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ARQUIMEDES: A TOOL FOR TEACHING PPC IN AN OPERATIONS MANAGEMENT COURSE

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Abstract

Production Planning and Control (PPC) is one of the most complex and important processes that students must learn in an undergraduate Operations Management (OM) course. Unfortunately, many traditional academic programs continue teaching the activities that comprehend the PPC process as a sequence of isolated stages, ignoring that PPC is an iterative process rather than sequential. In this paper we present ARQUIMEDES, a computer-based manufacturing planning and control systems developed to help undergraduate students understand the different stages involved in the PPC process (i.e. forecasting, aggregate production planning, master production scheduling and material requirements planning) and how they are related to each other in an integrated approach. We describe the most important modules of the application and include a guide on how this tool can be used to support the process of learning PPC.

Keywords: Production Planning and Control, OM Course, Education.

1. Introduction

Production Planning is one of the most important processes that must be done inside a company. Global competition, quality, speed, flexibility, costs and constant changes in customer necessities, require that Operations Managers develop a structured process of production planning that allows to achieve international standards, to take advantage of competitiveness and to get objectives of the company in a high level.

World class companies of the 21st century, need industrial and manufacturing engineers and operations managers with good foundations to understand the different stages involved in a production planning process and how this stages must be integrated, in order to face successfully the new challenges posed by the "New Economy" (Hayes, 1998, 2002).

Since our students will face these challenges, it is a responsibility of professors to change the approach traditionally used to teach PPC process, in which it is seen like a sequence of isolated stages, by a methodology that includes foundations and principles enough robust, that will allow future operations manager to make better decisions and understand the PPC process like an integrated approach. In this sense, teaching frameworks and several proposals for new teaching approaches have been reported (Shtub 2001, Julien *et al*. 1998, Starr and Farzad 1994)

At the Production Engineering Department at EAFIT University, the research group on Production Planning and Logistics developed "Arquímedes", a software that trainers can use as a tool that supports processes of learning and teaching of production planning in an introductory operations management course. In this paper we show and describe the main modules of the application and how this tool can be used.

2. Course overview

On undergraduate Production Engineering program at Eafit University, students have to take two mandatory courses: Production Planning in the second-year, and Production Scheduling and Control in the fourth-year. The first course covers mainly five topics:

forecasting, aggregate planning, capacity planning, master production scheduling and materials requirements planning. The second course includes Just in Time (JIT), Theory of Constrains (TOC) and Optimized Production Technology (OPT), line balancing and production scheduling. These are standard topics in production and operations management courses and there are found in many textbooks (Castro 2008, Chase *et al*. 2005, Sipper and Bulfin 1997, Vollmann *et al*, 2004). Figure 1 shows a general overview of topics that are include in both courses, emphasizing on Production Planning course, which is the main issue of this paper.

