

BRINGING ENTREPRENEURSHIP INTO MECHANICAL ENGINEERING CURRICULA

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Abstract. *There is a strong need to take measures enhancing the ability of graduated students to create their own job. It is one of the main policies the EU is developing to achieve higher productivity levels, to face open competition and to introduce innovation into enterprises, thus increasing competitiveness.*

The Operations Management course was chosen to bring together the (not so) classic contents of designing productive systems (both products and services), organizing and implementing operations strategy, carefully managing the processes to distribute those products and services, doing all this in an innovative way, with entrepreneurship in mind.

Traditionally this is a course specifically located in the 4th year of the five-year graduation in Mechanical Engineering and Industrial Management. The introduction of entrepreneurial skills has been an established goal since 1999. But only after a first external evaluation process was a momentum created that enabled this procedure to take place under the guidelines of the Bologna Declaration on the European Space for Higher Education.

The reorganization that followed made classes take place in labs where internet access was easy. The curriculum was modified so that the four initial weeks were used to approach the main subjects and to discuss them based on case studies (Zara, Optimus, Vulcano/Bosch, Benneton, Birmingham airport, Marks and Spencer and others). A short entrepreneurship course was provided, addressing the issues of creativity (finding and evaluating an idea), opportunity, teambuilding, work planning and business planning, evaluating legal constraints and finding money. As students were previously well-informed on the way the course was structured, they were expected to state their own idea of an innovative service within an existing enterprise (including the one where they were working) or of an enterprise itself. Therefore, the operational contents that followed the unfolding course were approached in a very applied way, i.e., applied to their very own case.

This paper ends with an insight on the final assignments delivered by students and with an evaluation of the impact on their level of success.

Keywords: *entrepreneurship, engineering curriculum, collaborative learning*

1. Introduction

The big challenge that companies face today is associated with goals like increasing productivity, improving the quality of their products, rational use of energy, environmental protection, product diversity, the creation of new areas of competitiveness and growing aggressiveness in the global market. To win this challenge, companies need qualified technicians with knowledge in two distinct areas: Engineering and Industrial Management. It was based on this increasingly prevailing fact that the five-year graduation in Mechanical Engineering and Industrial Management (MEIM) appeared. If, as regards Engineering, integrated knowledge of subjects such as materials, electric and electronic machines, plants and energy management are important, the same subjects will have to be grouped by knowledge related to productivity and competitiveness and, therefore, to Industrial Management. In this context, one can say that Industrial Management undoubtedly represents an important part in the graduation.

In order to embrace the most important issues within the scope of Industrial Management, five fundamental areas are studied during the graduation:

- Maintenance Management;
- Investment Projects Analysis;
- Strategy, Quality and Innovation;
- Human Resource Management;
- Production and Operations Management.

All these five areas allow students to have a global perspective of Industrial Management and to understand the importance of an efficient articulation between them.

This paper will discuss the Production and Operations Management area in greater depth and, particularly, the innovative teaching methods used in the Operations Management course.

2. The Operations Management Course

Within MEIM graduation, the Production and Operations Management area is explored in two different semester courses: Inventory and Production Management and Operations Management. The first appears in the 3rd year of the graduation and concerns 'production' in the classic sense of the word, i.e., production of goods, complemented with inventory management. Specifically, the contents of the Inventory and Production Management includes issues like strategy, design of productive systems (including size, location and plant layout), aggregate planning, production scheduling and control and inventory management. Until the school year of 1997/98/1997/98 academic year MEIM was just a three-year graduation (granting a bachelor's degree) and Inventory and Production Management was the only course in Production and Operations Management area. The curricular restructure that took place in 1998 has resulted in a five-year graduation that was implemented in the 1998/1999 school year.

The creation of two more years in the graduation allowed the introduction of a new course in Production and Operations Management area, with the established goal of complementing the course already underway in the 3rd year. That course was called Operations Management and appeared in the 4th year of the graduation with the purpose of looking at production management in a broader perspective. In other words, the term *production* is now applied for both goods and services. In fact, one can say that Operations Management is an extension of Inventory and Production Management and is concerned with the design, planning, control and improvement of an organization's resources and processes to produce goods or provide services, as illustrated in Fig. 1.

