Analysis and Diagnosis of a Hand Tools Production System

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Abstract

Engineers must have a set of professional competences, which includes sound technical knowledge and the ability to solve engineering problems, integrated with a set of transversal competences, which must mobilized for managing projects, working in teams and communicate with the others effectively. The development of these sets of competences can be supported by projects in interaction with companies. This article reports the work developed by a group of students on the Integrated Project of the 4th year of Industrial Engineering and Management of the University of Minho. The main objective of this work is to describe the type of project that a group of students can develop in interaction with an industrial company, and reflect about the main results that this project have for the development of their competences and for the company. This is a descriptive paper based upon on reports and the experience of the students. The target of the project was the diagnosis and analysis of a production system in an industrial environment. The company chosen to develop this project is a multinational and pioneer company on the manufacturing of hand tools. The content of this article will mainly cover the internal supplier of materials (Mizusumashi), namely the standardization of the Mizusumashi route and the improvement of the components` warehouse (materials organization and visual management). The suggested modifications can result in a 30% decrease of the time wasted in the warehouse, a 20% decrease of the time it takes the Mizusumashi to complete a full route, reaching the 45 minutes the company requested. The students were able to fulfil the project milestones and integrate the company culture in their weekly visits, during the 15 weeks of the project. Furthermore, the company showed to be very satisfied with their behaviour and performance.

Keywords: Active Learning; Project-Based Learning; Engineering Education; Industrial Engineering and Management

1 Introduction

Nowadays the higher education system is on an adaptation and transition phase regarding the student's position during their learning process. The usual teaching methodologies, in which the student plays a passive role makes it hard to develop important competences required in the professional world. The goal of the higher education system is to form professionals capable of facing the challenges proposed by the society and in order to succeed in those challenges a change should occur in the education process. With this same goal, innovative teaching and learning methodologies are being developed in University of Minho on the Industrial Engineering and Management degree. These methodologies have as main feature the focus on the students learning, giving them an active role in the process. One of the main methodologies used is Project Based Learning, in which a problem related to the professional reality is tackled by a team of students during a semester that solve that problem integrating several areas of knowledge (Barrows & Tamblyn, 1980; Powell & Weenk, 2003; Graaff, 2007). Project-Based Learning approaches were introduced in the Industrial Engineering and in Management degree in 2005 (Lima, Carvalho, Flores, & Hattum-Janssen, 2007), being present in the first and fourth years. The focus of the project developed in the first semester of the fourth year is the interaction between companies and students in order to develop a real project (Lima, et al., 2014).

The main objective of this work is to describe and reflect on the project of analysis and diagnosis of a hand tools production system developed by a group of students of the fourth year of the Industrial Engineering and Management degree of University of Minho. This description can make a contribution for understanding the type of project that can be developed with companies, and the analysis of the results obtained by the students

will show what can be the main contributions for the company. Additionally, the analysis of the results will contribute for evaluating the results for the formation of the students as future engineers.

In addition to the development of technical skills that helped in the process of resolution of the company's above-mentioned problems, were further developed transversal competences such as communication, teamwork , time management, planning tasks , goal setting , critical thinking and methodology of work that will be more detailed in this article.

The first part of the article will consist in a brief background of the interaction of the group - company and the appropriate work. The second part will cover the technical skills used to solve the project. The third part will focus on the analysis of the results in an integrated dichotomous perspective of the technical competences that allowed to solve the problem proposed combined with the transversal competences acquired during the project.

2 Scope

Engineering, and in particular the industrial engineering field, is known for its comprehensiveness and breadth in several areas, which require a wide range of attributes: from technical and technological competence to the management of people integration system. These attributes are increasingly supported by employers (Lima, Mesquita, & Rocha, 2013) and universities and they can be achieved with alternative teaching methods in which students can solve complex challenges under the professional's reality light (UNESCO, 2010).

During semester 7 (out of 10) of the studies' cycle of the Industrial Engineering and Management degree of the University of Minho, the 4th year students are challenged to develop and broaden their technical competencies via a project approach, under the umbrella of Project-Based Learning. The students' projects are undertaken in partnership with several industrial companies. It intends to act as the vehicle for interactively put in practice the theory learnt in the different courses and for learning those contents in a deeper way. Simultaneously, it is an opportunity for the students to develop solutions for the partner companies' issues and learn to deal with the companies in a professional way. In this sense, this project provides the opportunity to develop a closer contact with the industrial reality and it allows the students to experience the difficulties and barriers found in the professional world.

