for example. Games and simulations of this kind put process improvement or soft skills in the foreground. Table 1 summarizes the emphasis of the games and simulation. 21 out of 49 concentrate on the demonstration of a single or a few stand alone tools. 5S and kanban are the most often described tools.

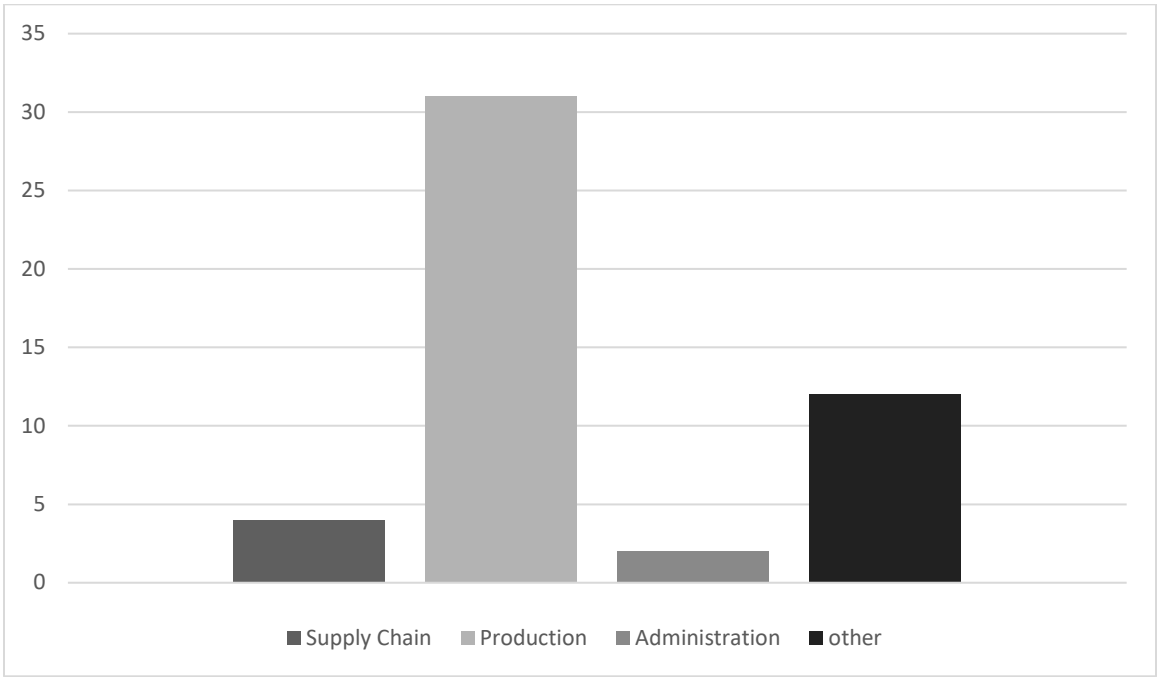

Figure 3. Focus of lean tools and techniques

4.2 Construction Methods of Simulations and Games Reviewed

The majority of simulation and games uses easily available materials such as paper (e.g. No. 38, 43) to simulate fabrication-like operations. Prefabricated modular components like LEGO (e.g. No. 49) are also very popular with vendors of professional trainings. Last but not least, dices, gaming cards and other easily available materials are used e.g. to simulate the variability in processes (e.g. No. 27). With exception of the games and simulations focusing on specific lean tools (e.g. No. 4, 16), the majority involved multiple iterations. To demonstrate the effectiveness of lean systems a pre-post comparison is usually used. The first run demonstrates the pre-optimization state. However, to demonstrate the transformation from a push to a pull-production multiple iterations (3-4) were used, improving the conventional operations step by step, highlighting the importance of the applied tools. Consequently, the execution time is highly variable. However, most games were designed to be played within 30 minutes. Preparation time is limited, too. Only few that require more involvement of participants take up to two hours (e.g. No. 49).

