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Simulation Games in Production Management - An Introduction

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The application of games for production management has widely increased in the past decade and has resulted in a large number of quite different games. Further advancement in the use of games, however, will depend on the acknowledgement that we need to differentiate between games and to be specific when selecting a game with respect to the learning environment in which the game should be placed, its pedagogical aim, the number of pre-defined jobs, the effort needed and the duration of the game.

Based on a number of dimensions useful for describing a game and its context, a classification of games in production management is proposed which may serve as a "road map" for displaying the variety of games existing for production management and for selecting a game appropriate to a specific pedagogical situation. At the same time, the road map serves to introduce the games to be presented in subsequent chapters.

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1. CHALLENGES

Teachers of production management are confronted with many challenges. The demand for shorter and precise delivery times in industry has stressed the importance of understanding the dynamics of a production management system. Graduates are expected to be able to make a significant contribution to an industrial enterprise in its effort to move towards World Class Manufacturing. In addition, new subject areas should be included in the curriculum, such as the supply chain aspects and the co-ordination with engineering design in concurrent development of new products.

At the same time, many universities and colleges have adopted a dual policy to increase both quality and productivity of teaching, putting pressure on teachers to continuously improve the effectiveness and efficiency of their teaching.

Over the years, games of different types have successfully been used in the teaching of production management and in the introduction of new planning methods and systems in industrial enterprises. Several indications point to a growing interest in applying games. This may be explained by an acknowledgement of the difficulties of comprehending the dynamic nature of production management. In teaching production management, games have proven to be a very useful means used as a supplement to traditional instructional methods.

Also in an industrial context games have been useful, e.g. as a means for creating awareness and understanding of the function of the present production planning methods, or for testing new planning principles. Especially company specific games indicate a new way of applying games as part of developing a new production management system.

One of the lessons learned from applying games is the need to use different types of games. No single game exists which successfully can be applied to all learning situations. To the contrary, the practical situation and the educational needs vary to such an extent that different games are necessary. This implies that each game should focus on achieving specific objectives and be able to capture the essence of a given production management situation.

The use of games in production management is, however, not a 'cure all' method. Rather, a game must be placed and used in a well defined pedagogical context. Most games enable the players to become deeply involved and very excited during the game. Despite initial frustrations, they experience a game as great fun, which is a useful entry to learning. Nevertheless, if the game is not placed as part of a course or seminar with clear learning objectives and supplemented by traditional instructional methods, the effect of the game vanishes, and, at best, it has just been an entertaining experience. As a consequence, the selection of a game and its use in a pedagogical context should be given much attention.

As in any other planning situations, the cost-benefit relationship should be addressed. Some games run for a few hours with one instructor capable of accommodating a score of students. Other games take three to five days requiring the support of two instructors. Some games are rather easy to manufacture, while others draw heavily on the school's budget to acquire. In addition, the teaching scheme of sessions of a few hours' duration imposes a limiting constraint on the choice of games.

In order for teachers and industrialists to exchange experiences from using games in production management and to extract lessons learned, we need to provide a way of classifying games. In this paper we shall present a "road map" of games which will be used for introducing the different games to be presented in this volume. The road map may also help a potential user to identify his own needs and to select an appropriate game. First, however, we need to introduce essential dimensions of a game and its context.

2. DIMENSIONS OF GAMES

To provide a basis for an exchange of experiences and viewpoints we need to be able to classify games. This will require identification of some of the key dimensions of games.

Following a well-proven methodology of designing games (Greenblat & Duke 1981), many parameters are needed to describe a game. We have selected the following dimensions, partly from our experience, and partly from the sample of games to be presented in subsequent chapters.

Pedagogic purpose

The games vary with respect to the pedagogic depth which may be reflected in the following three point scale:

- o To create awareness and insight, e.g. from experiencing the interplay of different sections and functions.
- o To teach, e.g. by creating understanding and knowledge on the basis of try-outs of different planning principles.
- o To train, e.g. by providing practical know how from handling a planning job.

Some games may cover several objectives, for example create awareness first and develop and try-out solutions afterwards.

In company specific games the three objectives may reflect phases in the design process in that the understanding phase also implies developing and testing new solutions in a prototyping mode.

Single decision maker or multi-functional interplay

A large group of games is geared to deal with planning issues pertaining to one single decision maker, e.g. a dispatcher. Most scheduling games belong to this category. Another group of games simulates a planning function or a decision center, e.g. a central planning group. This will allow a team to work together on a complex planning task which usually requires the formation of sub-groups. A third category of games demonstrates the interplay between various functions involved in production management, e.g. purchasing, sales and marketing, production planning, and work shops. Here, the players are assigned to the various functions and jobs, but may interchange during the game.

