A Student Team Project in Real Context: The Team View

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Abstract

In the Industrial Engineering and Management Integrated Master course the projects in real industrial context are assumed to play a crucial role in the development of key technical and professional skills in students. In the 7th semester of this integrated master course the students are involved in a large real context project integrating many different subjects covered in 5 different curricular units. Student teams must analyze and diagnose a production unit in a company, identify improving opportunities, design solutions and implement them if possible. These experiences are very demanding to students since many different uncontrollable variables are influencing their performance as team and as individuals. In this article the students will describe the experience from different perspectives, such as: personal interaction, group and project management, technical challenges, communication issues, as well as the challenges in meeting teachers and company staff expectations.

Keywords: Projects; real industry context; teamwork.

1 Introduction

As the market develops, a change in organizational paradigms occurs. At present, the need to process and act based on ever more updated information in order to maintain high competitiveness in the market, leads to the need of more skilled human resources, capable of acting accordingly in immediate and unexpected situations.

Dias (2011) states that the modern professionals must embody the ability to quickly make decisions, outline new strategies, motivate and inspire team workers, use new technologies and find out what customers desire. Still according to the same author, they also must be bold without being reckless, be focused on the development of human potential and their skills and seek to educate and inform to be tuned and aligned to the constant changes. Therefore, training more autonomous, innovative and able to respond to the demanding market requirements professionals is required. This leads to a challenge to the universities, since they have to seek new ways of training their students to these new market demands and so the need to link the theoretical knowledge provided by the universities with its real industrial application is increasingly higher. In this point of view, new approaches are being adopted by universities to deal with this problem, such as the application of projects that connect the universities and their students with the industry. These projects present improvement opportunities both to the teaching models of the universities and to the companies' structures, since they are presented with the opportunities of improving some part of their structure through the work performed by the students in their facilities. These projects also represent a significant advantage to the students that take part of them, because they generate the opportunity to these future professionals to observe how things work and act in real industrial context.

This article intends to present the point of view of a team of students of the Industrial Engineering and Management Integrated Master course of Minho University that participated on a project in real industrial context in a company. Students will describe how they perceived the project …

The company's name will not be mentioned in this article being only referred as the company. In the next chapter, an explanation of how the project we have participated in works and how we have organized ourselves to respond to its requirements is presented. In the 3rd chapter, a brief exposition of the work we have accomplished is made and, in the 4th chapter, our opinions about what are the positive and least positive aspects of our interaction with our professors and the curricular units involved in the project and with the company where the project took place and, an analysis on what went well and what went least well in our interaction as team members is presented.

2 Project Context

The project in which this article is based on is developed in real industrial context. A company along with the faculty presents a problem related to its production system that must be studied and some improvements or some possible solutions must be presented. During the evolution of the project students must develop the learning skills listed on the six curricular units directly involved in the project as well as other professional skills more linked to the real context project work (

Figure 1). These curricular units included in the seventh semester of the Integrated Master in Industrial Engineering and Management of Minho University which are: (i) Manufacturing Systems Organization II, (ii) Integrated Production Management, (iii) Production Information Systems, (iv) Ergonomic Study of Workstations, (v) Simulation and (vi) Integrated Project in Industrial Engineering and Management II. Note that the last curricular unit mentioned is the result of the interaction between all the others and the company (

Figure 1).

