LEAN LEARNING ACADEMY: AN INNOVATIVE LEARNING CONCEPT IN ENGINEERING CURRICULA

Ignace Martens, Katholieke Hogeschool Sint-Lieven, Technologiecampus Belgium, ignace.martens@kahosl.be
Jan Colpaert,, Centre for Modelling and Simulation / Research Centre for Operations Management, Faculty of Business and Economics, Katholieke Universiteit Leuven, jan.colpaert@hubrussel.be
Liesje De Boeck, Centre for Modelling and Simulation / Research Centre for Operations Management, Faculty of Business and Economics, Katholieke Universiteit Leuven, liesje.deboeck@hubrussel.be
Carlos Vaz de Carvalho, ISEP – School of Engineering, Polytechnic of Porto, Porto, Portugal, vcarvalho@ipp.pt
Paulo Ávila, ISEP – School of Engineering, Polytechnic of Porto, Porto, Portugal, psa@isep.ipp.pt
Manuel Lopes, ISEP – School of Engineering, Polytechnic of Porto, Porto, Portugal, mpl@isep.ipp.pt
João Bastos, ISEP – School of Engineering, Polytechnic of Porto, Porto, Portugal, joao.bastos@fe.up.pt
Luís Fonseca, ISEP – School of Engineering, Polytechnic of Porto, Porto, Portugal, lmf@isep.ipp.pt

Abstract: Today, companies are faced with decreasing profit margins due to economic crisis and global competition. At the same time, in many higher educational institutions, students attend rather unattractive courses by sitting and listening to lecturers teaching ex-cathedra. This paper describes how Lean Learning Academy, an innovative training programme on lean manufacturing, can contribute to the competitiveness of companies, to the employability of employees and students, to the motivation of students, and to the attractiveness of engineering curricula. The training programme can be considered as a successful innovative alternative for the traditional way of teaching.

Keywords: Lean, game, training, course, company, higher education, engineering

1. INTRODUCTION

An important way for companies to stay competitive is to focus on production efficiency and cost reduction (see e.g. Tinham, 2005.). That is what lean manufacturing is aiming at (see e.g. Wood, 2004). The maximum benefit from lean manufacturing is gained by considering all its elements (i.e. principles, tools, and mindset) together as a system, and by practicing them every day in a consistent manner. As such, companies should be able to train their managers and employees continuously in lean manufacturing principles, tools, and mindset.

At the same time, higher educational institutions are trying to prepare their students to function successfully in professional life. They are looking for ways to better develop their students' competences. More specifically, lecturers are looking for learning methods that raise students' interests, motivate them, make them better understand complex matters and allow them to study anytime and anywhere using course materials published on the web (see e.g. Yazici, 2006; Dobson and Shumsky, 2007).

To satisfy the need for training lean manufacturing principles in companies on the one hand and to improve engineering students' employability in professional life on the other hand, an innovative training programme on lean manufacturing in the framework of an Erasmus–Lifelong Learning Programme (LLP) project is being developed.

The paper is organized as follows. In section 2, we elaborate on the different features of this project. In section 3 we touch upon the innovative didactical concept of the training programme. Section 4 concludes the paper by presenting some critical success factors for academics considering using simulation games in higher education.

2. PROJECT FEATURES

The training programme is developed in the framework of an Erasmus-LLP project (that started in October 2009 and ends in September 2011). For this project, cooperation is set up between lean experts of a university and a company highly experienced in lean manufacturing in five different countries (Belgium, Poland, Sweden, Romania and Portugal). The goal of this cooperation is to develop a state-of-the-art training programme consisting of a lean production simulation game

that is alternated with 16 on-line course modules on different lean topics. Apart from teaching lean principles and tools, the training programme also aims at developing a lean mindset. This means there is a lot of attention to and feedback on the lean behaviour of the participants. In order to enhance the output quality, the authenticity of incorporated cases and the relevance of all material included, a lot of external experts (apart from the company experts) are involved in the project. Since a lot of development has to be performed in only two years' time, monitoring the project progress is important from the very beginning. As such, measures should be taken to keep all partners on track. In the following subsections, we will zoom in on these different project features.