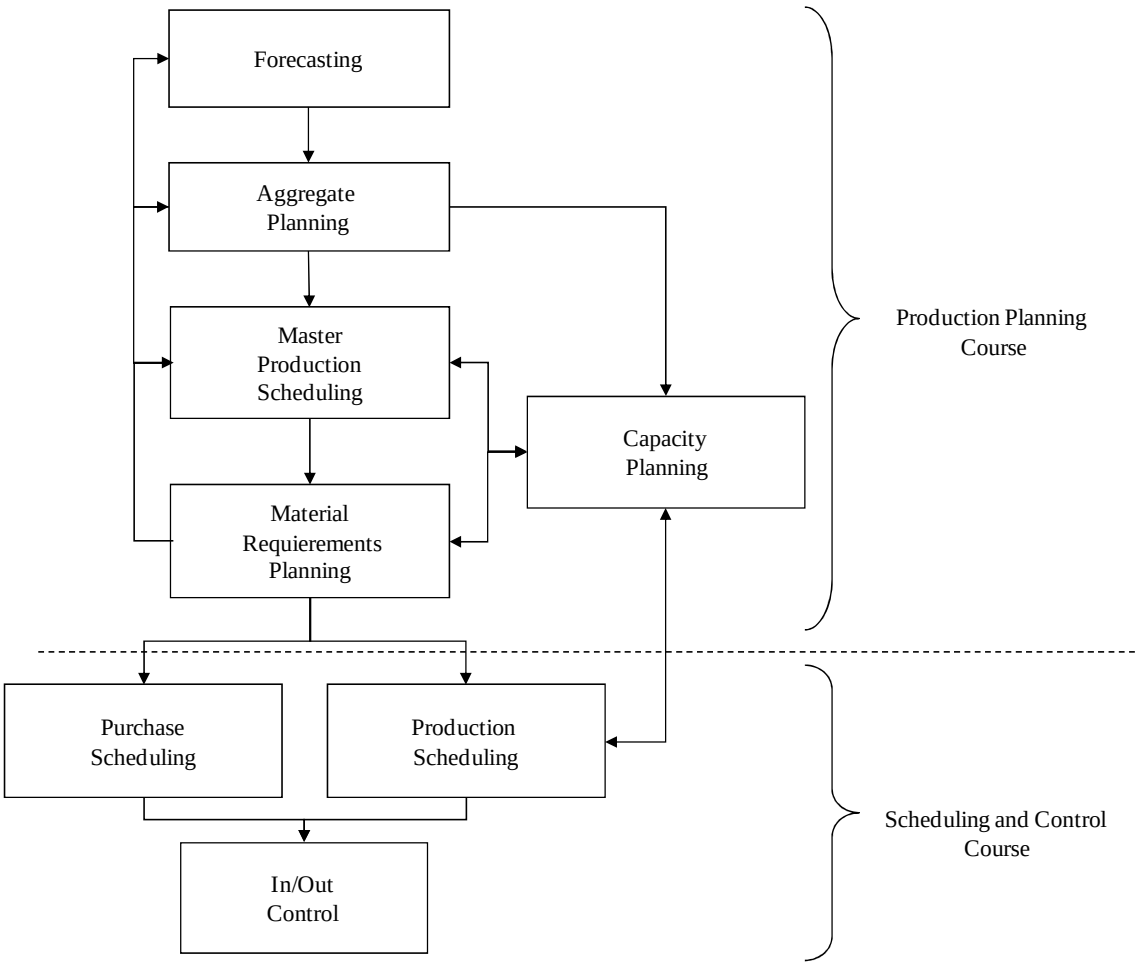


Figure1. Overview of Production/Operations Management courses

The typical student who takes this course is young, has not managerial experience and has had limited contact with industrial production processes. For this reason, these students usually have difficulty to understand the complexity of the production planning process and how it should be related to the different stages that the process includes.

In order to deal with this situation and improve teaching-learning processes in our students, the course incorporates the following activities in each one of the main topics (1) regular classes which covered the background and techniques for the individual decision situation, (2) use of homework and workshop with experimental exercises where students confront theory with practice, so they can understand deeply key concepts, (3) employ of spreadsheets in order that students understands operational part of techniques and (4) team working using a case that integrates all topics of the course. In this last activity is where software Arquímedes its plays an important role in the teaching-learning process of student since it allows him to understand: what is an information system, how the processes in PPC are connected and what is a support tool to make decisions.

3. Arquímedes Overview

Arquímedes is a computer-based manufacturing planning and control system developed to help students understand the production planning and control process. This tool can be used in an Operations Management courses to teach forecasting, aggregate planning, mater production scheduling, materials requirements planning, and scheduling, and how this stages are integrated in a PPC process.

The system was developed in Visual Fox language under Windows environment. This language generates an executable file with its own database, so the students not need to purchase a database. The student receives a file, which installs the application, the database and program aids.

Arquímedes was designed in a modular configuration, with a centralized database, so that modules share information among themselves. Figure 2 shows some modules used in the Arquímedes´ software to do the production planning process.