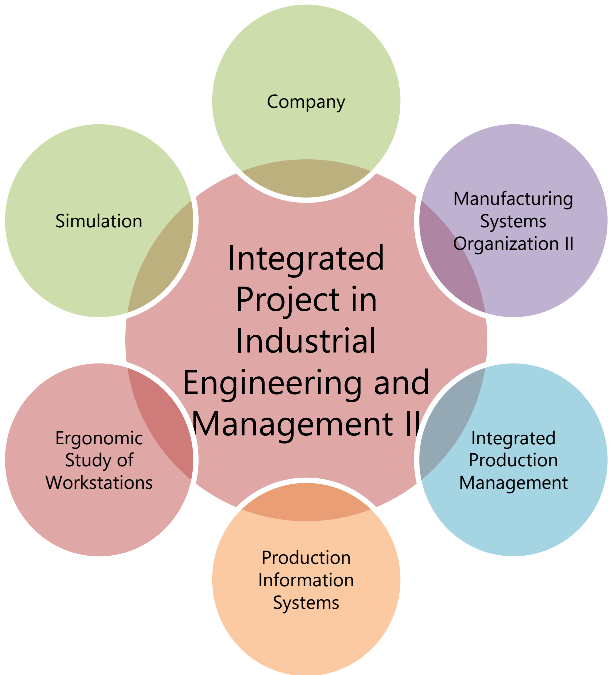

Figure 1 - Illustration of the interdisciplinary relationship between curricular units and the company.

During this project students should characterize and diagnose the existing production system and evaluate its performance, identify waste, identify and model planning processes and production control, partially analyse how the implemented systems meet the functional requirements and the production system information and, create simulation models of the production system. Furthermore, students should also characterize workstations in the ergonomic point of view and their physical environment, and identify possible alternative actions and expected results.

The project is divided in three stages (Figure 2): (i) company exploration/recognition, (ii) analysis and diagnosis of the production system and (iii) improvement proposals; each stage's end was characterized by a milestone.

Figure 2 – The three stages of the project.

2.1 Team's Organization

After the selection of the Company in which the team would develop the project, a spokesperson was chosen amongst the team members to be the one responsible for contacting the faculty or the connections from the Company on behalf of the team.

In order to accomplish the demands of each milestone, the team decided to split tasks by curricular unit among its members to increase productivity. During the course of the project, that division of tasks wasn't really fulfilled, because it was necessary to answer to different tasks from each course unit in different moments and so, if that division was truly maintained some team members would spend much time unable to do anything productive and the team members wouldn't be able to learn more about the subjects from curricular units that were applied in the project.

During the course of the project, the need of a spokesperson became less necessary since tasks splitting lead to the need of getting direct contact with the professors and the connections from the Company according to the theme of each member's task.

2.2 Theoretical background

The team had to use concepts, principles, as well as tools that are part of the subjects covered in the curricular units that support this project based learning case. Only the subjects that support the project pieces presented in the scope of this article will be described below.

2.2.1 Overall Equipment Effectiveness

The Overall Equipment Effectiveness (OEE) (Nakajima, 1998) is an indicator that measures the effective use of critical equipment that for some reason must be used as much as possible. This indicator helps in identifying the causes for capacity loses (Availability, Performance, and Quality) and should be continuously monitored and improved. The main idea of this indicator is that there is a set of constraints preventing you from using the equipment 100% of the time producing good parts. The conventional formula for OEE can be written as follows (Huang, Dismukes, Shi, Su, Wang, Razzak, and Robinson, 2002):

$$OEE = A \times P \times Q$$

Where

A = Availability Efficiency – represents the percentage of scheduled time that the equipment is available to operate. Often referred to as Uptime. It is related to losses that include non-scheduled downtime, break-downs, setup and adjustments, etc.).

P = Performance Efficiency - represents the speed at which the equipment runs as a percentage of its designed speed. Losses related to operate the equipment at a speed lower than the standard speed due to wear of equipment and tools, workers' failures, inappropriate material, etc.).

Q = Quality Efficiency - represents the good units produced as a percentage of the total units produced. It is related to defects.

2.2.2 Ishikawa Diagram

The Ishikawa Diagram or Cause and Effect Diagram, created by Kaoru Ishikawa, is a visualization tool for categorizing the potential causes of a problem in order to identify its root causes (Bamford et al, 2005). It was developed to determine and break down the main causes of a problem, by dividing them into categories, such as: (i) Machinery, (ii) Method, (iii) Maintenance, (iv) Personnel, (v) Product and (vi) Equipment. The Cause and

Effect Diagram was described by Ishikawa as a diagram that "can easily be understood by those on the shop floor" and "can be prepared showing assignable causes, different types of defects, etc" (Ishikawa, 2012).