4.3 Level of abstraction of Simulations and Games Reviewed

More than half of the reviewed games and simulations have a high level of abstraction, as illustrated in Figure 4. This means the training happens in a conceptual environment with the level of complexity reduced to a minimum. Participants rather follow prescribed rules, that on purpose differ from the real world, than playing a role in an abstracted and simplified real world system. In addition, the phenotypical simulations were designed for awareness training rather than putting the effects of given methods on physical aspects of the situation to the fore. Only 5 simulations provide a realistic environment where participants can learn about the results of the taken methods by

observing its effects on the product under construction. No transfer of theory based on the workers experience has to take place. Instead, these simulations allow for an observation of failure situations in an safe environment.

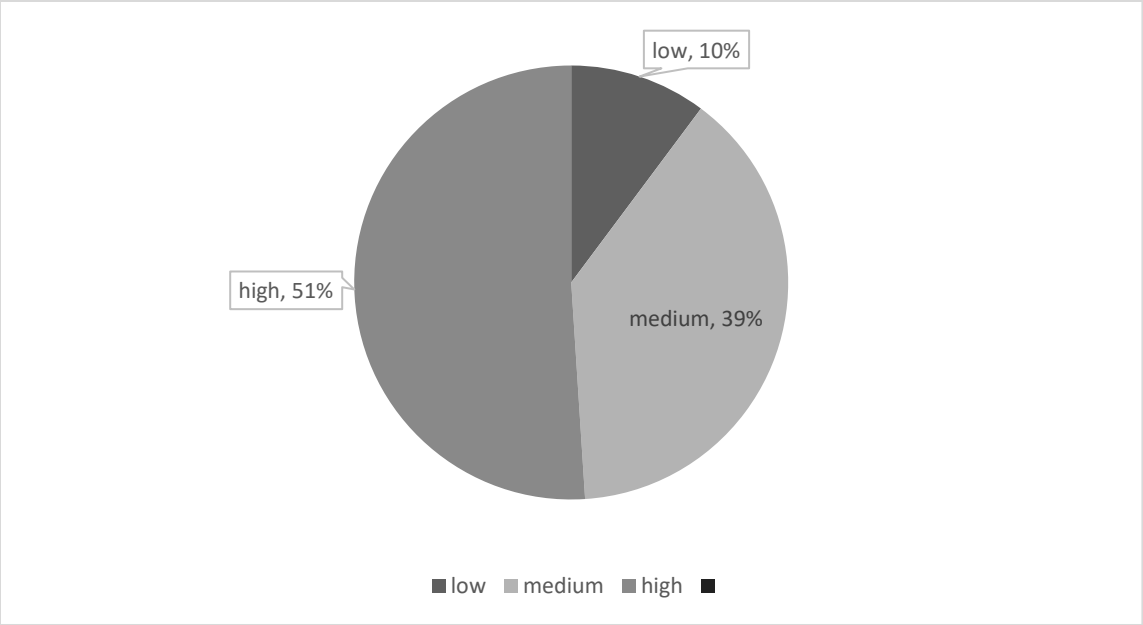

Figure 4. Level of abstraction of games and simulations reviewed

4.4 Online Readiness and virtual Simulation of reviewed Games and Simulations

Only one vendor offered a virtual simulation (No. 26). Participation can take place without an instructor after registration to the vendors website. The relevant content is delivered in the form of records and small video tutorials. The participants can participate spatially distributed. However, interaction is not possible. Another 15 games and simulations included brief information or ideas for an online variant, with a note that it will only be offered in the near future. The proportion on online ready games and simulations to teach lean system or specific tools is the same. However, most only read variants are hybrid versions. This means the group of participants is provided with the required resources and an instructor supervises the implementation virtually. A decentralized implementation is therefore not possible in most cases. It assumes that the participants meet in person to participate in a simulation or game. Only the trainer takes part remotely. Tabel 1 summarizes the online readiness of the reviewed games and simulations.

4.5 Learning Outcomes of Simulations and Games Reviewed

17 out of 49 games and simulation provide multiple learning outcomes. This means that they also consider reflection on the improvements, usually based on a single round of data. Beside concentrating upon the technical learning outcomes, they also try to put the focus on the lean principle of continuous improvement. However, the majority is designed to be completed within 30 minutes and a maximum of three to four runs. The focus is more on the pre-post-comparison of the lean transformation, highlighting the advantage of the lean concepts and tools.