2.1. PROJECT PARTNERS

To develop such an innovative training programme, a collaboration is established between lean experts from five EU-universities, each supported by a company with a lot of expertise in lean management as represented in Fig. 1. This partnership assures a didactically well thought training programme with relevant and authentic content. Indeed, the company partners contribute to the project by providing the academic partners with their expertise (a priori and a posteriori) and e.g. with authentic cases; the academic partners use this expertise to develop the training programme. EURASHE (European Association of Institutions in Higher Education) is added as additional partner to help disseminate the project results to her wide member network.

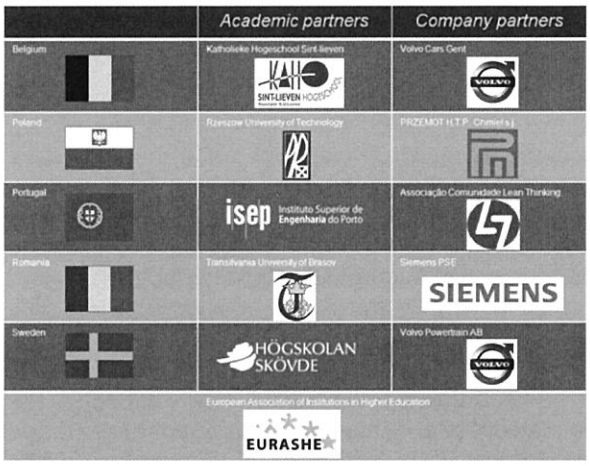

Fig. 1 - Logos of universities and companies involved in the project

2.2. PROJECT DELIVERABLES

Together, the five academic partners develop a state-of-the-art training programme in lean manufacturing consisting of 16 on-line course modules about different lean topics and a lean production simulation game. At their university, all academic partners reserved a production simulation room to set up the lean production game. In another room nearby, a team corner is equipped with team instruments and performance measurement tools.

A website (Lean Learning Academy, 2009) is developed where the different **on-line course modules** are easy to retrieve and ready to use as lecturer. Each module is supported by PowerPoint presentations. Explanations in the text box below most slides allow participants to use these course modules as e-learning packages. The modular approach also allows to compose different variants of learning sessions, from one-topic lessons to a complete lean programme of one week or even more. The industrial partners safeguard the professionalism and the technological relevance of the course contents while the academic partners safeguard their didactical quality and pedagogical relevance.

The lean learning contents consist of elements in the following three principal areas: operating system, mindsets and behaviours and managerial issues:

- The **operating system** is the 'tool kit', or a collection of tools and techniques that is used to run a manufacturing system under optimal conditions. Safety assurance, problem solving, quality assurance, visual management, variability reduction, process improvements, process measurements, total productive maintenance and standardized work are only a few examples.

- The **mindsets and behaviours** component focuses on lean behaviour. Aside the lean leadership behaviour, which is definitely a task for management, each employee needs to understand and get acquainted with the lean manufacturing mindset. By doing so, every employee is directly involved in the continuous improvement efforts of the direct work environment and the business process. Lean behaviour is trained during the theoretical lessons by introducing a number of mutual agreements between coach and participants to keep the classroom clean and tidy and by paying attention to a few other lean rules. Here follow some examples to clarify this:
  - When entering and leaving the classroom, every participant has to put a strip with his name in the right column (in/out) on a magnetic board outside the classroom.
  - Every participant must be on time for the sessions.

- When leaving his place, a participant must put his chair right under the table and leave materials on a clearly marked dedicated position on the table.
- The dress code for the classroom is as follows: safety jacket, safety shoes, no helmet, no safety glasses, no earplugs, no gloves.
- ...