The Cause and Effect Diagram is part of the Seven Basic Quality Tools (Tague, 2005) first emphasized by Ishikawa, which the remaining ones are Pareto Analysis, Check Sheets, Control Charts, Histograms, Scatter Diagrams and Flow Charts.

2.2.3 SMED – Single Minute Exchange of Die

The setup or changeover time is a variable playing an important role when the same equipment is used to produce different parts. The higher the changeover time the larger must be the batch in order to dilute the cost of the setup. So in order to reduce the batch size, so important in lean environments (Womack and Jones, 1996) a method was created under the TPS development (Ohno, 1988) called SMED (Shingo, 1985). SMED stands for Single Minute Exchange of Die which can be translated into fast tool change on a digit minute and proposes that the setups are performed within 10 minutes, which is a possible time to be achieved from the rationalization of the tasks performed by the machine operator.

The implementation of SMED starts with a preliminary stage consisting in a previous analysis in order to clearly understand the changeover process, identifying all the setup operations involved. The video recording of a changeover occurrence is very useful, as some characteristics of the setup operations can be easily obtained (e.g. duration and necessary resources). Usually, informal meetings with the involved workers are also necessary to clarify other aspects/characteristics (e.g. technical details and eventual existence of precedence relations). After this preliminary stage, three more stages are necessary to implement SMED: 1) separation of internal and external setup operations, 2) conversion of internal into external setup operations, and, 3) rationalization of all the setup operations. Unlike the external operations, the internal ones can only be executed if the production equipment is stopped, and, thus, it is obvious the importance of the transformation of internal into external setup operations (stage 2). In some cases stage 3 may become complex, but its execution is determinant to achieve relevant setup time reduction. An extensive list of techniques/tools that can be used in each stage can be found in Shingo (1985) as well as in PPDT (1996).

3 Diagnoses and improving opportunities

The company where this project took place produces furniture parts in three different production areas: BOF (Board on Frame), PFF (Pigment Furniture Factory) e Warehouse. The PFF was the production area where the team had to pay more attention. One of the main challenges proposed by the company was related to the large number of defects existing in a specific part of this PFF area, the spray lines. The non-conformed products need rework, which decreases productivity and further induce an increase costs. Therefore, the team started to analyse the overall process including the internal logistics and then decided to focus on the painting area, more precisely in the spray line 14.

3.1 Production Planning and Control

In order to have an overview on how the production was managed the team decided to study the production planning and control (PPC) activities. At the Master Production Scheduling level, named as Master Plan by the Company, the demand for 52 weeks is assumed and then an effort is made to create a reasonable even production schedule (production leveling). For example, in case the demand is superior than the maximum production capacity of the factory, it is necessary to distribute this excess of demand for the nearer weeks with low demand. Because of that, the company produces for immediate delivery and stock. The next stage, named as Production Plan, what is necessary to produce is balanced with the stock existences, the work in progress and the delayed production. As in the previous stage, it may also be necessary to level the quantity to produce without forgetting the priorities since the delayed products are more important than the production to stock.

Last but not least, it comes the weekly plan which determines for every production line/machine the order to produce including the product's name and code, the start time, duration and the time to finish that production order. Given the magnitude of the factory, this stage of PPC requires three employees responsible for different family products. While products of different families can share production lines/machines, people in charge of this plan need to work together and maintain a good level of communication so that everything works the best way. At the PPC level the team detected that the Company dependence to this people since they work based on personal experience and no document stating the priority rules to launch weekly production orders exist. The team decided to create a standard set aspects that must be taken in consideration by week planners. To do so the team had to interview different people with experience in this planning in order to establish a proposal of a set of aspects to be considered during the development of a week plan (Figure 3).

Figure 3 – Standard to create the week plan for spray lines.

Setups and color sequences are important because the setup time depends on the sequence of colors. As an example, the setup time from grey to white is higher than from white to grey. It is still necessary to know the interval between setups and the time spent on it without forgetting priorities like delivery deadline. Although the company produce for immediate delivery is also obliged to produce for stock, result of leveling. But when it comes to priorities is more important to produce for immediate delivery than for stock without forgetting that there are jobs in delays these should be considered as the delivery thereof. Since there are conveyors along the line it is important to consider the dimensions of the parts in order to reduce transport.

