# Optimisation and Redesign of a Bicycle Production

*An interactive planning game for team oriented education and self-training*

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Abstract: During a project in the frame of the European Leonardo-da-Vinci-Programme five simulation games have been developed in order to engage awareness of the participants for problems in real production processes. The games focus on different areas of the production environment and are based on a common scenario: the optimisation and redesign of a bicycle production. The simulation games have been played by both industrial managers and students and could succeed in team oriented education. Additionally, the completion of a book describing the games and including software versions of the used simulation tools enables self-training in the field of production management. In this paper the common scenario of the simulation games will be presented. Two selected simulation games will be arranged according to a game classification scheme in order to characterize the games. The advantages and disadvantages of the two different kinds of learning methods - self-training and team oriented education – are also shown with the help of the classification scheme.

## 1. THE CAESAR PROJECT

The CAESAR project (Computer Aided Education with a Simulation Approach for the Redesign of Production Processes) was financed through

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the Leonardo-da-Vinci-Programme of the European Community between December 1995 and May 1998. The objective of the CAESAR project was the development and dissemination of simulation games for a continuing vocational training in cooperation with universities and industrial partners. Learning by doing, practising in teamwork and using simulation techniques are the main characteristics of the developed simulation games. This special form of education using computer simulation supported planning games gives the participants the opportunity to improve their abilities and core skills in production management. The simulation games contain aspects of modern computer aided planning and optimisation techniques. As a special feature, simulation as a newcoming tool for prospective evaluation of planning ideas is used by the participants. By this, the resentments concerning this technique can possibly be reduced (cf. BRINKMEIER, STRATE 1998, S. 106). Furthermore, the simulation games also use other common computer aided techniques, e.g. spreadsheet calculation and project management software.

As a result of the project five different simulation games have been developed with regard to industrial demands. The first game *PROSIGA* (Project Simulation Game), developed at the Department of Design and Manufacturing Engineering of the University of Zaragoza (Spain) concerns major aspects of project management. At the ifab-Institute of Human and Industrial Engineering of the University of Karlsruhe (Germany) the Integrated Simulation Game for a Comprehensive Redesign of Production Systems (*INSIGHTS*) has been developed, including a production planning and control module, a production controlling module and an operations re-structuring module. Concluding, the *DIC_XIM* game (Distribution Channels Expert Simulation), developed at the Department of Industrial Management of the University of Ghent (Belgium) concerns the optimisation of distribution and logistic chains.

As a special product, a manual book is currently being developed (MULLER, CANO, ZÜLCH 1999). This book will contain the needed information about the games (theory review, description and a simplified software version) to enable interested readers to train themselves in the field of production management. In the following reading the book and using the software will be called as self-training game.

## 2. THE COMMON SCENARIO OF THE PLANNING GAMES

For the seminars and the book being published, a common scenario has been developed wherein the different simulation games have been integrated

(cf. Fig. 1). This integration should simplify the understanding of participants for relations between the different aspects of production processes. The scenario consist of a virtual bicycle company with headquarters in Brussels facing a rough time. In the initial situation many customers of the company refrain from buying their products and wander off to other competitors. The quality of the products is poor and due dates merely exist on paper. Unlike its competitors, which also produce other sportsgear, the company's product range is very limited, as only three types of bicycles are manufactured.

The holding company has four production plants within the European Union. From inside these plants complaints about scheduling problems, expensive warehousing and distribution are reported (of course the number of plants will be adapted in a seminar to the number of groups participating in a seminar). As a consequence management is thinking aloud about outsourcing and moving the production abroad. Additionally, the holding company in Brussels threatens to close down one of the four plants after an upcoming performance review.