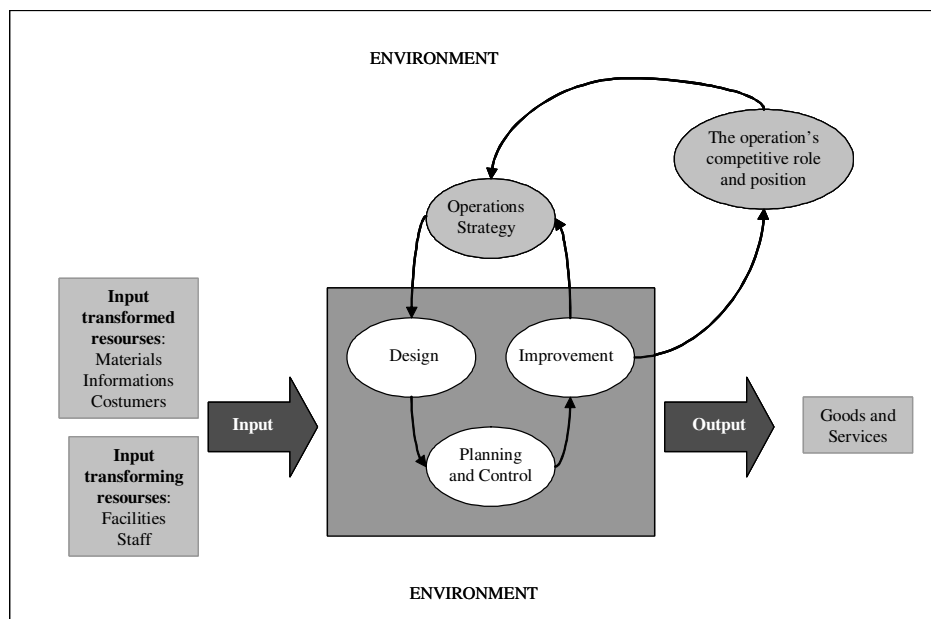


Figure 1. A general model of operations management (Johnston *et al.*, 2003)

In the first four years (from 1998 until 2002), the course was taught in a classic way, with the typical contents of operations management, as the ones described above in the course of Inventory and Production Management, but with emphasis on services. However, almost from the beginning, the need to establish more ambitious goals for Operations Management course was felt in order to follow the present-day reality that demands increased innovation in enterprises so as to face global competition. The introduction of entrepreneurial abilities has been an established goal since 1999, but, only after a first external evaluation process was a momentum created that enabled this procedure to take place under the guidelines of the Bologna Declaration on the European Space for Higher Education.

2.1. The Reorganization in Operations Management Curriculum

It is well known that one of the main policies of the EU is to achieve higher productivity to face open competition and increasing innovation, thus boosting competitiveness. The introduction of entrepreneurship in the Operations Management course was found to be the best way to help students to create their own job, or allow them to contribute

towards increased competitiveness in the enterprises where they work (or in those where they will work). Therefore, and in order to achieve this goal, a reorganization in the Operations Management curriculum took place, bringing together the (not so) classic contents of designing productive systems (both products and services), organizing and implementing operations strategy, carefully managing the processes to distribute those products and services, doing all this in an innovative way, and entrepreneurship. The first change was for classes to take place in labs with internet access. The curriculum reorganization that followed *has* divided the Operations Management course into three distinct parts, as described below.

2.1.1. Using Case Studies in Teaching

The four initial weeks are used to approach the main subjects and to discuss them based on case studies (Zara, Optimus, Vulcano/Bosch, Benetton, Birmingham Airport, Marks and Spencer). It's a fact that the decisions that operations managers take each day in their organizations cannot be easily studied by simply listening to or reading texts. Certainly these will give students important and helpful insights, but it is also a fact that the subject does not come to life until it is practiced. That is why case studies are essential to teaching practical and applied subjects such as operations management. Case studies allow students to understand what operations managers actually do and how they work, as well as the issues they have to face. Most importantly, case studies also provide students the opportunity to experiment the situations that operations managers face in a safe environment, giving them a chance to analyze and evaluate those situations and to develop and discuss possible solutions with peers.