3.2 Description of the spray line 14 production system

The company evaluate its performance by financial and non-financial indicators. The financial indicator evaluates the production costs and the non-financial evaluates efficiency, absenteeism, overtime, breakdowns, scrap and rework. The team calculated the OEE (Overall Equipment Efficiency) indicator, a non-financial indicator, which aimed to measure the operating performance of the machinery.

An overview of the spray line 14 is shown in Figure 4 where main processes and route is represented. After the loading of parts into the spay line, operation performed automatically without human intervention, comes the sander process, which performs the smoothing of the surface of the parts that come from the machining in order to remove surface irregularities. After this, parts are subjected to an extraction process to remove dust in order to reduce impurities. Subsequently, the process takes place in a painting box in which the parts are subjected to application of base layers (first topcoat layer which reduces and equalizes the absorption surface and also gives some colour to the substrate) and a top (the last layer of paint that by having more additives provides the colour, desired strength and brightness), by spray.

At the end of this operation, the parts are sent to a hot air oven for drying. Here takes place the formation of a rigid layer of ink on the surface which can occur in a hot air curing oven with ultraviolet lamps (UV) or in a curing oven with infrared lamps (IR). Finally, they pass through a cooler and then they go through a quality control and automatically unloaded from the line.

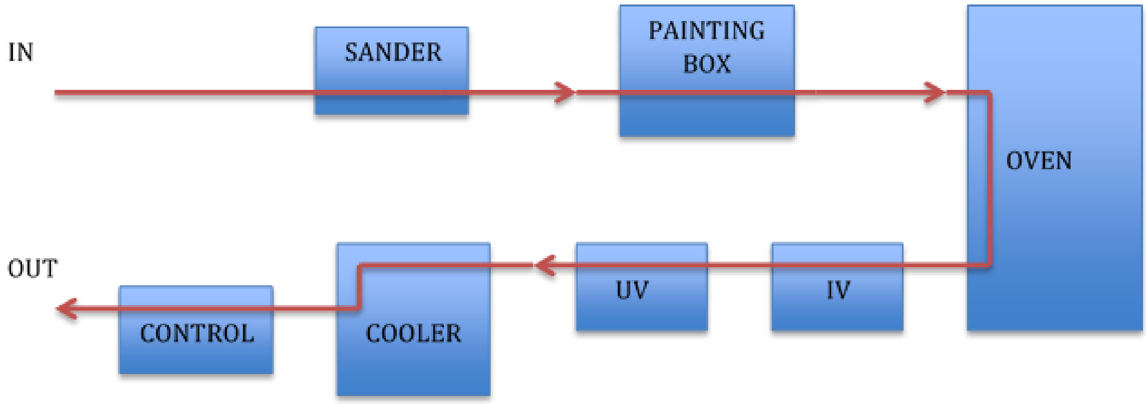

Figure 4 – Overview of the spray line 14.

3.3 OEE – Overall Equipment Efficiency

Table 1 presents the performance indicators of spray line 14 measured on October 2015 whose OEE value was 41,58%.

Table 1 - OEE for spray line 14 on October 2015.

Performance measures	Average
Availability (%)	66,81
Performance (%)	65,61
Quality (%)	94,36
OEE (%)	**41,58**

Through the OEE results, the team concluded that the factors that contribute to the decrease of OEE are mainly availability and performance. The performance is affected by failures in the processing speed of the machines and by operators' inefficiency while the availability is affected by breakdowns, and setups. Despite the defects in October did not significantly affect the performance of the line, they were responsible for the low availability, since the high frequency of occurrence led the company to invest in preventive maintenance and planned stops. The team also investigated, for October 2015, the time spent in cleaning the painting box and realized it was the one that most influenced the reduction of availability. The evaluation of the time spent in cleaning the box was assessed by SMED application mentioned in chapter 3.2.3.

3.4 SMED – Single Minute Exchange of Die

The cleaning of the painting box occupies lots of producing time, which led the team to apply the SMED (Single Minute Exchange of Die) method in order to reduce this time. Although the main objective of the SMED method is to reduce the changeover time, in this project this method is used to reduce the setup time as well as to reduce the maintenance time of the line and allow more time for the production of parts.