In some games known from the behavioural sciences a player is asked to play a person with a specific character and background. Such games are seldom used in production management.

Subject area

The most frequent subject areas are:

- o Scheduling, e.g. jobs on a number of machines.
- o Master planning.
- o Main production principles and methods.

In addition, some games may address the One-of-A-Kind production situation whereas others focus on Continuous Flow production .

General games or company specific games

In any pre-fixed game, players have to be introduced to the game situation, e.g. the specific products, processes and market conditions. This may take from one hour to three hours of introduction and preparatory analysis. When a game is developed for employees in an industrial enterprise and reflects the specific nature of that company, players very quickly capture the idea and operation of the game, because of their familiarity with the company.

General games have been used for many years in education and to some extent also for in-company training. Only recently the development and use of company specific games has gained momentum as a new and effective tool for stimulating an organizational change process, cf. Mikkelsen *et al.* 1990. A major challenge to apply company adapted games is the effort required to develop the game. With less than one man week's effort we have developed rather simple company specific games which have been successfully used to create awareness and even to try out new solution concepts.

In addition to creating understanding and to training as part of an educational program, company specific games may play a new role in the design of new production management systems.

Effort and duration

The effort needed covers several items, such as the cost of the game, the necessary preparation time, the staffing during the game runs, and the consumption of materials.

The effort needed will vary very much. For example, a small JIT Game and the LEGO Truck Game (to be presented in a subsequent chapter) require rather little time and effort for set-up. Moreover, the equipment is relative inexpensive.

At the other extreme we have games like the Ruler Game and ADVANTIG (to be discussed in subsequent chapters), which easily cost more than \$10,000 to acquire. Furthermore, several instructors are needed to prepare and run the game.

For a Cost/Benefit analysis of a game, of course, the number of players which a game may be able to accommodate is essential. It may vary from a handful of players to more than 20.

Additional dimensions

In addition to the above mentioned dimensions games may also be classified according to the following

- o **Computer based or manual.** The power of computers for simulation has been used in the single decision maker games, in particular treating scheduling issues (TRAIN-F) and in multi-function games as well (e.g. the CIM game). Most of the manual games are multi-function and aim at creating awareness and understanding.
- o **Target group.** It turns out that most games may successfully be used for many different target groups, such as students, foremen, dispatchers, top executives, operators. Only rarely does a game require special qualifications in order to benefit from playing the game (e.g. the CIM game presupposes knowledge of ORACLE).

- o **The degree of competition between parallel teams.** In some games teams compete on the market place, whereas other games challenge the players to compete with themselves, i.e. to improve their own performance.
- o **The extent to which the rules and underlying models may be changed.** For example, the LEGO Truck game is rather fixed, whereas the ADVANTIG game encourages the players to be creative.
- o **The extent to which the rules of the game are known to the players.** In some games the aim is to disclose the underlying models, whereas other games have open rules known to everybody. To make an analogy, in chess the rules are known to the players; yet, the game may be quite challenging.
- o **The advancement of time.** In some games, the time is advanced by the game manager from one period to the next when all players have completed their tasks. Other games advance in real time, although condensed, e.g. an hour may correspond to a week.

3. A "ROAD MAP" OF GAMES

In an attempt to depict different games in a comprehensive way we have selected two dimensions, respectively the number of pre-defined jobs in the game and the pedagogical objective. In view of the dimensions introduced above we are well aware that this classification does not pay tribute to the complex variety of games existing for production management. However, the two dimensions will provide a useful "road map" for selecting a game. At the same time it will serve as an introduction to the games to be presented in subsequent chapters.

Figure 1 shows the two-dimensional classification in which we have placed the games discussed in this volume, as the result of a joint effort. Furthermore, the games will briefly be introduced below, thus providing an overview of different games.

The games selected represent a broad spectrum of different games, and as such demonstrate the variety of games for production management. They do not in any way constitute a complete list of games, and the number of games in each category may not be taken for a general picture.

3.1 Games with a single decision maker

TRAIN-F Simulation Game

This game represents a computer-aided training system which offers the opportunity to become familiar with the logistic process itself and the results of parameter changes on it. An experimental environment has been designed in which it is possible to influence a simulated job shop by varying production planning parameters.

