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# The Lean Production Educational Simulation Game
## Edukacyjna gra symulacyjna dotycząca szczupłej produkcji

**Abstract:** The paper presents theoretical and practical analysis of the actual mapping mechanisms involved in the simulation game. In particular, the educational nature of real logistics processes modelling was emphasized. A secondary, but no less important aspect of reality as presented is attractive to buyers entertainment which helps receivers make the right decisions, known in the theory of assimilation issues. The presented simulation game is based on the creation of simple elements, which does not require additional knowledge and manual skills in this area from the participants. Suitably organizing jobs, reflecting the real production cells helps to understand the essence of the production control support tools based on Lean Production, pointing out the differences between conventional work cells,and the push and pull system.

**Keywords:** educational game, simulation game, logistics game

**Streszczenie:** W artykule przedstawiono zagadnienia teoretyczne oraz analizę praktyczną odwzorowania mechanizmów zachodzących w rzeczywistości przy pomocy gry symulacyjnej. W szczególności podkreślono edukacyjny charakter modelowania realnych procesów logistycznych. Drugorzędnym, choć nie mniej istotnym aspektem tak przedstawianej rzeczywistości, jest atrakcyjny dla odbiorców aspekt rozrywkowy, który ułatwia odbiorcom podejmowanie właściwych decyzji, a jednocześnie przyswajanie poznanych w teorii zagadnień. Przedstawiona gra symulacyjna oparta jest na stworzeniu prostych elementów, co nie wymaga od uczestników dodatkowej wiedzy czy umiejętności manualnych w tym zakresie. Odpowiednie zorganizowanie stanowisk pracy, odzwierciedlające sytuację realnych komórek produkcyjnych, pomaga zrozumieć istotę narzędzi wspomagania sterowania produkcją w oparciu o metody Lean Production, wskazując różnice między produkcją tradycyjną w komórkach, systemem pchanym i systemem ssącym.

**Słowa kluczowe:** gra edukacyjna, gra symulacyjna, gra logistyczna

## Introduction

Many people working as educators in the area of logistics, logistics management, strategic management and marketing are facing problems with the monotony of the forms presented in a variety of theoretical content. Most of them are based on the theoretical analysis of the processes supported by practical analysis carried out in the industry. Mostly the knowledge passed to both

a younger audience, such as high school students, as well as for more specialized audiences, e.g. students of certain specialties, as well as the professional training or postgraduate studies, most commonly used method of providing content is a theoretical lecture. In the practical part the most common form of exercises, projects, occasional seminars, case studies analysis and technical visits are used. They are of course accepted by the audience, confirming the theoretical content in practice. A new trend currently carried out by educational and training is the realization of projects combining several items, which offer a number of aspects of the research problem and support the computer forms of education, such as b-learning or e-learning methods. However, there often is a repeated performance of the same exercise in various items of logistics, because what's known and emphasized is its interdisciplinary nature. There is thus a need to formulate new current educational forms, among which a very attractive one seems to be an educational simulation game[1,2]. It is a good tool, not only for attractive knowledge spreading, but also allows the observation of comprehension among the participants while identifying additional advantages such as commitment, teamwork, motivation in the group and others connected with human resources. The personalization principle, one of the design principles of multimedia learning, states that people learn better from multimedia presentations when instructions are in a conversational style rather than a formal style, possibly due to the learners' increased interest[3].

## An educational game as a didactic tool

The idea of placing selected aspects of a modelled reality in the reality of a game is not new[4]. A special branch of the representations of reality development can be called educational simulations, among - next to training flight simulators or defibrillation - there is also the most famous in the area of logistics: the Beer Game[5], which allows observing the bull-whip effect[6] and measuring it[7]. Using the beer distribution game in a controlled laboratory setting, we test four behavioural hypotheses – bounded rationality, experiential learning, systems learning, and organizational learning – by systematically