Each time a participant violates a rule, the coach will give him a yellow note (a yellow post-it) with the violated rule written on it. These yellow notes are input for the team reflection meetings in order to come up with improvement actions. They stimulate a lean attitude of continuous attention and discipline.

- The managerial issues are more focused towards leaders with a broader responsibility in the manufacturing facility such as superintendents, production leaders, quality, and logistic managers. Lean leadership behaviour is a core element in that they have to show exemplary behaviour towards the other employees. Specific management tools like policy deployment, confirmation process, time and date management, coaching and assessment are also part of it.

The **lean production simulation game** enables the application of the lean concepts into a small scaled production line. In that production environment, a gift box with two ball pens is assembled. A lot of lean concepts are applicable like e.g. 5S, standardised work, line balancing, setup time reduction, one piece flow, layout optimisation, JIT/kanban, push and pull production, customer order decoupling point and many others. During a round, a PC programme graphically visualises customer lead time and a beamer projects it on a wall to allow participants to follow up customer orders. Lean behaviour is trained during the lean production game by keeping participants' attention on a number of safety rules. Again, some examples to clarify this:

- At the entrance door of the simulation room, signs indicate who is allowed to enter the room and what kinds of protection clothes people should wear inside the room.
- Inside a marked area around certain workstations, it is mandatory to wear additional safety clothes like e.g. gloves.
- The implementation of pull production requires from the workers the discipline not to produce when there is no demand from the next workstation, although they have available all necessary production resources.
- ...

And again, every violation against these rules leads to a yellow note.

By running several production rounds, the process improvements are leading towards a best-in-class lean production process. After each round productivity and efficiency metrics are visualised on the team board and discussed in the team.

During the entire course the participants are part of a team of seven to nine persons. Each team has its own fully equipped team corner with visualisations, performance measurements, team management tools, follow-up instruments and communications. The team dynamics and team member interaction is an important part of the lean learning process.

2.3. PROJECT MONITORING

In order to end up with a training programme that meets the high standards for training employees of well-known companies, project progress and output quality are continuously monitored. This monitoring is performed by several experienced people:

- **Resonance groups:** All five academic partners compose their own resonance group consisting of at least ten people from higher educational institutions and companies. To enhance the relevance and the quality of the project output, at least three times in the project lifetime, this resonance group gives feedback on materials developed by their academic project partner.
- **External evaluator:** An independent external evaluator (from Amelior management consultants, Belgium) monitors project output quality and project progress. He gives feedback on the published project deliverables, contacts partners who are far behind schedule and coaches them to keep pace with the project milestones. His reports are published on the project website.
- **To-do list published on the website:** In the 'Partners Only' section of the project website, a to-do list is added in which is mentioned for every milestone what should have been done by each partner. As soon as the task is done, the web master changes the red X in a green OK button. When there appears an arrow on the green button, clicking on it activates a link to an output document related to the task. This is represented in Fig. 2.

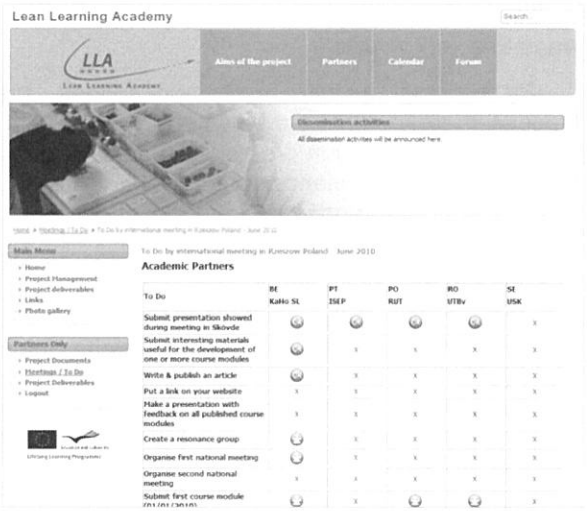

Fig. 2 - To-do list in the 'Partners Only' section of the project website

Apart from the above mentioned experienced people, eight national and four international project meetings are scheduled to discuss project progress and output quality among partners.