All cases studied in Operations Management course are real, based on real situations, in real organizations which make them especially interesting. Case studies have the ultimate goal of helping students to develop a range of skills that could be of great importance in their professional lives, as operations managers or as entrepreneurs. These are:

- Analytical skills– dealing with both qualitative and quantitative data to analyze situations;
- Application skills– providing opportunities to practice using tools, techniques and theories learned in class or found in many operations management texts;
- Creative skills– using imagination and creativity to assess and solve unique problems;
- Critical thinking skills– applying clear and logical reasoning to the information available;
- Communication skills– listening to colleagues and constructing and expressing arguments, debating options and presenting findings;
- Decision-making skills– expecting students to reach conclusions and suggest decisions based on their analysis;
- Interpersonal skills– working with peers, learning how to deal with them and in conflict situations;
- Time management skills– scheduling time carefully to reach presentation or submission deadlines;
- Written communication skills– developing effective writing skills through written case reports.

These skills do not just appear out of nowhere, they must be worked at, and it is the students' responsibility to develop their own skills through an adequate approach of case analysis, treating them as problem-solving opportunities and following a sequence of activities specifically for problem solving. Those activities should be: observation, understanding objectives and context, analyzing situations, determining options, evaluating possible solutions and making choices.

2.1.2. Introducing Entrepreneurship

In a second part of the Operations Management curriculum, a short 10-hour Entrepreneurship course is given, following the National Collegiate Inventors and Innovators Alliance guidelines (NCIIA, 2002). It addresses the following issues:

1. creativity (finding and evaluating an idea),
2. opportunity,
3. teambuilding,
4. planning work and business planning,
5. evaluating legal constraints and
6. finding money.

Those general issues are deeply analyzed and discussed in class with students. Another important aspect is the goal of making them understand that, in order to be successful in any business or to be a successful entrepreneur, they must master a complex set of skills and, most importantly, that they must understand that successful businesses are those that satisfy needs of a community.

Entrepreneurship education is a way to teach students to embrace changes rather than fearing them. Entrepreneurship means change. It is the teacher's duty to help students to understand their options in a free market economy, and to encourage them to look for entrepreneurial opportunities themselves.

A fundamental issue of the Entrepreneurship course is how to evaluate business ideas. In fact, in analyzing business ideas, students must be able to make them pass a test to determine if whether or not they are valid opportunities. All ideas must have demonstrated a need found a market and proven the ability to provide a solid return on investment.

Some questions that must be asked are: is the idea feasible in the marketplace? Is there a demand? Can it be done? Is it possible to pull together the people and resources required to pull it off before the window of opportunity closes? All these questions must be considered and answered.

Entrepreneurs look at "risk" and see opportunity for their expertise rather than opportunity for failure. In the Entrepreneurship course, students are also taught to how to analyze opportunities available to them. This might include:

- A better way to accomplish a task through inventions, new services, and new approaches;
- Examining a growing segment of the population that may be open to a special version of a product or service targeted to their life-style or needs;
- A cheaper product or service than is currently available;
- A new technology that enables a business to solve customers' problems in an entirely different way;
- A business location that is more convenient to customers than your competitors' location.

Students must be aware that small businesses and entrepreneurs often provide needed innovations in all areas of industry when larger companies cannot change quickly. This kind of entrepreneurial flexibility causes a constant fluctuation of the market, as well as pressure for businesses to be more competitive.