[1] Ammar, S., Wright, R., *Experiential learning activities in operations management*, International Transactions in Operational Research 6/1999, p. 183.
[2] Ruohomaki, V., Viewpoints on learning and education with simulation games, [in:] Riis, J.O. (Ed.), Simulation Games and Learning in Production Management., Chapman & Hall, London, 1995, p. 13.
[3] Brom C., Bromova E., Dechterenko F., Buchtova M., *Personalized messages in a brewery educational simulation: Is the personalization principle less robust than previously thought?*, Computers & Education 72 (2014), p. 339.
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[5] Sterman, J., *Instructions for Running the Beer Distribution Game*, System Dynamics Group, MIT, Cambridge 1984.
[6] Metters R., *Quantifying the bullwhip effect in supply chains*, Journal of Operations Management 15 (1997), p. 89.
[7] Dejonckheere, J., Disney, S.M., Lambrecht, M.R., Towill, D.R., *Measuring and avoiding the bullwhip effect: A control theoretic approach,* European Journal of Operational Research 147 (3)/2003, p. 567.

manipulating training and communication protocols[8]. A special feature of simulation games is the exclusion of engagement in simulated risk processes that, in fact, normally accompany them, whether in the form of exposure of life, materials, equipment, and finally the functioning of the entire organization at management level[9]. It should be noted that the simulators of the strongest attributes of the game represent a special didactic value, as their entertaining nature provides a good basis to be involved in the mechanism of this type of training tool. This asset of strength reveals different among multiple versions of well-known educational games.

## The lean production educational game

Terms of the scheme of the institutional teaching methods, classes using The Lean Production Educational Game (LPEG) can take on characteristics indicating that the establishment of each of the basic types, ranging from lectures, through exercise, workshops and experiments. In their summary, the applied methods successfully develop new knowledge, which is best suited to discussion and dialogue. In order to fully exploit its potential, the game requires an even combination of different methods. The possibility of introducing a schedule of assemblies is the biggest advantage of the discussed simulations. It is difficult not to agree with the statement that this kind of extension of the conventional exercise is not only a good way to observe the work of students, but that the stimulation of their activity through the use of a new form, presenting the opportunity to test their skills in the context of simulation. In these simulation methods - The Lean Production Educational Game is also in this group and belongs to the class interactive teaching methods that combine the advantages of feedback interactions and activation[10] together with role-play games[11]. An additional, but very important element supporting the motivation of participants in the game is the competition aspect, which is an additional group activating factor, and also a good tool to increase skills in the field of group work.

## Example of the simulation game

The idea of transferring real manufacturing processes into a game is not new[12]. The Lean Production Educational Game which will be presented in the article is based on the Lego Lean Game by Danilo Sato and Francisco Trindade[13].

[8] Yan Wu D., Katok E., *Learning, communication, and the bullwhip effect*, Journal of Operations Management 24 (2006), p. 839.
[9] Kołodziejczyk P., Szołtysek J., *Beer Game – praktyczne refleksje o grze logistycznej w dydaktyce*, Czasopismo Logistyka 1/2012, p. 69.
[10] Boczukowa B., *Jak kształcić dorosłych – refleksje andragoga*, Wydawnictwo Adam Marszałek, Toruń 2010, p. 38.
[11] Korhonen K., Pekkanen P., Pirttila T., *Role game as a method to increase cross-functional understanding in a supply chain*, International Journal Production Economics 108 (2007), p. 127.
[12] Riis, J.O., Johansen, J., Mikkelsen, H., Simulation games in production management − an introduction,[in:] Riis, J.O. (Ed.), Simulation Games and Learning in Production Management. Chapman & Hall, London, p. 3.
[13] Sato D, Trindade F., *The Lego Lean Game*, in: Agile Processes in Software Engineering and Extreme Programming, Lecture Notes in Business Information Processing Volume 31, 2009, p. 192-193.

The first element of the Lean Production Educational Game (LPEG) preparation was to design a suitable item that will be the primary object on which game participants involved in the production of the item will focus on. Because the game was conducted among students of transport logistics, the most popular blocks – LEGO blocks model palette was designed (Fig. 1).