The majority of lean games and simulation focus on the optimization of information and material flow, only. Less than a quarter of them also consider the social skills needed to encourage the transformation (e.g. No. 13, 25). Lean role definitions and lean behaviors of individuals are usually neglected.

No.	name	Emphasis		Digital Version		level of abstraction	multiple learning outcomes
		Specific tools	Lean system	Online ready	Virtual Simulation		
1	Word point-Game	X		X		high	X
2	Lean Start-up Snowflake Game		X			high	
3	Mr. Happy Face	X				medium	X
4	Standard Pig		X	X		medium	
5	5S Numbers Game	X		X		high	
6	The White Albatross		X	X		high	X
7	Envelope Suffing Videos		X	X		medium	
8	Lean Ball Game		X			high	X
9	The Penny Game		X			high	
10	The Kanban System Game	X		X		low	
11	Lean Project Management		X	X		medium	X
12	Lean Bucket Brigade Game		X			medium	
13	Lean Box Game		X			medium	
14	Making Pamphlets		X			high	
15	The Beer Game		X			low	X
16	The 5S Alphabet Game	X		X		high	
17	Bears in Space	X				high	
18	Balancing Planes		X			low	X
19	Lean Bicycle Factory		X	X		low	
20	Lean Lego Simulation		X			medium	
21	Lean-Lingo-Bingo		X	X		high	
22	Kanban game with Lego	X				medium	X
23	Variability Dice Game	X				high	X
24	The Pizza Game		X			medium	X
25	Lean Circuit Board Simulation		X			medium	

Table 1 Summary of Reviewed Lean Simulations and Games

No.	name	Emphasis		Digital Version		level of abstraction	multiple learning outcomes
		specific tools	Lean System	Online ready	Virtual simulation		
26	The Multitasking Test		X	X		medium	
27	Lean dice Game		X	X	X	high	X
28	Kanban 1´s Game	X				medium	
29	Lemonade Tycoon		X			Medium	X
30	Card Drop Exercise		X			high	
31	The Name Game		X	X		high	
32	Toyota University Lean Game	X				low	X
33	Two Team Building Games		X			high	
34	Paperwork Simulation		X			medium	
35	Push-Line / Pull-Line	X				high	
36	The 5s Shapes Game	X				high	
37	The Kanban Pizza Game	X	X			high	X
38	Paper Airplane Lean Game		X			medium	X
39	Frog Factory		X			medium	
40	The Bean Game		X	X		high	
41	The Marshmallow Challenge	X				high	
42	Lean Dot Game		X			high	
43	Paper Airplane Lean Simulation		X			medium	
44	The Bottleneck Game		X			high	
45	Lean Paper Airplane Folding		X			medium	X
46	Never-ending Card Game	X				high	
47	Kanban Story Game	X		X		high	
48	Red Beard Experiment		X			high	
49	Lean Lego Game		X			medium	X

Table 1 Summary of Reviewed Lean Simulations and Games

5. Discussion

The success of lean management in production processes has been confirmed several times all over the world, so it seems natural that most vendors of lean training for professionals and executives have those on offer. However, besides the classical lean production, a transfer to other divisions was conceivable. Although administration plays a crucial role in creating customer value, with more than 50 percent of the workforce ling in the office (Brill, Weidemann, Alard, Olson, & Keable, 2001), over one third of administrative processes are waste (Westkämper, et al., 2011). Up today, lean administration still is largely underestimated (Schuh, Potente, Jasinski, & Nuyken, 2013). With administrative operations representing over 60 per cent of consts associated with meeting customer demands, lean methods are becoming highly relevant within the administrative level (Danielsson, 2013; Tapping & Shuker, 2003; Brenner, 2018). However, it is precisely the use in administration that is often more difficult to understand and, as a rule, significantly less transparent. A very good understanding of the methods and the entire concept is therefore essential. Thus, the use of simulations and games in lean training for professionals and executive can boost the sustainable implementation of lean administration, preventing employees from falling back into old patterns too quickly. However, the range of simulations and games focusing on administrative level is very low and urgently needs to be expanded.