The project mentioned in this paper resulted from a work developed by a team of 9 students throughout 15 weeks, from the end of September 2015 to the middle of January 2016. There was a total of 48 students divided in 6 different teams, each with their respective company. In this work reported in this paper, the team was in direct contact with a multinational company and pioneer in the manual tooling field and in which it was conducted the analysis and diagnosis of its production system. The analysis of the production system focused in important industrial engineering areas, in particular applying and integrating areas of knowledge related to the courses offered in semester 7, processes of production management, ergonomics, simulation and production system organization. During 15 weeks, the group worked on multiple study areas, however, this paper will focus on the Mizusumashi route, its development and the internal gains it achieved.

The symbiosis between the project team and the company was fundamental to the project's success and it stood out for the close and active working relationship between the two parties. This interaction was possible especially due to the weekly visits of the project team to the company from which several meetings were organized with the senior management team, including the Chief Operating Officer and engineers from Production and Logistics. The project team usually met the management team in the morning to clarify some doubts, to request documentation and to share the milestones set for the day. Another meeting was held once the morning shift was finished in order to discuss the results of the work carried out and to define goals for the following sessions. Another important factor to improve the relationship with the company was the persistence of the Chief Operating Officer in having frequent communication between the company and the project team via weekly feedback reports of the work carried out.

3 Mizusumashi

In this section will be approached the methods used by the students that provided improvements in intern supply system. Although this methodology is directly connected with the development of technical skills, other competences were developed too and will be explained with more detail in section four.

3.1 Analysis and diagnosis

The analysis and diagnosis of the production system when in contact with the organization enabled the identification of a set of opportunities for improvement such as the weak factory's internal supply system. This supply system consists of a logistics train known as Mizusumashi and which is responsible for the supply of materials to the different production cells. Its main advantage is the concentration of the non-productive time (motion and transport) in one single operator (Droste & Deuse, 2011; Alnahhal, Ridwan, & Noche, 2014; Nomura & Takakuwa, 2006).

After recording data for 5 weeks, it was noted a high variability in the Mizusumashi route's duration. The causes of this variability were related to the lack of a standard route and of a standard sequence of tasks to undertake. It was concluded that during its route, the Mizusumashi was spending a big portion of time in the components warehouse sector. This was due to the poor parts organization and to the lack of visual management in the warehouse. These factors contributed to the fact that only an operator with a significant level of experience would be able to undertake this task in a reasonable time.

3.2 Suggestions of improvement

While the project was being develop, some ideas emerged in order to improve the company's results. One of those problems was the Mizusumashi route. Usually one lap would take 56 minutes, but the company wanted that time reduced to just 45 min. That improvement was done using some visual management in the components warehouse, due to the fact it was the section were the Mizusumashi took the longest amount of time. This visual management was created with a more equal distribution of the components with the criteria being the necessity of their supply. Labels were created to identify the boxes of each component with the product picture, the hall identification and the shelf were it was stored.

Other methods were important to make enhancements like applying the standard work method to the entire route and using the standard worksheets as complement. With the application of the standard worksheets in each supply section, the intention was to make the Mizusumashi comply with the established timetable assuring a reduction of the supply time. The results of these improvements are summarized in Table 1.

Table 1. Actual average time and planned results with the suggested changes in route of the Mizusumashi

	Actual Average Time (min)	Planned Average Time (min)
Component's Warehouse	14	10
Total Supply Time	50	38.5
Total Transportation Time	7	7
Total Route Time	56	45

3.2.1 Standard Work

The Standard Work is a Lean tool, whose goal is to create a pattern of the work that should be followed by the operators, reducing variability in the process and increasing productivity (Arnheiter & Maleyeff, 2006; Dennis, 2007). Due to the absence of standard work in the Mizusumashi tasks, was decided to apply this tool in order to achieve the goals stipulated by the company. In order to be able to apply this tool, the team needed to develop an intensive process of time measuring and observation of the Mizusumashi route and tasks. In order to be able to define the standard work, the team measured the average time of each task of material handling and transportation of materials, of the operator of the Mizusumashi. Considering the time measurements and the observations, it was possible to discuss the best solutions with operators and managers of the company.