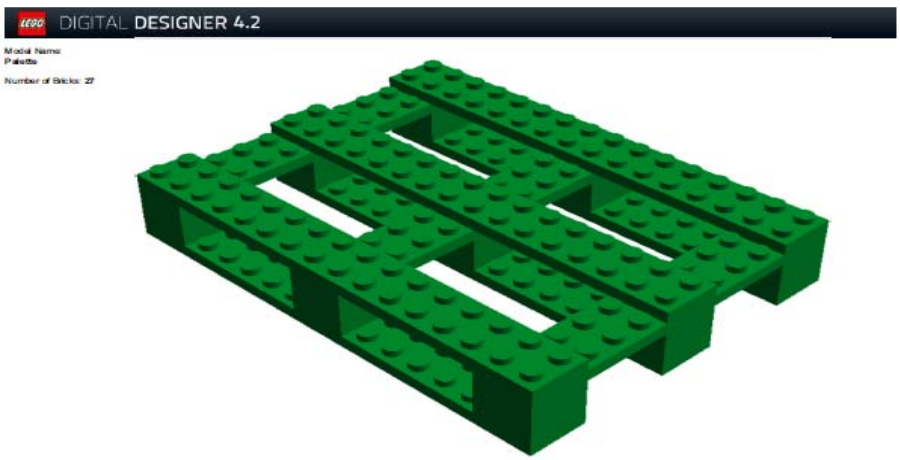



**Fig. 1. Lego blocks palette designed for The Lean Production Educational Game purpose**

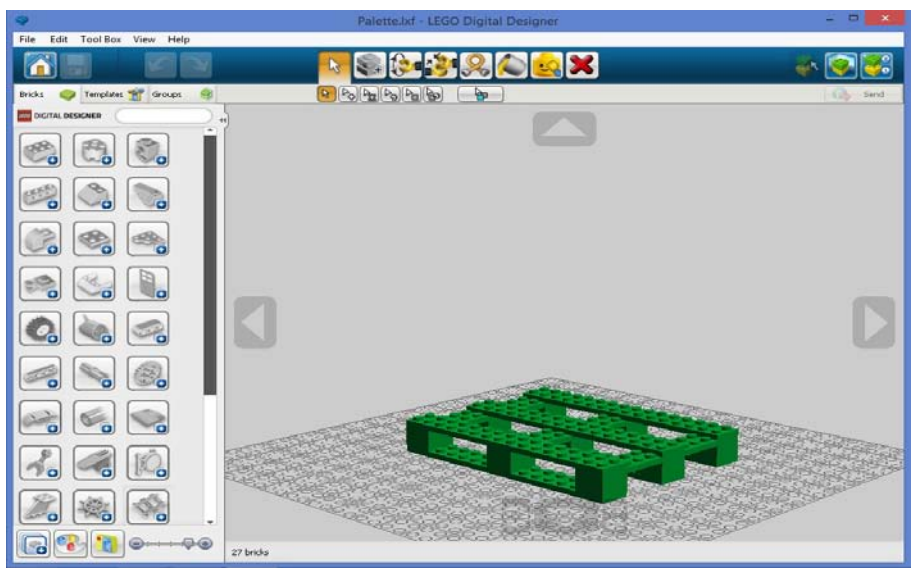


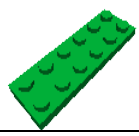
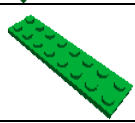

**Fig. 2. LEGO Digital Designer ver. 4.3.8. – a suitable tool for LPEG object design**

For designing the palette Microsoft used free Lego Digital Designer software with the latest 4.3.8 version which allows building any object with a very

comprehensive database produced by the LEGO blocks. At the same time a very friendly interface permits one to easily create a building manual that shows the step-by-step manner in which the object was constructed. It should be remembered that the object designed for the purpose of the LPEG game should not be very complicated, because it has to show the various operational capabilities in the field of production of these same elements rather than the manual skills of the players.

Tab. 1 presents LEGO bricks specification with the quantity of every one, which is needed to build one palette. Palettes in the game will be "produced" (made) in 4 different colors: green, blue, red and yellow.

**Tab. 1. LEGO bricks specification used for one palette**

| Brick visualisation | LEGO Bricks types | Quantity |
|---|---|---|
|  | Brick: 2x2 | 9 |
|  | Brick: 2x6 | 6 |
|  | Brick: 2x8 | 12 |