A crucial component of the training transfer is to understand the concepts by analyzing the more conceptual aspects of work. De Vin, et al. (2018) argue that successful training requires critical reflection and rounds of discussion between all participants. The goal is to allow the participants to discuss the insights gained and thereby further strengthen their understanding of the use of lean system and tools. Further, the reflection has a positive impact on the personal and social skills of the participants. An experienced lean trainer is required to moderate these discussions, setting new impulses if needed (Pasin & Giroux, 2010). However, the majority of existing games and simulation is designed to be completed within 30 minutes and a maximum of three to four runs. The focus is more on the pre-post-comparison of the lean transformation, highlighting the advantage of the lean concepts and tools, than on the reflection upon the application of lean concepts for continuous improvement. The design therefore, allows for an unrealistic improvement where the application of lean tools can be done at ease resulting in big performance improvements, eliminating the identified problem. This stirs up unrealistic expectations among participants. Real world problems often stay after system improvement. We therefore, argue that the experience of incremental changes of a lean transformation must be put to the fore. Participants must already experience the necessity of continuous efforts during the training, to prevent unrealistic expectations on the lean transformation. Therefore Deming's (2000) Plan Do Act Check (PDCA) Cycle must be fully applied within simulations. Existing ones usually concentrate on the first part, stirring the expectation that rapid improvements are the norm and lean transformation means jumping from one improvement to the other. The reflection of the system at hand and the identification of measures to keep the system stable are neglected.

This also covers misassumptions on human interaction, roles and peoples approach to change. Existing games and simulations do not cover social or individuals skills needed to implement a sustainable lean transformation. Liker, et al.(2008) argue that the lean approach differs from classic ones, by concentrating on the workers technical skills first before concentrating on problem solving. After standardization of all the task and mastering skills needed, the more conceptual approach to problem solving sets in. This requires simulation concentrating on practical activity first, giving the opportunity to reflect on the problem before introducing conceptual aspects. Existing simulation do not cover these approach. We therefore call for simulations, that facilitate the idea of learning through failures and success. By experimenting with the problem solving and reflecting on the social and technical skills and the way the people and tools behave. Participants must learn on the soft skills and learn to facilitate the lean concept. This requires a design that allows participants to not only experience the concept of incremental change, but also to reflect on the different roles in a team and the desired soft skills. Multiple runs and enough time for reflection are necessary, allowing the participants to switch roles between runs. Last but not least, participants must get the chance to see that continuous improvement, means active participation of workers. Lean transformation also means enabling the workers to do the problem solving. This requires a solid reflection on all roles.

Training transfer for experienced workers also heavily depends on the level of realism they provide (Pourabdollahian, Taisch, & Kerga, 2012; Dukovska-Popovska, Hove-Madsen, & Nielsen, 2008). However, a high degree of realism also means higher complexity and thus, a higher degree of difficulty. Thus, the risk of frustration or anxiety of overwhelmed participants threatens the learning outcome. On the other hand, too simple games may bore the participants. Kolb (1984) discuss the balance between the simplicity and difficulty level in simulations and games. It is important to provide a training environment that allows the participants too grasp the simulation in all details, so

that the correlation between actions and results become visible (Johannson, 2012). Still the task must present a challenging problem, to encourage participants to participate in the problem solving (Dukovska-Popovska, Hove-Madsen, & Nielsen, 2008). This means a learning through experience must be possible. This requires few boundaries presenting a simplified but still realistic environment with real problems. The problem solving must be rather open than in a linear way. Therefore, that learning can take place at an application level. However, most existing simulations and games concentrate on awareness training only. In particular, experienced workers ask for a level of abstraction of the learning environment that allows for experimental learning. Recent literature argues that learning takes place best if the trainee moves back and fourth between his comfort zone and the challenge zone. The latter steps up the degree of difficulty presenting participants with a challenging problem to be solved. This is where learning outcome at an application level is generated, enabling the trainee to understand how trouble shooting using the tools at hand works and can be applied under various conditions. The desired skills and insights are consolidated in the so-called comfort zone. Therefore, it is important in professional and executive training to provide a realistic environment that is familiar to the trainee, to teach them to learn from failures. Lean philosophy does not mean to tolerate failures but also means to realize that "you have to fail to progress" (Osono, Shimizu, & Takeuchi, 2008). This insights can't be generated at an awareness level.