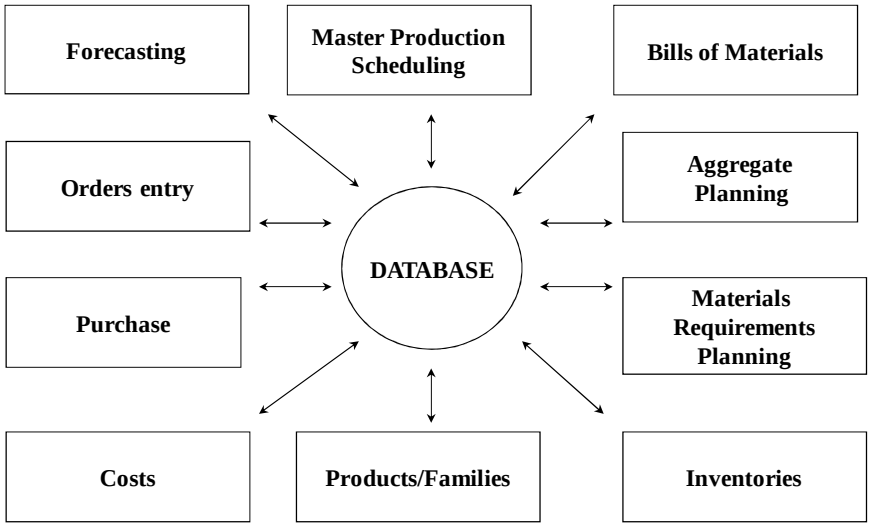


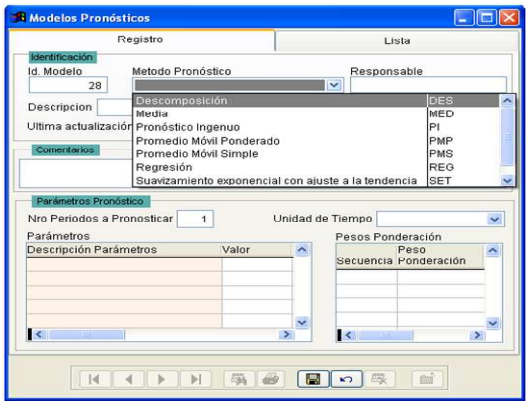
Figure 2. Main modules of Arquímedes Software

A more detailed description of the more important modules is presented below

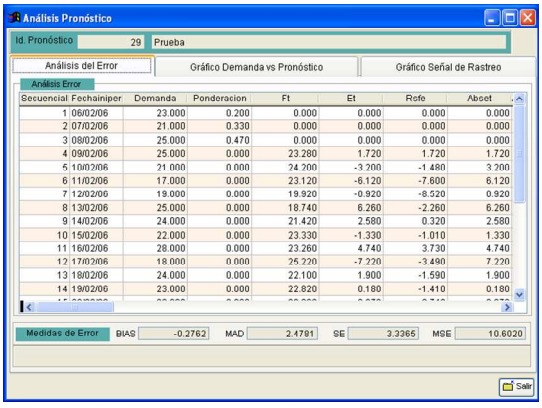
(1) ***Forecasting Module***. This module is used to estimate future demand for individual products or product families with time series models. Students can choose to do forecast between: simple moving average, weighted moving average, exponential smoothing simple and with trend, linear regression and multiplicative decomposition. Forecasting module is linked with Products/Families module because each product or family only can have one type of forecast model. Students can use different forecasting

models and simulations can be done to understand how its parameters affect forecasts, but finally they have to decide which model they will use for each individual product or product family.

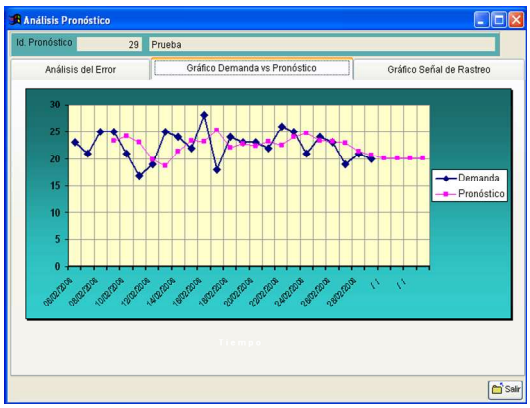
To help students to make a decision after simulation of each forecast model, a complete report is generated by the software. This report includes information about forecasting for period, measures of forecasts errors (bias, mean absolute error, mean square error and standard deviation error). Furthermore, the tool generates a plot of track signal to check the right behavior of the model in the time. Figure 3 displays four screens of the forecasting module.