3.2.2 Standard Worksheet

The standard worksheet is a Lean tool for visual representation of the standard work. "The standard worksheet is one of the main steps to achieve Lean production, it allows a graphical view of the workstation, the operator route and the necessary amount of WIP to keep the production process balanced" (Surekha, Gowda, & Kulkarni, 2013). The worksheets developed by the team have a table with a description of the each task and the expected time. Furthermore, it should represent graphically the route of the operator in each production section.

3.2.3 ABC analysis

The ABC analysis is an inventory categorization technique. The ABC (Sanders, 2014) analysis provides a mechanism for identifying items that will have a significant impact on the inventory, while also providing a mechanism for identifying different categories of stock that will require different management and controls. This way the use of this tool was a huge help to create a better stowage of the components in the components warehouse and as a consequence an optimization of the operations done in that area. According to the ABC analysis, 20% of the items represent 80% of the overall consumption value and the 80% items left only represent 20% of the overall consumption. The items classified with an A will receive special attention when stored. Figure 1 represents the study that was developed for identification of different classes of components, using the ABC classification

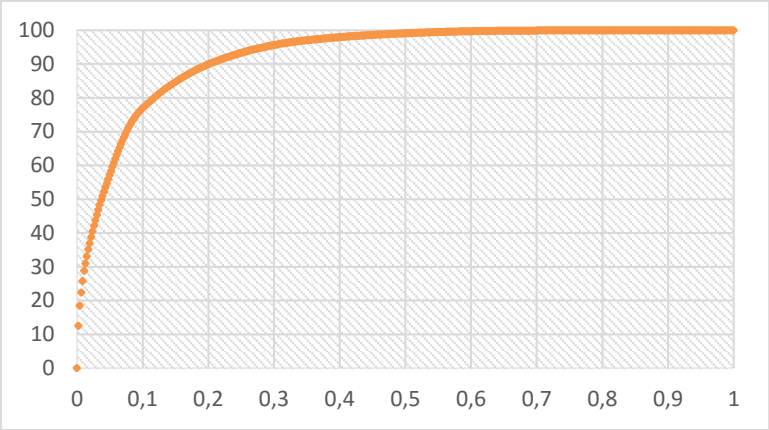

Figure 1. Components warehouse ABC analysis's graphic

4 Technical Results

The Project-Based Learning turned out to be a highly defying challenge capable of allying the technical knowledge of the Industrial engineering and management as well some other soft skills. This project was the first real contact of the group with the industrial world and, as such, it took a preponderant role in the preparation and reduction of the possible impact that could be felt when the transition from the academic to professional reality occurs.

The previously presented methods and tools were used with the main goal of solving the problems found at the company, allowing the students to acquire technical skills useful for the professional future. At first, it was necessary to acknowledge the need of a task standardization in an industrial world, as well as the importance of visual management and organization, from the production planning and control to the basic processes and operations. The technical competences were developed along the projects' 15 weeks through the constant analysis of the company's internal supply system.

The first step into the company's internal supply system analysis consisted on the observation of the different routes the "Mizusumashi" would take and the respective measurement of the total route time, time spent on each section and time it took to gather the required materials.

On a second stage, the establishment of a new, the most adequate, course for the Mizusumashi was the primary focus. The standard times for the different operations and sections were also determined. Once a more detailed study of the records was concluded it was easily observed that the lack of standardization theory was strongly corroborated. It was perceived that a time reduction from 56 to 45 minutes was, not only possible but viable once the warehouse's organization was optimized. This optimization was achieved by reorganizing the articles present in the warehouse in a more logical way following and ABC analysis regarding the articles rotation, as well as an improvement to the labelling system present in the racks. Figure 2 represents a visual image of the new organization of the warehouse, with the identification proposed for the rows and the routes of the Mizusumashi. Additionally, it is possible to see the proposed identification for the components positions.