By knowing the operations which the cleaning of the painting box includes, their observation and timing was performed. Since all the activities were internal, the team evaluated the possibility of changing the activities to external, one by one. It was possible to change one of the activities to reduce the cleaning time in six minutes, meaning a gain of 6,9% of time. In addition, also in order to reduce the time spent on internal activities, it was suggested to put two operators in the execution of another activity which was being performed by only one operator, which would allow a decrease of about thirteen minutes, corresponding to a percentage gain of

14.9% of time. In conclusion, with SMED application, it was possible to obtain a reduction of nineteen minutes, which is about 21.8% of the time spent in the painting box's cleaning.

3.5 Quality

The items' quality is one of the most important indicators for the Company as it is related to the performance of the production system and customer satisfaction. The nonconforming occurrences massively disturb the production, in one hand, because it's required to stop the manufacture for corrective and preventive maintenance and, in the other hand, because it causes over processing due to the rework of defective parts.

To determine which defects were the most representative, the team developed an ABC analysis to the occurrences on October 2015. In category A are the impurities, broken/fissured parts and, deep marks and scratches. However, impurities and deep marks and scratches do not need to go to scrap, unlike broken/fissured parts. Those defects provide the option of reworking the parts because, although it doesn't add value to the product, it allows the parts to re-enter the system and, in a way, they don't become a total waste.

Thereby, the costs involved were analysed. It is known that the Company has spent, in October 2015, about €106.100 in rework and €20.000 in scrap which means a total of approximately €126.000. Of this total, the impurities are those that entail more costs.

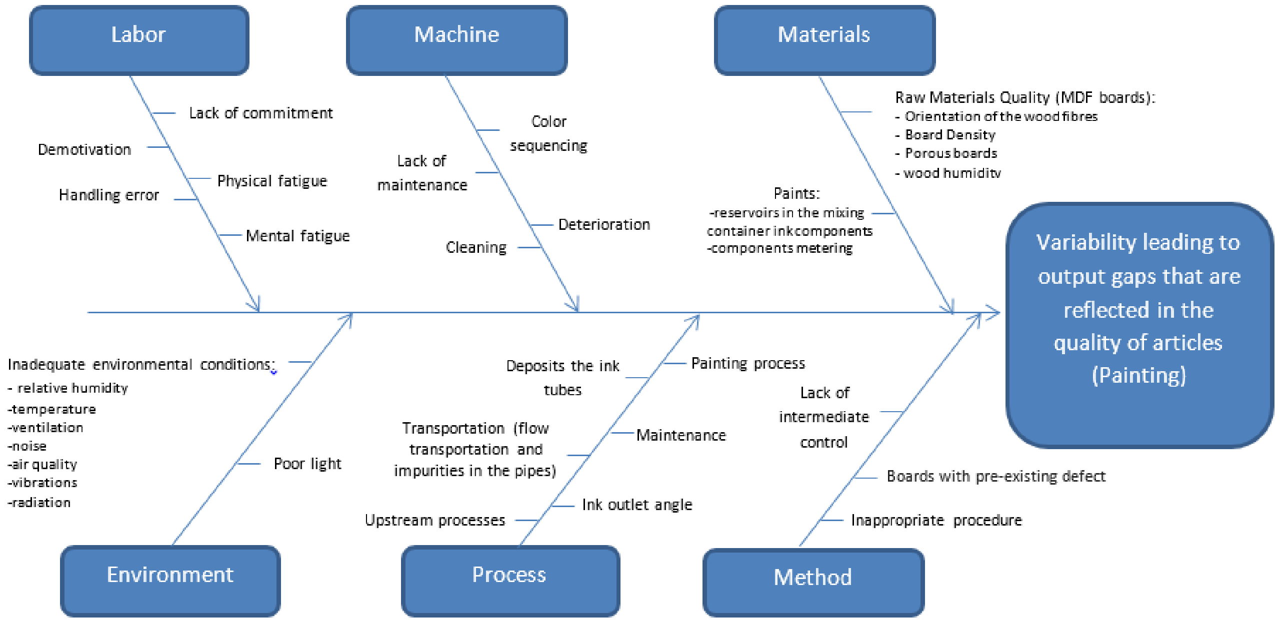

Figure 5 - Ishikawa diagram of the variability in the spray line 14.