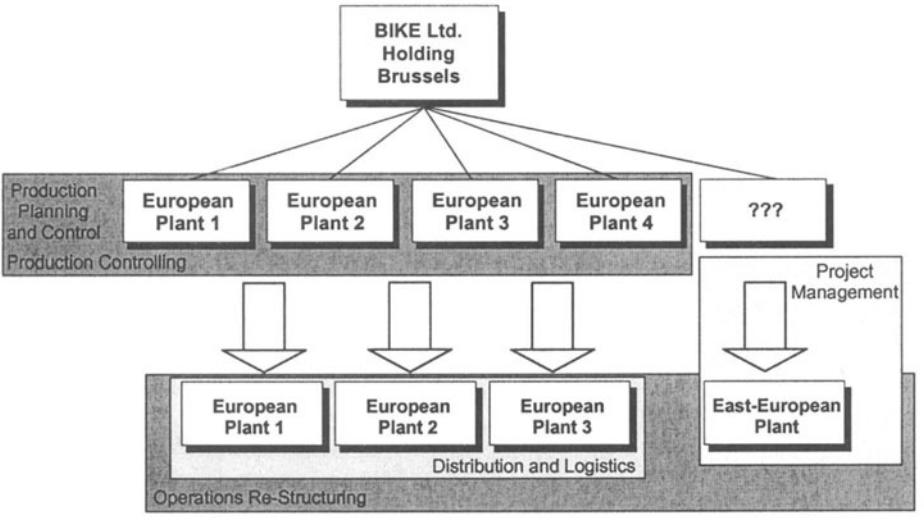



Figure 1: Common scenario of the planning games

These problems lead to the introduction of the production planning and control module *INSIGHTS-PPC* (Production Planning and Control; cf. chapter 3.1). Each group of participants is responsible for one of the four production plants. At the end of the PPC-module, a comparison of performance criteria leads to the shutdown of the worst performing plant. As a fundamental need, the evaluation of performance of the production systems should be improved at the different plants to ensure a better identification of

the potentialities for improvement. These issues will be adressed in the production controlling module *INSIGHTS-POC* (Production Operations Controlling; cf. chapter 3.2).

The distribution optimisation using the module DIC_XIM should be thereafter the next topic due to the shutdown of the worst performing plant and as a consequence of the changes in the distribution channnels (cf. chapter 3.3). The holding company is eager to obtain an adequate solution for their logistic chain. The solution developed at a pilot plant shall be implemented afterwards into all other production plants. For this purpose, several groups – representing the pilot plant - work simultaneously at this problem, but only one solution shall be implemented.

The holding company decides in afterward, that a new model is necessary to open up East-European markets. Production of this new model will be moved abroad to an East-European country and a project team is assigned to investigate this venture. In the project management simulation module *PROSIGA* this new factory is planned and the resulting plan executed in the following (cf. chapter 3.4). Groups work simultaneously on different instances of the same model just as in the distribution and logistics part of the seminar.

The previously completed re-engineering of distribution channels has opened the field for the last module of operations re-structuring *INSIGHTS-ORS* (Operations Re-Structuring; cf. chapter 3.5). The optimised distribution channel reveals some structural problems within the production plant. Therefore, redesign of the work structure becomes necessary considering not only economical or technical aspects but also human issues. Again, one plant is used as an example with all groups working for, but following different production principles, such as segmentation according to products or group work.