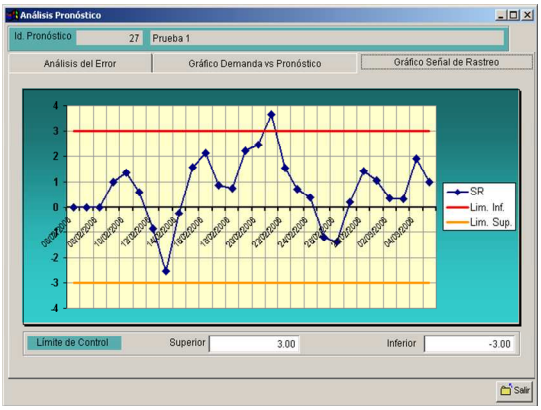
a) Forecasting models screen



b) Forecasting report screen



c) Screen of graphs of demand/forecast



d) Screen of graph Track Signal

Figure 3. Screens of Forecasting Module

(2) ***Aggregate Planning Module.*** In this module, students must decide the monthly production levels (in regular time, overtime and subcontracted production) for a period of 3 – 18 months in the future for a family of products, in order to meet the sales forecast established in previous stage (forecasting module). To make a production plan, the system must have gathered the following information for each family of products: products included in the family, production rate, production cost, overtime cost, subcontracting cost, hiring/firing costs, carrying cost, stock out cost, number of shifts per day and hours per shift, number of available recourses (tools, employees or machines) and working days for month. For a family of products, students can simulate different strategies of production like the chase plan or level plan and others production strategies (mix plans) depending of constrains imposed to the problem. Based on the results of simulations carried out which are displayed in a report that includes: regular, overtime and subcontracted production, inventories levels, workforce levels, and cost associated to each plan; students should select the plan that they consider more adequate for each product family and it must be feasible. Figure 4 shows the input screen of aggregate planning process and the report that the tool generates.

a) Input data screen

b) Output data report screen

Figure 4. Screens of Aggregate Planning Module

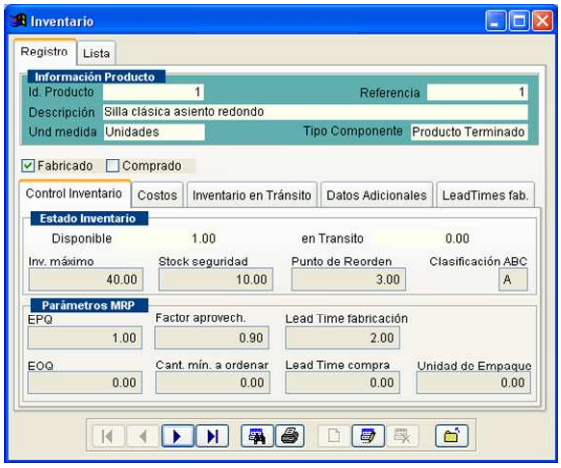
(3) ***Master Production Scheduling Module.*** In this module, students must decide about what and when products will be produced. In essence, the master production scheduling (MPS) takes the aggregate production plan selected in the earlier step and disaggregates it into a production schedule of specifics products to be produced in particular time periods (normally weeks or days). Further of data that gives the production plan, the MPS can take information from order entry module and/or from forecasts module of individual products, it is because not all products are manufactured in make to stock environment (MTS) or they cannot be grouped in a family. Figure 5, shows a MPS generated by the software

Figure 5. Example of MPS

(4) ***Materials Requirement Planning Module.*** Once the MPS is confirmed, the next step is convert it in a detailed production/procurement schedules (quantities and time) of all components (manufactured or purchased) and raw materials that make part of final product. To make the materials requirement planning stage is necessary that previously the system has the following information: Bill of materials (BOM), current inventory status (on hand, on order, security stock) and lead times (external and internal). This information must be entered to the system for all products, components and raw materials. The outputs are procurement and manufacturing

orders of all items involved in this process. Figure 6 shows two of the most important files that MRP needs to make the explosion of MPS.