Opportunity-focused entrepreneurs must always start with the customer and the market in mind and that is how students are encouraged to think. This course also teaches how to analyze some important market issues like market structure, market size, growth rate, market capacity, attainable market share, cost structure, strategy issues, and time to breakeven, opportunity costs and barriers to entry. To sum up, the Entrepreneurship course has an ultimate goal of helping students answer the following questions, which any entrepreneur should use to evaluate his business ideas and plans:

- What is the need you fill or problem you solve (value proposition)?
- Who are you selling to (target market)?
- How would you make money (revenue model)?
- How will you differentiate your company from what is already out there (unique selling proposition)?
- What are the barriers to entry?
- How many competitors do you have and of how good are they (competitive analysis)?
- How big is your market (market size)?
- How fast is the market growing or shrinking (market growth)?
- What percentage of the market do you believe you could gain (market share)?
- What type of company would this be (lifestyle or high potential, sole proprietorship or corporation)?
- How much would it cost to get started (start-up costs)?
- Do you plan to use debt capital or raise investment? If so, how much and what type (investment needs)?
- If you take on investment, how much money do you think your investors will get back in return (return on investment)?

By using these questions students should be able to do a thorough job of analyzing the business ideas they come up with. This type of entrepreneurial education has numerous benefits. The most important are: community understanding, business management skills, orientation to change, individual personal growth, expanding creative thinking, decision-making skills, sense of career choices and application of technical skills and experiences.

2.1.3. Written Projects

The third part of the Operations Management course appears as a natural sequence of the Entrepreneurship short course. Previously, during the first week, students are well informed on the way the course is structured. Therefore, by the end of the fourth week they are expected to state their own idea of an innovative service within an existing enterprise (including the one they are working at) or of an enterprise itself. So, after the Entrepreneurship course, pair of students start to develop their own projects, based on the idea they have presented, applying concepts acquired up to that point.

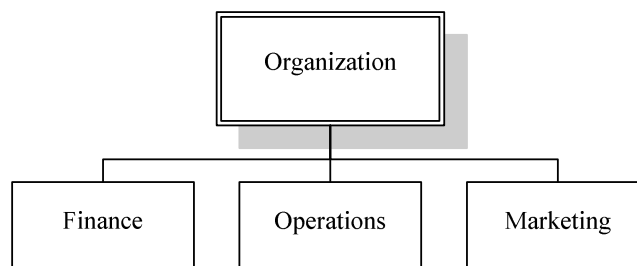


Figure 2. The three basic functions of business organizations (Stevenson, 2005)

The operational contents (planning and control) that follow the unfolding course are approached in a much applied way, i.e., applied to their very own case. Those contents could vary depending on students' specific needs, following their work in classes.

Considering that, in their projects, students make an effort trying to create as real a business as possible; the final assignments handed in by students are expected to approach the three basic functional areas of any business organization, as depicted in Fig. 2: Finance, Marketing and Operations.

Each of these functions has a fundamental role when developing a new business. Students use Finance when they consider the start-up costs, investment needs and how to get money; they make use of Marketing when they analyze market issues like consumer's wants and needs and market size. The Operations function is primarily responsible for producing the goods or services offered by the organizations, which is obviously the main issue in the Operations Management course. Therefore, Operations functional area should be the one which is most highly-developed in students' final assignments, allowing them to apply their knowledge and demonstrate how much they have learned.

The two final weeks of the Operations Management course are usually reserved for the presentation and discussion of the assignments handed in. Each group prepares a Power Point presentation with a ten-minute time delay, followed by a brief discussion where students are questioned about their work. All presentations are open to classmates.

2.1.4. Assessment

Assessment of the Operations Management course has also undergone some changes in order to motivate students to attend classes regularly. It is divided in the following way:

- Case studies carried out in class– 10%
- Presentation of an application assignment of theoretical concepts taught in the scope of the Operations Management course, particularly as an entrepreneurship application, in an existing enterprise (including the one they were working at) or of an enterprise itself– 35%
- Quality of classroom participation– 10%
- Written test– 45%

Beyond motivating regular attendance, this assessment allows students to increase their chances of successfully completing the Operations Management course, since passing does not depend exclusively on a single assessment moment.

2.2. The Results Obtained with the New Curriculum

As stated before, the curricular reorganization of the Operations Management course took place in 2002 and since then classes have been run according to this new curriculum.

For this analysis, it is essential to say that the vast majority of students attending the fourth and fifth year of the MEIM graduation are working students and, therefore, classes are taught at night. For this reason, attendance levels are unfortunately low. Finding a solution to this problem has been one of the main concerns of the MEIM faculty.