Figure 2. Reorganization of the Warehouse, including new routes and a visual management system

The last stage of the standardization process consisted in standardizing the operations within each area by resorting to Standard Worksheets (Surekha, Gowda, & Kulkarni, 2013) that would be posted in each cell. Figure 3 shows an example of the visual illustration used in the worksheets. The main purpose was guaranteeing that the Mizusumashi would carry out the established times minimizing the operation times within each section and, as a result, minimizing the total route time. Some simulations were ran while adopting the new organization and labels and the results showed a gain, in some instances, of nearly 40%. With these improvements it is estimated a considerable reduction of the wasted time by the Mizusumashi on the components' warehouse and thus, improving the existing route.

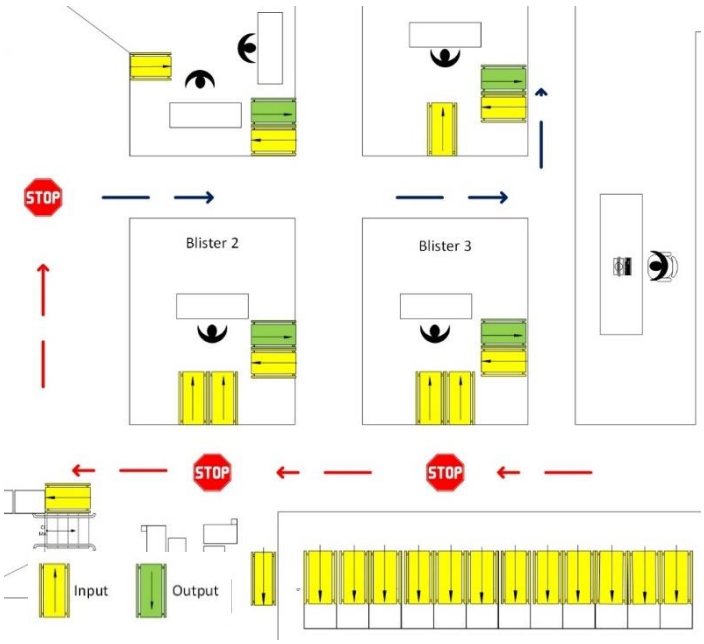

Figure 3. Worksheet example - visual illustration of routes of the Mizusumashi and the operator

5 Discussion

There are multiple examples of soft skills developed by students, one that was quickly highlighted was communication. This was promoted via acquaintanceship with, not only the elements of the group but with the company's employees. These exchange of ideas and discussion about the different subjects grappled during the project's lifespan lead to a broader acceptance of different viewpoints and contrary opinions. A healthy communication between the group's members also lead a better and improved method of teamwork since the management of time, tasks' division and an easier definition of the methodology to be used was imperial and learnt. The company's availability and kindness was enormous as the group was granted almost total freedom one day per week, or more if the group found it necessary. This freedom lead to a better and healthier development as it was possible to identify multiple improvement opportunities and, perhaps one of the key factors, the communication not only with the higher ups on the hierarchy but with the operators. As such, it was possible to hear the operators' opinion and find and confirm some of the identified problems with their help. The interactions with the company's multiple hierarchy levels helped the group feel ingrained within the company instead of an unknown and estranged member.

A fair share of the problems encountered, as well as the solution for the same problems, were not subjects directly taught at classes so, another soft skill the group had to develop was the ability to search and find answers to these problems on the various sources available, strengthening attributes such as creativity, proactivity and dynamism.

The interpretation of all the gathered information and its applicability to the encountered problems was possible with both the help from the company's management and the teachers involved. The group was frequently faced with distinct and sometimes clashing opinions on the same topic so it was required to absorb and analyse all this information while trying to come up with the best and most viable solution to the problems at hand. This process was responsible for the strengthening of some skills such as synthesis ability, critical analysis and decision making. The dichotomy observed between the theory taught at university and the industrial experience and reality, mainly the difficulties that occur when trying to apply some theoretical concepts from the industrial management field. It is also noteworthy that, not only is the knowledge and investigation important, but it is also crucial that these other transversal competences, such as communication and these professional experiences suffer improvements in order to solve multiple problems such as the ones found in this project.

6 Conclusion

The purpose of this article is to present how the work performed by the group, for the Integrated Project in Industrial Engineering and Management, on the first semester of the academic year 2015/2016, benefited and helped the group in learning technical and soft skills.