a) BOM File screen



b) Inventory File screen

Figure 6. The BOM and Inventory Files used in MRP

As can be seen, Arquímedes is more than a tool that students can use to make and simulate the different stages involved in a PPC process. It is also an information system which integrates these stages through modules connected by a central data base that share information between them. In Arquímedes different stages of PPC process are connected, because outputs of each decision individually upstream are inputs to the next stage downstream in the process. Thus, with historical data on the demand of products, students generate forecasts of future demand, which in turn are used to make a monthly production plan, which in turn is used to make a master production scheduling, to finally use this information to obtain production and procurement orders with MRP. In this way, Arquímedes allows students to understand and learn how are related the different activities involved in PPC process and how individual decisions impact the entire process.

4. Important Issues to support PPC teaching with Arquímedes

For those interested in using the system Arquímedes as a tool for teaching production planning processes, it is important to consider the following issue:

- *Teaching and learning must be focus in main objectives of the course, not in the software*. The main objective of the course is that the student understands and learns which is the production planning process in a company, what decisions are made in each stage of the process and how its stages are integrated. Student must demonstrate their knowledge through testing, assignments, homework, workshops and other activities inside and outside of classroom. The software must be viewed by students only as a tool to facilitate teaching-learning processes of main production planning concepts.
- *Before using the software, students must learn to apply techniques and models employed in each stage of the process.* Arquímedes is a tool that has different models inside some modules (f.e. forecasting and aggregate planning), so it can help students to make simulations of different models and scenarios faster. Arquímedes is not systems which "make decisions" for itself; student is who makes decisions. For this reason is essential that students understand deeply models and techniques used in the process. The use of spreadsheets for students to develop the models for themselves is a good option to apply a "learning-by-doing" approach.
- *The use of experimental exercises is critical for a good teaching-learning process.* One difficulty that instructors face to teach operations management is the lack of experience in the students, because they think that always exits one "magic formula" to solve any problem. With experimental exercises students are forced to think

logically about the problems (that is, beyond the formulas), because they are facing a more realistic problem (Miyaoka, 2005, LaForge and Busing, 1998). One example of this kind of experimental exercises is that students must select and justify the most appropriate model to forecast future demand for a historical data series of one kind of products or family.

- *Create a simple case of production planning, with familiar products and processes for students.* In order to apply concepts and techniques studied and learned in the course and understand how different stages are integrate in production planning process, students must face a case that includes the topics viewed in the course. Case must have products and processes in which students are familiar with, and these must be simples and few, because complexity should come from interrelationships between stages and not from the quantity of data. Using few products and process in the case, allow students be able to make manual calculations and verify many of numerical data that were made internally in the software. Additionally it is important that the case contains essential elements of a real problem.
- *Solve the case using Arquimedes software.* To solve the case in Arquímedes software, the first step is input static information on each module (f.e. product, historical data, process time, bill of materials, costs, etc.). To do this, the software has an user`s guide which explains the process of input data. In this step, student understood which is the relevant information required in each stage in production planning process and allows than students learned the operating principles of commercial software. After input data process, students must solve the case with a disaggregating approach, where individual decisions are defined and performed sequentially, that is, outcomes of previous decisions influence the range of possibilities for successive decisions. Students must follow all stages that were

explained in Figure 1 of production planning process. Finally, students make a final report with the results and conclusions based on guidelines provided in the case.

5. Summary

Production planning is one of the most complex and important processes that undergraduate Production Engineering students must understand and learn, because they will be the future Operations Managers that will implement this process in companies. As we mention before, Arquímedes has three characteristics: is an information system that allows generate a data base in which is possible to storage information about products, process, inventories, vendors, clients; etc.; is a tool that support and facility the make decision processes of production planning; and is a system where different stages of production planning process are integrate. Therefore, Arquímedes becomes an option that instructors in OM courses can employ as a tool to teach production planning and control in an integrated approach and it can facilitate learning process in our students.

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