The implementation of the new curriculum in the Operations Management course and its assessment process has contributed towards lessening the problem of attendance. In fact, this new approach has brought significant improved students' motivation, increasing attendance levels, as shown in Fig. 3.

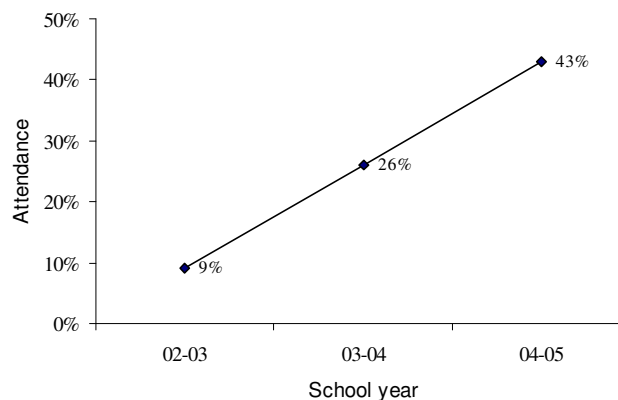


Figure 3. Evolution on assiduity levels of the Operations Management course

Another interesting fact is that nearly 95% students who attended classes regularly, in the last two years, succeeded in this course.

The assignments handed in over the past two years have been very interesting and, in some cases, the ideas that students have come up with are quite original. Some examples of those assignments are:

- Creating a new mobile phone operator – this new company appears in the market with competitive prices and a set of innovative services to compete with those already in place.
- Creating an institution that provides, in a unique space, a complete set of student services – this institution provides all sorts of information that students need; it is also a study center, with a library, an internet room and a coffee shop, all this in a single, open space.
- Creating a fresh vegetable export enterprise– the main goal was to provide to some European countries with fresh vegetables out of season.
- Creating an enterprise law consulting firm – this enterprise would provide consulting services, legal support and standardization services.
- Creating an enterprise that provides fire prevention services – this enterprise provides training courses to firefighting corps, analyzes risk situations and provides enterprises with safety inspections.
- Creating a professional school.

Those assignments, along with all the work developed during the semester are proof that students have acquired some operation management and entrepreneurial skills and that they have learned how to explore and develop those skills. The increase in the levels of success verified over the last two years (see Fig. 4) encourages the teachers of this Operations Management course to further develop this new approach.

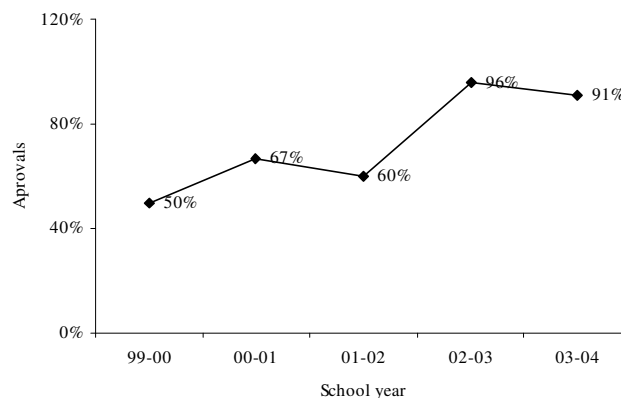


Figure 4. Students' approval in the past seven years

The next few years will show if this innovative teaching method is, in fact, the right one.

As a conclusion, one can say that there are two key points or main goals with this new curriculum that have been achieved so far:

- The first, is to make students to take an active role in their own learning and to make them understand that they should take personal responsibility for their own learning and development;
- The second is to provide students with entrepreneurial abilities and exercise skills so they can, more easily, create their own job or to allow them to give a valid contribution to increase innovation and competitiveness in the enterprises they will either work at or are currently working for.

3. Conclusions

The results obtained so far are insufficient to establish some final and definite conclusions, if we look at them from a quantitative point of view, trying to establish a direct connection between the measures that have been undertaken and the final grades. Nonetheless, there is some evidence of positive trends directly related to this approach, making it appear to be a valid way to further implement entrepreneurship using some applied Operations Management skills.

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