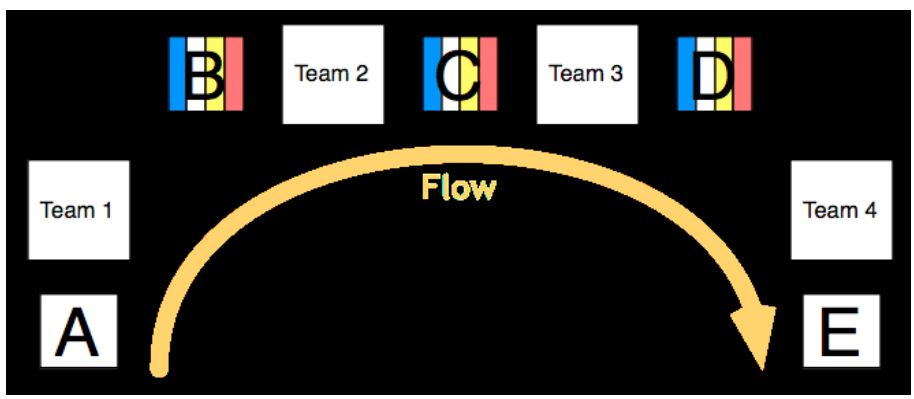



**Fig. 3. Tables set-up**
Source: http://www.dtsato.com/blog/work/lean-lego-game/

The figure 3 shows the tables set-up. Worksites described as Team 1-4 are tables of each production cell; every Team (3-4 persons involved) has his own

standardized procedures. ‘A’ is the place to seize materials – LEGO Bricks, and ‘E’ is the place where produced palettes are transferred to. ‘B’, ‘C’ and ‘D’ are the boxes where sorted LEGO Bricks are stored. Table 2 shows the standardized tasks for each team. The Lean Production Educational Game (LPEG) can be played according to different simulations: push system, pull system, workcell system or module production, which present how cooperation of a production line or information can help to make work more efficient.

**Tab. 2. Tasks of each team in the game**

| Team 1 | Team 2 | Team 3 | Team 4 |
|---|---|---|---|
| 1. Walk to ‘A’,<br>2. Seize a handful of LEGO bricks,<br>3. Sort them by colour<br>4. Store the sorted bricks by colour on ‘B’,<br>5. Repeat. | 1. Walk to ‘B’,<br>2. Grab all the bricks of a chosen colour,<br>3. Sort them by colour and size,<br>4. Store the sorted bricks by colour and size on ‘C’,<br>5. Repeat. | 1. Walk to ‘C’<br>2. Take enough bricks of one colour to fulfil the specification,<br>3. Store the sorted bricks on ‘D’,<br>4. Repeat. | 1. Walk to ‘D’<br>2. Grasp one set of bricks<br>3. Take the bricks to your table,<br>4. Build a palette according to the specification,<br>5. Launch the house market on ‘E’,<br>6. Repeat. |

## Simulation: The Push system

*The Push* system is characterized by products 'pushed' to other processes, regardless of the reasonableness of production (fig. 4). The result is the accumulation of surplus stocks, which unfortunately must be maintained as long as the market does not appear in the demand for manufactured goods. In this system, the demand is not known and based on forecasting, the production volumes are determined, which is also associated with the risk of producing unnecessary amounts of goods or of insufficient quantity.

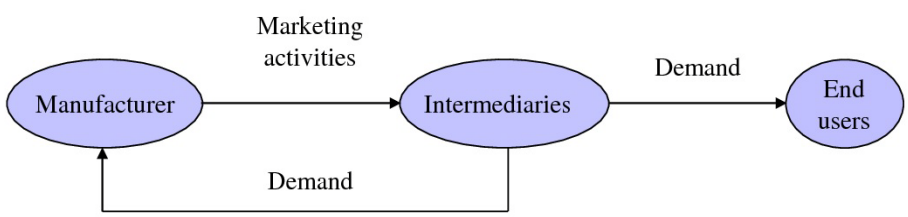



**Fig. 4. The Push system**

The simulation of the push system in the LPEG game results show the imperfections of the system. A first colour of the palette has been provided after 5 minutes and 40 seconds, next palettes of different colours were finished after: 6:13, 6:38, and 7:08. During the simulation there was a lot of chaos between

co-workers and between the teams, so it took a few of turns until the first palette left the production line. Tough situation was on table of Team 1, because this team should perform their tasks faster than others but it occurred to be the centrum of waste time and materials.

**Simulation: The Pull system**

*The Pull* system is a manufacturing system in which production is based on actual daily demand, and where information flows from market to management in a direction opposite to that in traditional (e.g. push) systems (fig. 5). The Pull system works backwards, starting with the customer's order then using visual signals to prompt action in each previous step in the process. The product is pulled through the manufacturing process by the consumer's demand.