FMS Design Game

This computer based game aims at training the design of flexible manufacturing systems. Understanding the influence on loading and dispatching rules on the performance is in focus. A player is asked to design a plant, specify loading and dispatching rules and to meet market changes in production mix. A simulation program will calculate the average work load and other performance measures.

OPT_SIM

This game is built on a shop floor simulator of a manufacturing cell that includes three machines, three types of products, two raw material sources, five processes, workmen, automatic transportation systems, investment opportunities, commercial and financial restrictions. It has been designed as a further development of the OPT-game of "Creative Output". The OPT_SIM game is described in the paper by Muller *et al.*

DIC_XIM

This physical distribution game simulates a supply chain that consists of one factory warehouse, one national import house and three wholesalers. The game player has to decide on the amount of goods to be shipped from one node in the chain to another at a certain point in time in order to maximize total profit. The DIC_XIM game is described in the paper by Muller *et al.*

No. of pre-defined jobs

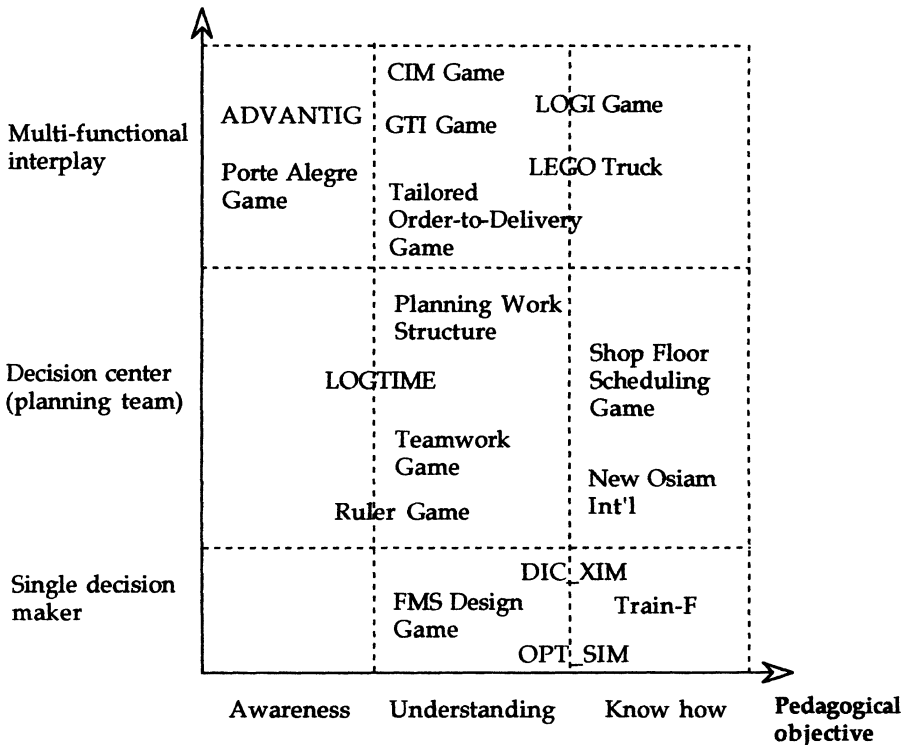


Figure 1. Different games located on a two-dimensional map.

3.2 Games with a decision center (planning team)

Logtime

A simple production model is used in this game, in which participants perform various management functions (sales, manufacturing, assembly, quality control, etc.). Two products are manufactured in six variants on six workstations. A continuous improvement approach is demonstrated by asking the group to reorganize the manufacturing organization and improve the performance towards lean production with short and reliable lead times.

The Ruler Game for a Production Group

In this game an actual production of small wooden rulers is carried out by means of seven work stations equipped with hobby drills and pneumatic controlled processes. A production group is simulated using the information system from a real plant. Seventeen activities (jobs) are assigned to players, i.e. five operators, a set-up fitter and a foreman. At the end of the game, the players are asked to make process improvements and to plan for a new mix of the four types of rulers.

The focus of the game is to demonstrate the operations of a production group, e.g. the close interrelationship between quality performance, the meeting of dead lines, and the incentive based wage system. The game usually takes two afternoons.

Teamwork Game

This game has been developed for teaching principles of group work for teams in industry. Teams of three to eight members answer question cards, discuss and solve problems, and then analyze group experiences.

Simulation Aided Planning of Work Structures

This game deals with a bicycle production and aims at enhancing the understanding of problems and solutions in the field of work structuring and at stimulating the interest in using simulation tools for analysis of production systems. The planning game is supported by a guideline of work structuring and the simulation system FEMOS for dynamic analysis of proposed systems.