In conclusion, the impurities are the most substantial type of defects, not only by its frequency of occurrence but also by the ignorance of the causes that originate this defects. Thus, the team conducted a brainstorming on possible causes for variability in the production of spray line 14, which was represented by the Ishikawa Diagram presented in Figure 5, where a large possibility of causes, however inconclusive, due to lack of data on that subject are suggested.

4 Interactions between different parties

4.1 Interaction with the University and professors

The professors' role in the execution of this project was a very significant factor mostly because they were the ones who established contact with the companies and enabled the realization of this project.

The interaction between the team and its professors provided some benefits such as the support provided by the professors during the course of the project and their ability to promote the project since they established contacts with major international companies.

However, sometimes there was a lack of communication with the Company in establishing the problems that were to be analysed by the team in which it was possible to apply knowledge obtained in the course units (since that was required to this project). A negative point was that the professors required the delivery of work related to their course units and so much time was spent doing that instead of spending that time working on the problems that the Company really need the team's study.

4.2 Interaction with the Company

In general, the team's relationship with the Company was very positive despite some difficulties felt in the beginning. From the team's point of view, this interaction was one of the most important parts of the project.

An advantage of this interaction was the possibility to deal with real industrial context. Furthermore, it allowed the establishment of professional contacts, important for the team members' future, and, since this interaction took place along five months, some professional experience was obtained.

The difficulty of transforming theoretical knowledge into practice was one of the disadvantages identified by the team because as students the team lacks professional experience.

In the beginning of this project there were some difficulties in scheduling meetings and even professors involved in the project felt some gaps in communication with the Company, because it was the first time that the Company was involved in this kind of project and so it wasn't aware of how the project was supposed to run. This led to loss of time by the team due to the Company's reluctance in providing data.

A team's suggestion for future projects in a company is the establishment of an advisor that should guide the students during the project's development. This should facilitate the exchange of data and give the students a view of an engineer's life.

4.3 Interaction with the team and between the team members

The relationship between team members was another of the most important aspect of this project. It provided the opportunity to improve the team members' soft skills, such as communication ability, problem solving and time management. Despite the existence of leaders and followers, it was managed to cooperate in order to achieve the best possible result. This project also allowed the distribution of tasks which lead to its quicker execution and, therefore, to a greater productivity. Lastly, the discussion of ideas made the project run successfully.

In a least positive side of this project were the interaction difficulties between some team members, because in some cases it was the first time a member was working with others which lead to some problems. Another difficult point was the schedules conciliation since the members live far from each other and that made it difficult to schedule meetings. Also, the failure to meet the stipulated tasks by some team members lead to excessive workload for the others. It should also be mentioned that some unjustified absences by some members in the meetings turned out to be an obstacle since the work plan had to be changed to adapt to this situations.

5 Conclusion

This article reports a real context project work carried out by a team of student in a company under a PBL (Project Based Learning) platform. This team of students on their 7th semester of the integrated master course in industrial engineering and management, identified improvements opportunities in the assigned company and designed effective solutions to perform the required improvements. Among other interventions that are not mentioned in this article they analysed the OEE indicator and in order to improve it they applied the SMED method to reduce the painting box's cleaning of about 21.8%, they identified improving opportunities in the PPC system and managed to diagnose sources of quality problems. In terms of the PBL experience the students pointed out the importance of the project in terms of the provided interaction with company´s reality and all benefits that come with it. On the other hand they also pointed out the difficulty in managing that interaction, especially in a company that was the first time involved in this type of PBL integration. Students also mentioned the important soft or professional skills developed during this project and the difficulties they felt in managing the project, their interactions with colleagues as well as the time management difficulties. Finally the students also recognized the classic dilemma between the syllabus and the project technical needs that almost impossible to match completely.

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