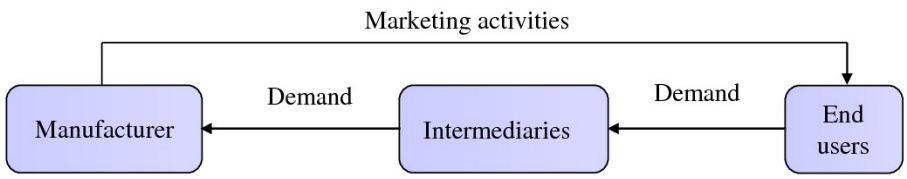



**Fig. 5.The Pull system**

In this system, the demand (colour of the palette) was known by Team 4 before the first round of the game started. In this case, Team 4 focused on producing something the market (table 'E') needed, and not only what the previous team was able to deliver. Every team worked more efficiently and quickly, in comparison to the previous production system. As a result, the exact ordered colour of the palette left the production line after 3 minutes and 7 seconds.

**Simulation: The Workcell system**

A workcell is an arrangement of resources in a manufacturing environment organized to improve the quality, speed and cost of the process. Workcells are designed to improve these by improving the process flow and eliminating waste during production. They are based on the principles of Lean Manufacturing. This system gives the workers the tools to be multiprocessors, operating multiple processes, and multifunctional, owning quality improvements, waste reduction, and simple machine maintenance. In the game simulation, it was decided to set-up the initial buffer for each workcell. As a result, the time production for four palettes was 4:18, which means that approximately 1 minute for each palette was needed for the production. It was noticed that the material flow was very fast and as a result Team 4 was working full-time.

## Simulation: Module production

In this system, every team had to build a module of palettes and store them for the next team. Fig. 6 shows modules of the palettes for each team. Time production for four different colours palettes was 4:47, so it was quick but not as efficient as the previous workcell system.

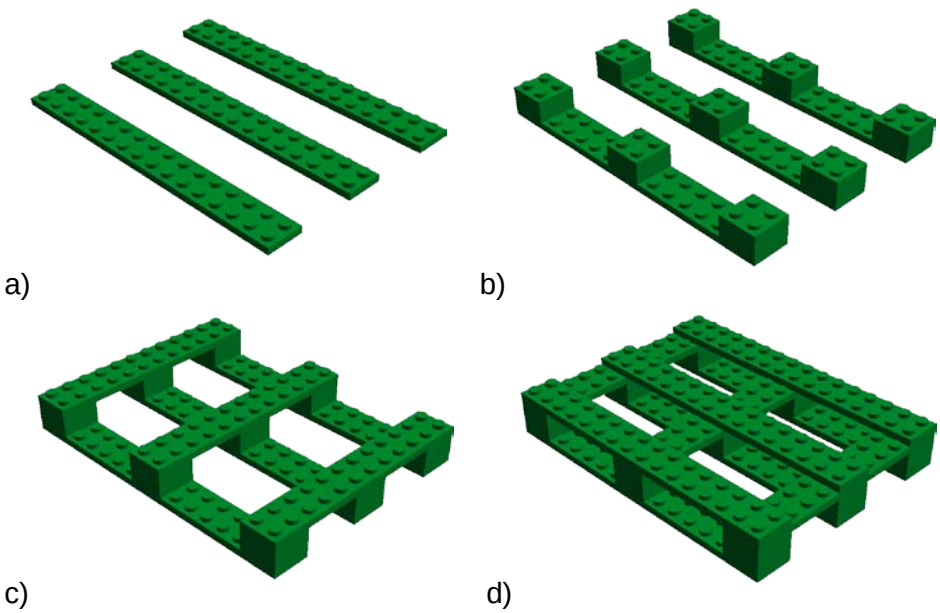



**Fig. 6. Instruction to build a palette module for: a) Team 1, b) Team 2, c) Team 3, d) Team 4**

## Conclusions

Educational games like The Lean Production Simulation Game can be very effective in the education of processes in manufacturing. Problems which were met during the simulation are common in real manufacturing processes. After The Lean Production Educational Game every participant should know the advantages and disadvantages of every production system, the difference between the Pull and Push systems. The biggest advantages of The Lean Production Simulation Game is the possibility of the implementation of one's own production system (e.g. the module system) to test how this system works and if it is effective. The participants of the game can be also involved in designing their own object of studies and should also be encouraged to try their own manufacturing organizing possibilities.

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