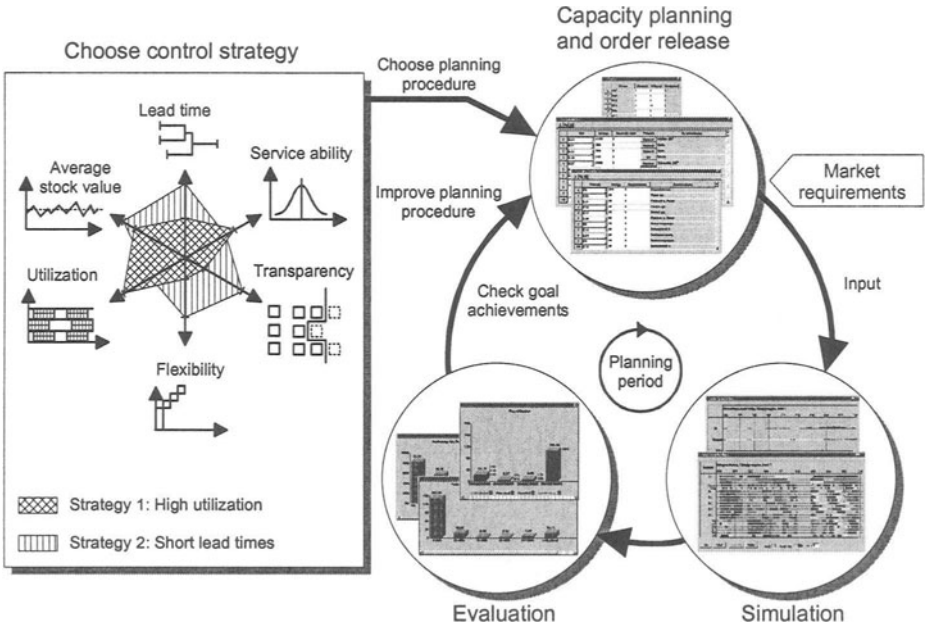
At the end of the seminars the competitiveness of the bicycle company should have been improved in a way that the company is able to survive and flourish in the international arena. In the following a closer look on the above mentioned simulation games will be presented.

# 3. THE SIMULATION GAMES

## 3.1 INSIGHTS-PPC

The *INSIGHTS-PPC* game confronts the participants with the main production planning and control problems that can occur in real production systems. The performance of the bicycle production locations should be

adjusted to suit the market requirements (cf. Fig. 2). The criteria to be taken into consideration are: service ability, capacity utilization, average stock and inventory values, the costs of production and the profit made. The participants start the game by choosing a prime strategy such as the realization of a high utilization. As a derivation they work out a planning procedure under the use of given information such as the list of parts, process plans, precedence diagrammes, process and set-up times for all




operations and data on capacity and costs of workplaces.

Figure 2: Production planning and control with *INSIGHTS-PPC* (following ZÜLCH, BRINKMEIER, JONSSON 1998, p. 27)

With respect to this information and the market requirements they make decisions for each planning period, covering a time span of a week, on the purchase orders (quantity, order day), the production orders (quantity, batch size, release day), and the needed production capacity (additional shifts, overtime). After the modeling and simulation of the so planned production period with the help of the simulation tool *FEMOS* (cf. ZÜLCH, GROBEL 1996) the goal achievements can be checked. Using the deficiencies of the achieved results and the new market demands as a basis, the planning procedure for the next period can be started.

## 3.2 INSIGHTS-POC

Performance evaluation of the production system is a topic of growing importance for every company and hereby especially the ability to identify potentialities of improvement. The focus of the *INSIGHTS-POC* module is not merely on the monetary evaluation although process cost data are also part of the analysis. Especially logistics- and process-oriented measurement is taken into consideration. The planning game is divided into a static and a dynamic part (cf. ZÜLCH, JONSSON, RINN 1997, pp. 110). The static part deals with the controlling of product structures, process chains, departmental structures and order programmes. With the help of the simulation tool *FEMOS* the participants learn to analyse the dynamic system behaviour by monitoring e.g. Ghantt-charts or waiting queues during the simulation run. Afterwards the simulation results such as the utilization of personnel can be analysed by the participants. The *INSIGHTS-POC* game represents the logical link between the production planning and control part, where the basic structure remains untouched and the work restructuring part, where layout and production principles may be altered and different work structures can be compared (ch. chapter 3.5).