3. INNOVATIVE DIDACTICAL CONCEPT

The training programme can be seen as an innovative didactical concept. Rounds of the lean production game are alternated with short courses on lean topics. The learning cycle starts with the bottom rectangle as represented in Fig. 3:

1. The lean learning programme starts with a first round of the lean production game.
2. After that round, team members compute and measure lean key performance indicators (KPI's).
3. Looking at the indicators, team members formulate problems and/or make suggestions for improvements.
4. To assist the team in fully understanding the problem and providing the team with an appropriate improvement tool, the coach teaches the related course module.
5. Afterwards, the team members use this knowledge to find the most appropriate improvement actions.
6. As soon as the whole team agrees on the actions to be taken, they implement them in the lean production game by changing the game setup. Then, the team is ready to play a next round and a next learning cycle can start.

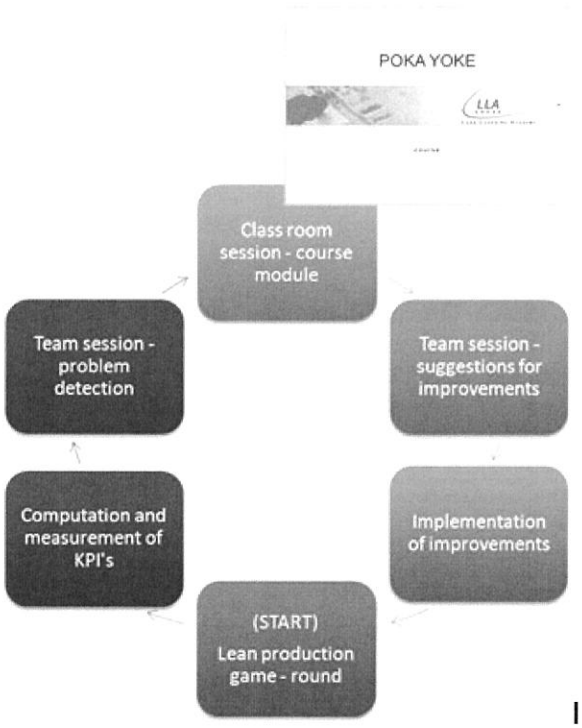

Fig 3 - The innovative learning cycle

4. CONCLUSIONS

In this paper, we elaborate on an innovative training programme on lean manufacturing in the framework of an Erasmus–LLP project. This programme is developed to satisfy the need for training lean manufacturing principles in companies on the one hand and to improve engineering students' employability in professional life on the other hand.

Positive experiences with a former lean production game in an educational setting let us expect that this innovative training programme will challenge his participants (Martens, 2006). All academic project partners agreed to implement it into their engineering curriculum. We know this makes a curriculum more attractive, motivates students, enhances learning yields and results in higher employability. Moreover, this project establishes a knowledge network between lean experts and therefore lays the foundation for successful cooperation in future projects.

However, academics who are considering using simulation games in higher education should consider some critical success factors.

- A good simulation game confronts students with the results of their proposed actions. It gives them an impression of the huge impact of certain improvement actions on KPI's. Often, many years after participating, some parts of

the game are indelibly printed in on their memory.

- The game development team must be convinced that the simulation game creates a unique learning experience for his students. Students will not stay motivated if the simulation output is in line with their expectations. In that case, a simulation game is not the most efficient didactical learning method.
- For the current generation of young people, there should be enough learning experiences in the simulation game which should intermittently follow each other. The game should advance with swiftness to prevent that students get bored.
- Ask students about their learning experience afterwards and correct or improve game aspects accordingly. Prepare for new directions in the storyboard of the game depending on decisions students possibly can take.
- And last but not least: do not undertake the whole process on your own. Involve some colleagues. Not only developing, but also preparing and coaching a simulation game is very demanding. We think here of the whole setup that must be checked before you start the game, the required interventions on several locations at the same time during the game, the quick setup change between two successive runs of the game, etc.