This way, as soon as some problems that occur in the company were identified, the group proceeded to investigate some possible solutions that, besides helping the learning and consolidation of the subjects taught in classes, namely the ABC analysis, Standard Work and standard worksheets, allowed, and in a certain way obliged, the simultaneous development of some soft skills, especially the ability to self-teach ourselves some technics and subjects we wouldn't learn in classes. Because of that, it was needed to search new technics to solve these issues encouraging creativity and proactivity. On the other hand it also allowed the group to vastly improve the communication skills seeing that it was required to talk with both the higher ups of the company, such as the production manager, and the operators on the shop floor.

Furthermore, due to the massive influx of clashing information and ideas, it was also possible the development of synthesis capability, critical analysis and decision making skills.

7 References

Alnahhal, M., Ridwan, A., & Noche, B. (2014). In-plant milk run decision problems., (pp. 85 - 92). Duisburg, Germany.

Aquere, A. L., Mesquita, D., Lima, R. M., Monteiro, S. B., & Zindel, M. (2012?). Coordination of Student Teams focused on Project Management Processes. International Journal of Engineering Education.

Arnheiter, E. D., & Maleyeff, J. (2006). The integration of lean management and Six Sigma.

Barrows, H. S., & Tamblyn, R. M. (1980). Problem-based learning. An approach to medical education. New York: Springer Publishing Company. Retrieved Fevereiro 2016

Dennis, P. (2007). Lean Production Simplified, Second Edition: A Plain-Language Guide to the World's Most Powerful Production System. New York: Productivity Press.

Droste, M., & Deuse, J. (2011). A Planning Approach for In-plant Milk Run Processes to Optimize Material Provision in Assembly Systems. (pp. 2-5). Montreal, Canada: Reconfigurable and Virtual Production (CARV2011).

Graaff, E. &. (2007). Management of change – implementation of Problem based and Project based learning in Engineering.

Lima, R. M., Carvalho, D., Flores, M. A., & Hattum-Janssen, N. v. (2007). A case study on project led education in engineering: Students' and teachers' perceptions. European Journal of Engineering Education, 32(3), 337-347.

Lima, R. M., Dinis-Carvalho, J., Campos, L. C., Mesquita, D., Sousa, R. M., & Alves, A. (2014). Projects with the Industry for the Development of Professional Competences in Industrial Engineering and Management. In N. v. Hattum-Janssen, R. M. Lima, D. Carvalho, S. Fernandes, R. M. Sousa, F. Moreira, . . . D. Mesquita (Ed.), Project Approaches in Engineering Education (PAEE'2014). Medellin, Colombia: University of Minho.

Lima, R. M., Mesquita, D., & Rocha, C. (2013). Professionals' Demands for Production Engineering: Analysing Areas of Professional Practice and Transversal Competences. International Conference on Production Research (ICPR 22), (pp. 352a[1-7]). Foz do Iguassu, Brazil.

Nomura, J., & Takakuwa, S. (2006). Optimization of a Number of Containers for Assembly Lines: The Fixed-Course Pick-Up System. (pp. 155-166). Japan: Nagoya University, Graduate School of Economics and Bussiness Administration. Retrieved Dezembro 10, 2015, from http://ijsimm.com/Full_Papers/Fulltext2006/text5-4_155-166.pdf

Powell, P. C., & Weenk, W. (2003). Project-Led Engineering Education. Lemma.

Sanders, N. (2014). The Definitive Guide to Manufacturing and Service Operations. In N. Sanders, The Definitive Guide to Manufacturing and Service Operations (p. 192). Pearson FT.

Surekha, S., Gowda, R. V., & Kulkarni, M. (2013, Abril). STANDARDIZED WORK: AN IMPORTANT PRINCIPLE IMPLEMENTED IN THE MANUFACTURING INDUSTRY. International Jounal of Management Research and Business Strategy. Retrieved Novembro 2015

UNESCO. (2010). Engineering: Issues, Challenges and Opportunities for Development. Paris, France: United Nations Educational, Scientific and Cultural Organization. Retrieved 10 06, 2012, from http://unesdoc.unesco.org/images/0018/001897/189753e.pdf