NEW ORSIAM INT'L

In this game teams of three to six participants operate a firm manufacturing high-tech computer toys in competition with other teams. The teams are facing a progressive enlargement of the problem area, a broadening decision horizon and an increasing hierarchical responsibility while going through a "typical" engineer career. The participants start as an industrial engineer, move to the job of a plant manager, further on to company manager and corporate executive officer.

The Shop Floor Scheduling Game

The aim of this game is to acquaint participants with scheduling under uncertainty and time pressure. Smaller teams in parallel are asked to run a small firm with a job shop, assembly and a painting section. There are two types of customer orders, normal orders which are based on long term contracts and quotation orders offered competing firms according to the best bid.

3.3 Games with multi-functional interplay

LEGO Truck Game

Using four LEGO bricks to represent essential parts of a truck, this game demonstrates planning and control of procurement, production, assembly and shipment in a factory which produces both a standard type of trucks according to sales forecasts and special trucks according to incoming customer orders. No computer is used, and the players are assigned to different tasks (purchasing, production, assembly, sales, etc.).

The focus of the game is to demonstrate various planning principles and methods in the course of 3 - 4 hours. It can also illustrate the effects of shorter lead times and increased speed of communication. Each player, or a small group of players, is asked to perform a pre-assigned task.

CIM-Game

To illustrate the tasks of production management in an integrated manufacturing environment a CIM game has been developed. 10 - 15 players are assigned to one of five functions in a One-of-a-Kind production. During the game the company moves from a production of two types of candle sticks to offering a variety of products based on a fixed set of components (top, middle and bottom piece), and further on to offering a custom designed product, using CAD and CAM.

Tailored Order-to-Delivery Simulation Game

This game is used as a participative method for management of change towards lean production and order-to-delivery of in industrial enterprises. The game is tailored to the specific company and allows managers and employees to experience a new idealized solution before it is implemented.

The ADVANTIG Game

This game is aimed at demonstrating the issues of improving the production function by implementing new technology, e.g. CAD, CAM, and robots. It is a role-playing game, because each of the 15 - 20 players is assigned to a specific function, e.g. sales, engineering, production, and finance. The game takes eight hours to run.

The GTI Game at Bang & Olufsen

As a means to stimulate the improvement process in an assembly section, a simple manual game was developed and applied. A circulating table with a number of workplaces simulates the actual assembly lay-out, and the game gives participating operators and foremen an understanding of the many factors influencing through-put time. Two runs are carried out, first the current situation is depicted, and second a new, improved mode is simulated.

The LOGI Game - A Dynamic Modular Logistic Game

This game addresses management of the materials flow along a logistic chain and aims at training participants (industrialists and students) to develop and test alternative strategies. There are three production departments, wholesalers, retailers and shops in the distribution channel. A Game Model Bank offers to the participants a variety of models. A modular structure allows for focusing on different issues.

Porte Alegre Game

This game is based on war game concepts like chess and checkers with two competing players, a manager and a Murphy. Management of manufacturing is conceived as a game where opponents attempt to reach pre-established goals via strategic and tactical plans.

3.4 Key to success in applying games

The classification of games offered above represented by the simple "road map" and the brief outline of different games may offer to the reader a basis for selecting a game appropriate for his/her needs. In pursuing this we shall suggest the following keys to success in applying games, derived from our own experience:

1. Define the pedagogical and learning context for the game. Almost every player will experience that a game is a lot of fun. Furthermore, those who have run games of various kinds have been convinced of the potential to change knowledge, attitude and behaviour of people.

Most often a game is capable of standing alone. However, to be useful the experiences and the learning which have taken place during the game must be related to the players' own situation, either as an employee or as a student who is to learn a given subject matter.

2. Define the subject area and the objectives of the game. As the sample of games given above clearly demonstrates, a large variety of games exists with different subject areas and aims. The question may also arise as to whether a new game should be developed to cover subject areas of special interest or to describe the specific situation of an industrial enterprise.

3. Identify the constraints on applying a game. Several constraints may be imposed on the game situation, such as (1) the cost of acquiring or running a game, and (2) the duration of the game, including its initiation.

4. CONCLUSION

Successful application of games for production management rests on the acknowledgement that we need a variety of different games. In this paper essential dimensions of a game and its context were introduced, of which two were selected for a "road map". This offered a coarse classification of games to be presented in this volume.

In selecting a game it was stressed to look at (i) the pedagogical context in which the game will be used, (ii) the subject areas and aims, and (iii) the constraints imposed on the situation of applying the game.

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