## 3.3 DIC_XIM

With the educational support of the simulation game *DIC_XIM* several problem solving techniques for inventory and distribution management are introduced. The seminar is built aroung a simulation model of a physical distribution system in order to give the participants the opportunity to gain artificial experience in efficient management of external distribution systems. The most important and challenging issues that are adressed in the seminar are:

- Design of physical distribution systems
- Inventory management and optimisation
- Transportation management and optimisation
- Integrated supply chain management

The first step of the game is the definition of objectives and performance criteria for the distribution system. After having designed the general system structure, an optimisation of the entitities must follow. The last step is the optimisation of the operational policy that controls the system. The simulation tool *DIC_XIM* has been designed to provide insight in the different aspects of the physical distribution management. It simulates a three level distribution chain consisting of one factory warehouse, one national import house and three wholesalers. The game is played over a limited number of periods and at each period, the decision maker (or group

of participants) has to make decision on the amount of goods to be shipped from one node in the chain to another in order to optimize either profit, cost, client satisfaction levels or other demands. Additional constraints that are to be taken into account are e.g. the limited availability of trucks on the transportation links or the limited inventory capacities of warehouses. Further information concerning the *DIC_XIM* game can be found in VANMAELE and MULLER (1998, pp. 261-266).

## 3.4 PROSIGA

The main objective of the project management simulation game *PROSIGA* is to train the participants in the field of project-oriented work and decision making. The participants of the game assume the role of a project manager, who finds him- or herself obliged to make a series of decisions to fullfil the given objectives of the project. Right from the beginning of the game, the participants have to work against time to resolve matters in which the solutions required affect the course of the project in different ways (cost control, time scheduling, group motivation, management support etc.). A realistic interactive environment has therefore been created in which management skills can be developed without a real risk of failure.

The project management game is divided into two individual stages. The topic of *PROSIGA I* is the project planning. This involves the planning of all activities within the project: Determining the time schedule, the budget and the work loads of the involved staff. The participants learn how to handle the concepts of project scheduling by interacting in a practical manner. They go through the different learning levels which include e.g. how to prepare an initial draft of a master plan and later how to adjust it to time limits and how to weigh the different alternatives available. The main issue of *PROSIGA II* is the project evolution. The participants should learn to manage a project through a series of situations which arise during its winding-up. The purpose of this stage is to experience in decision making that will be required as the project progresses. Furthermore, the impacts should be observed, which these decisions will have on the project. For more informations about *PROSIGA* refer to CANO, SAENZ and SANZ (1998, pp.620-628).

## 3.5 INSIGHTS-ORS

The initial situation of the production in the planning module *INSIGHTS-ORS* demonstrates many problems such as too long lead times or too high stock keeping, so that the need for redesign becomes evident. In addition to the technical and economical point of view, human aspects have to be taken into consideration in order to design new work systems with a high

productivity and flexibility (cf. ZÜLCH, BRINKMEIER 1995, p. 92). This module aims especially on aspects of the relationship between abilities and assignments of personnel and functional requirements of production orders. In order to offer the participants the possibility to experience the effects of new forms of departmental structures, production principles - such as segmentation according to products or group work - and principles of work structuring (e.g. job enrichment, job enlargement, or job rotation) can be modeled and simulated.

For the evaluation of the planning results in the before- and afterwardsituation, a simulation model depicting the starting situation and featuring its specific performance is compared to the model of the changed production. For this purpose, the participants alter the model by defining new work places or by introducing new operation structures, etc. With the help of several simulation runs using the simulation tool *FEMOS* it is possible to evaluate the dynamic characteristics of the planned solutions and to obtain a fast feedback of the effects of the chosen planning ideas.

## 4. GAME CLASSIFICATION

Hundreds of planning games have been designed to support education or continuing professional training (BREHLER 1998, p. 159). For a comparison of the various games, a basis is needed to enable the exchange of experiences and viewpoints. The identification of key dimensions and their associated characteristics assures that different games can be classified and compared. In order to point out the main differences between the team-oriented planning games and the intended self-training game, two main simulation modules developed at the ifab-Institute *INSIGHTS-PPC* and *INSIGHTS-ORS* are classified in a game classification scheme (cf. Fig. 3). This classification scheme is based on the dimensions of games introduced by RIIS, JOHANSEN and MIKKELSEN (1995, pp. 5). The two team-oriented games have the purpose to teach participants in different fields of the production area. One of the main differences between the two games is the higher effort of the *INSIGHTS-ORS* game, that leads as a consequence to a longer duration of the seminar. The extent to which rules and models can be changed also differs between the two modules.