ACKNOWLEDGEMENTS

This training programme is developed in the framework of an Erasmus-LLP project, action 'Multilateral Projects', sub-action 'Co-operation between Universities and Enterprises', project name: 'Lean Learning Academies', ref: 503663-LLP-1-2009-1-BE-ERASMUS-ECUE

that started on October 1, 2009 and ends on September 30, 2011. This project is granted by the EU and co-financed by the academic partners.

References

Dobson, G., Shumsky, R. 2007. Web-based simulations for teaching queueing, Little's law, and inventory management. INFORMS Transactions on Education 7 (1): 106-124. Available online at http://ite.pubs.informs.org/.

Lean Learning Academy, 2009. http://www.leanlearningacademy.eu

Martens, I., 2006. Lean Production Game. Available from http://associatie.kuleuven.be/nieuws/dvdd2006/presentaties/Martens.pdf [in Dutch]

Tinham, B., 2005. How to make your supply chain lean. Manufacturing Computer Solutions 11 (3): 4-7

Wood, N. 2004. Lean thinking: what it is and what it isn't, Management Services Volume 48 (2): 8-10

Yazici, H.J., 2006. Simulation modeling of a facility layout in operations management classes, Simulation and Gaming 37 (1): 73 - 87

BUSINESS SUSTAINABILITY 2.0

Management, Technology and Learning for Individuals, Organisations and Society in Turbulent Environments

Edited by:

Goran D. Putnik

Paulo Ávila

Chaos and Sustainability – the 2nd Order 2.0

Universidade do Minho

isep Instituto Superior de Engenharia do Porto

About the authors:

Goran D. Putnik

Prof. Dr. Goran D. Putnik is (Full) Professor at Department of Production and Systems Engineering, University of Minho, Portugal. His scientific and engineering interests are production systems and enterprises design and management theory and implementations: CIM, intelligent production systems and enterprises, machine learning as a design theory model, concurrent and collaborative engineering, information systems management, formal theory of production systems and enterprises, distributed, agile and virtual enterprises, and complexity management in organizations. He is supervising a number of PhD projects as well. He regularly publishes and participates on international scientific conferences. His publishing record comprises more than 200 publications in international and national journals and conferences proceedings, and 9 books, of which the "Encyclopedia of Networked and Virtual Organizations" is distinguished. He serves as a member of Editorial Board for several International Journals. He was also invited lecturer on a number of universities.
Presently, he is the member of the following professional societies and scientific networks:

- Member of the CIRP – "The International Academy for Production Engineering"
- Member of the IFIP WG 5.5 – "COoperation infrastructure for Virtual Enterprises and electronic business – COVE"
- Member of the ECCON – "European Chaos and Complexity in Organisations Network – ECCON"

Paulo Ávila

Prof. Dr. Paulo Ávila is Coordinator Professor in the Department of Mechanical Engineering, at the School of Engineering – Polytechnic of Porto, Portugal, and the Director of the same Department. He received his Dipl.Eng. from the University of Coimbra in the domain of Mechanical Engineering, his MSc from the University of Minho in the domain of Computer Integrated Manufacturing and his PhD from the University of Minho in the area of Agile and Virtual Enterprises. His scientific and engineering interests cover the subjects of Production System Organization and Management, Computer Integrated Manufacturing (CIM), Total Quality Management (TQM) and Virtual Enterprises. He regularly publishes in international and national scientific conferences proceedings, journals and books. He is a consultant in several enterprises in the field of Industrial Organization and Management.

ISBN 978-972-8692-66-7
ISBN 978-989-95907-3-1