The current situation has also caused many providers of training courses to rethink their existing approach. So far, there are hardly any digital versions of lean simulations and games. However, many start to concentrate on hybrid versions. Still a lack of variants that enable decentralized participation not missing on the moderation of an experienced facilitator must be noted. The incorporation of the topics discussed above are particularly difficult. In particular, the opportunity to develop personal and soft skills must be given in a virtual environment as well. The mapping and reflection of different roles in spatially distributed teams also represents a challenge that has not yet been addressed. What must not happen under any circumstances is that the participants are left to their own devices. Even if learning with the help of tutorials and video recordings promises a lot of flexibility, sustainable lean training requires an experienced facilitator who guides the discussions and reflection on tools, roles and skills and promotes the self-learning process through targeted input to the discussion rounds.

6. Conclusion

The main conclusion of the evaluation summarizes as follows:

- The analysis of 49 simulations and games from vendors of professional and executive training showed that the majority has a production line focus. Lean administration is usually neglected or it is recommended to book the same simulation or games, since the learning outcome can be transferred. Therefore participants are usually confronted with a high degree of abstraction or an unfamiliar situation that makes it hard to see behind the concept, e.g. focusing on physiomotric skills instead. Thus, more realistic simulations of office environments to teach lean administration are needed.
- The majority of games and simulation focus on an awareness training. This means participants are trained to apply the theory and discussed tools in an unique and simplified situation, learning how to apply lean tool in a single set of conditions. We argue that simulations and games should present real life problems, which also includes stress or uncertainty. Learning must happen at an application level, enabling participants to put their know how to practice under various conditions. Also more attention must be paid to teaching soft skills and the understanding of different roles.
- Almost all existing simulations and games concentrate on a single pass approach demonstrating the transformation of a current to a desired state. The design is set up to reach the ideal situation within a single run. This conveys the wrong image and raises unrealistic expectations. We argue that simulations must be a preview of the real world to experience incremental change in lean transformations, also allowing participants to discuss and reflect on the humans role and behavior during the problem solving.
- Digital or virtual versions are not existing. Spatially distributed teams pose a particular challenge, both in terms of application and as an object of simulation. Not to be neglected is the role of the moderator, who, as an experienced lean expert, has to slip into the role of thefacilitator.

However, results only included games and simulations that provided detailed information to be analysed. Many vendors offer different variants or versions of the reviewed games and simulations, that might address learning outcomes differently. In particular, information on digital versions was only sporadic.

References

Adobor, H., & Daneshfar, A. (2006). Management simulations: determining their effectiveness. Journal of Management Development, 151-168.

Badurdeen, F., Marksberry, P., Hall, A., & Gregory, B. (2016). Teaching Lean Manufacturing With Simulations and Games: A Survey and Future Directions. 465 - 486.

Ballé, F., & Ballé, M. (2005). The Gold Mine, a novel of lean tourunaround. Cambridge: Lean Enterprise Institute.

Brenner, J. (2018). Lean Administration: Verschwendung in Büros erkennen, analysieren und beseitigen. Münche: Carl Hanser Verlag.

Brill, M., Weidemann, S., Alard, L., Olson, J., & Keable, E. (2001). Disproving Widespread Myths About Workplace Design. Jasper: Kimball International.

Chris, A. (01. 06 2021). Top 10 search engines in the World. Von https://www.reliablesoft.net/top-10-search-engines-in-the-world/ abgerufen

Crawford. (2003).

Crookall, & Saunders. (1989).

Danielsson, C. (2013). An explorative review of the Lean office concept. Journal of Corporate Real Estate, 15(3/4), 167-180.

De Vin, L., Jacobsson, L., & Odhe, J. (2018). Game-based Lean Production training of university students and industrial employees. Procedia Manufacturing.

Doudos. (kein Datum).