To show the differences between these modules and the intention and objectives of the self-training game, played by reading the book and using the simplified software-versions (cf. chapter 2), the differences have been marked in Figure 3 with grey boxes.

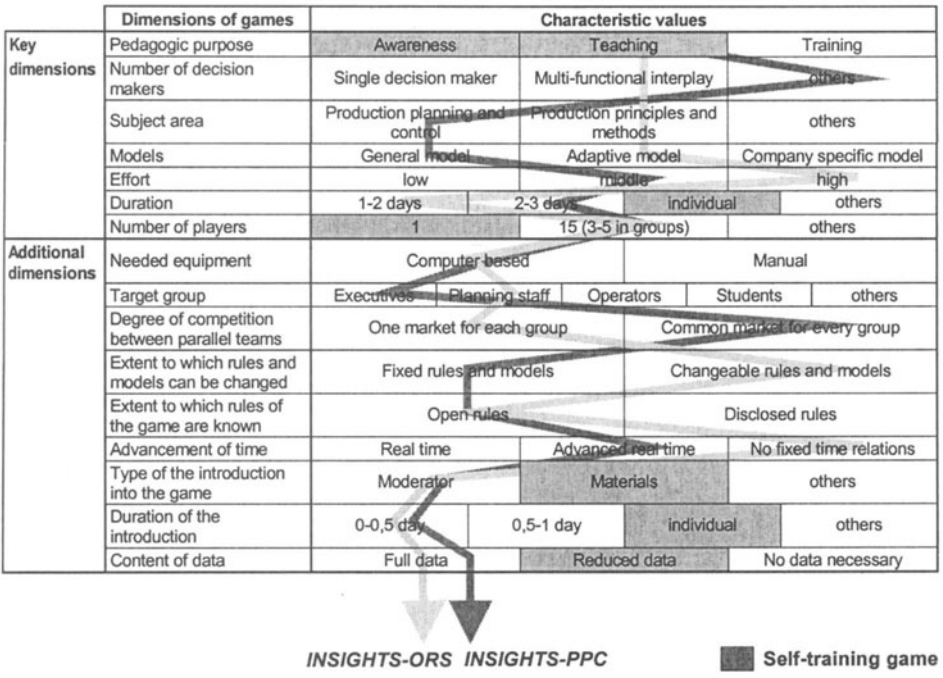



Figure 3: Game classification scheme (following ZÜLCH, BRINKMEIER, HEEL 1996, S. 207)

First to mention as difference between the team-oriented education games and the intended self-trainig game is the pedagogic purpose that enlarges from teaching to creation of awareness. With such a book, interested readers can be reached. As an effect, a reader may get interested in different aspects of the planning process he probably did not consider before. The teaching point is handled through a theoretical review for the specific topics needed for the simulation games. The reader is introduced to planning aspects and to descriptions for the use of the software tools. Following this point, the introduction time to the game will be longer than in the seminars due to the missing help of a moderator.

Nevertheless the introduction time can be reconfigured individually. This is an advantage because the reader can go through the book in a way that accords to his level of knowledge. He can use his own timeplan, e.g. in his sparetime, and so learning will not disturb his daily work. The main disadvantage of this individuality is of course the lack of education in group dynamics. In the software versions reduced data are provided in order to decrease the complexity of the self-training games. Also an undesirable application of the simulation games – namely the realization of seminars can

be excluded. Last to mention as an advantage is the advertising purpose of the book to gain new participants for seminars.

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# 6. BIOGRAPHY

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