Dukovska-Popovska, I., Hove-Madsen, V., & Nielsen, K. (2008). Teaching lean thinking through game: some challenges. Proceedings of 36th European Society for Engineering Education (SEFI) Conference on Quality Assessment, Employability & Innovation.

Faria, A., & Dickinson, J. (1994). Simulation gaming for sales management training. . Journal of Management Development, 13(1), 47 - 59.

Heinrich, Molenda, Russel, & Smoldino. (1996).

Johannson, D. (2012). Convergence in Mixed Reality-Virtuality Environments - Facilitating Natural User Behavior. Örebro University.

Kolb, D. (1984). Experiential learning: experience as the source of learning and development. Englewood Cliffs, NJ: Prentice Hall.

Kriz. (2003).

Larsson, L. (2008). Lean administration. Malmö: Liber.

Letrud, K. (2012). A rebuttal of NTL Institute's learning pyramid. Education, 133 (1), 117-124.

Magenheimer, K., Reinhart, G., & Schutte, C. (2014). Lean management in indirect business areas. Modeling, analysis, and evaluation of waste. Production Engineering, 143-152.

Nadarajah, D., Latifah, S. A., & Kadir, S. (2014). A review of the importance of business process management in achieving sustainable competitive advantage. The TQM Journal Vol (26), 522-531.

Osono, E., Shimizu, N., & Takeuchi, H. (2008). Extreme Toyota. New York: John Wiley.

Pasin, F., & Giroux, H. (2010). The impact of a simulation game on operations management education. Computers & Education.

Pasin, F., & Giroux, H. (2011). The impact of a simulation game on operations management education. Computers & Education, 57, 1240-1254.

Pötters, P., Szedlak, C., & Leyendecker, B. (2019). Prevelance Study of Lean Management in Academic Education. Proceedings of the International Conference on Industrial Engineering and Operations Management, (S. 1723-1732). Pilsen.

Pourabdollahian, B., Taisch, M., & Kerga, E. (2012). Serious Games in Manufacturing Education: Evaluation of Learners' Engagement. Procedia Computer Science, 15, 256-265.

Schuh, G., Potente, .., Jasinski, T., & Nuyken, T. (2013). Lean Administration - potentials, Content and Implementation. International Journal of Businiess and Managment Studies, 5(2), 85-94.

Stanley, J. (18. 07 2013). The Phuket News. Von https://www.thephuketnews.com/photo/listing/1374138536_1.jpg abgerufen

Tapping, D., & Shuker, T. (2003). Value Stream Management for the Lean Office: Eight Steps to Planning, Mapping, and Sustaining Lean Improvements in Administrative Areas,. New York: Productivity Press.

Tautrim, J. (2014). Lean Administration. Taschenbuch/Beraterleitfaden. Wesentliche Konzepte und Werkzeuge für mehr Effizienz in der Verwaltung. Berlin: epubli.

Thavikulwat. (1999).
Tisch, M., Hertle, C., Cachay, J., Abele, E., Metternich, J., & Tenberg, R. (2013). A Systematic Approach on Developing Action-Oriented, Competency-Based Learning Factories. Procedia CIRP 7, 580 - 585.
Westkämper, E., Sihn, W., Schneider, R., Schöllhammer, O., Meizer, F., & Lingitz, L. (2011). Lean Office 2010 - Erfolgsfaktoren der Lean-Iplementierung in indrekten Unternehmensbereichen. Stuttgart: Publica IPA.
Wiegand, B. (2018). Der Weg aus der Digitalisierungsfalle Mit Lean Management erfolgreich in die Industrie 4.0. Wiesbaden: Springer Gabler Verlag.
Womack, J., & Jones, D. (1996). Lean Thinking: Banish Waste and Create Wealth in Your Corporation. New York: Simon & Schuster.
Yonglianga, T., Hua, L., Jiaob, Y., Mingqianga, L., & Guanghuia, W. (2015). Evaluation of simulation-based training for aircraftcarrier marshalling with learning cubic andKirkpatrick's models. Chinese Journal of Aeronautics, 128(1), 152-163.
Zantow, K., Knowlton, D., & Sharp, D. (2005). More than fun and games: reconsidering the virtues of strategic management simulations. Academy of Management Learning and Education, 451-458.