

The Ruler Game

Physical simulation of production activities

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Abstract

This paper describes a production game used in teaching of production engineering students at Aalborg University. The elements of the game are described and related to a theoretical course dealing with process and production planning issues. It is concluded that the game so far has been a successful supplement to the traditional teaching program.

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Keywords: Simulation and modeling, General; Miscellaneous

1. INTRODUCTION

The Ruler Game is a plant in miniature. Four types of wooden rulers are physically being produced on slightly rebuilt electrical hobby machines, e.g. drilling machines, grinding machines, milling machines, and saws.

During the production game the participants are introduced to the operations, as they are found in the modern production plant. That includes:

- Understanding and implementation of production papers from parts-lists to order forms.
- Understanding of the relations and dependences between control systems.
- Cooperation among colleagues in solving operation problems.
- Improvements of quality and productivity.
- Setting up production plans

1.1 The history of the Ruler Game

The Ruler Game was developed and tested as a Master's Thesis at the Technical University of Denmark in 1977 [1].

In the beginning and middle of the seventies a number of Danish companies were experimenting with the change of the traditional functional layout to production cells based on the concept of group technology. In Denmark the most comprehensive changes were introduced by the radio and television company Bang & Olufsen. Their experiences showed that substantial reductions in the throughput time could be realized and additionally that there were great potentials for job enrichment and job enlargement.

However, the introduction of production cells also required new skills and attitudes among the workers, foremen, and production planners. For example, in addition to mastering several processes, the workers also had to learn completely new modes of cooperation and new kinds of activities, e.g. quality control and planning. Obviously, this called for great efforts to develop new training programs.

The Ruler Game was intended to be an essential part of such training programs. The following principles were formulated for the development of the game [1]:

1. The game must simulate a "real life production cell" by letting the participants take part in an actual production process.
2. The game, on the other hand, must be fairly simple, so that the participants easily can be introduced to the game.
3. In order to stimulate the learning process the game should be carried out by switching back and forth between a production and a reflecting period. In the former the participants produce on the machines, and in the latter they discuss the group behavior, solve problems, and prepare for the next production period.
4. The game should be able to bring different problem areas into focus, for example production scheduling, materials management, methods engineering, quality control, wage systems, group behavior, and the role of the foreman and production planner.

This concept of the game seems to be right because the game is today widespread in the Danish educational sector, and ranges from training of unskilled workers to teaching of mechanical engineering students at universities.

2. DESCRIPTION OF THE GAME

The products of the game are four types of wooden rulers (see figure 1).

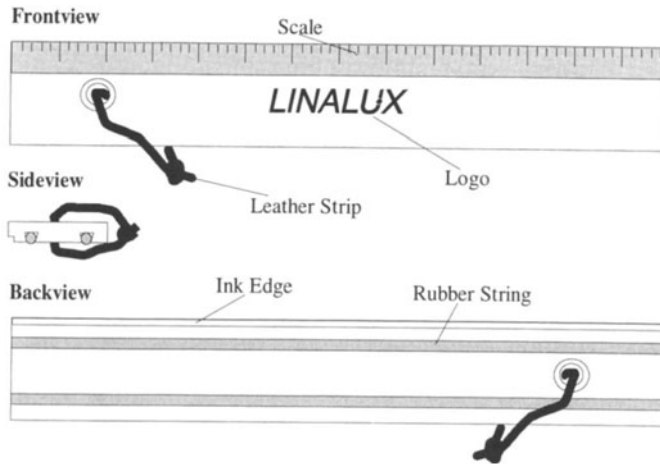


Figure 1 Basic features in the wooden rulers

The four basic variants of the rulers are specified as follows (see table 1):

Table 1
Ruler variants

Product type	Length	Width	Hole diameter	Number of rubber strings	Leather string
799 DeLuxe	194 mm	19 mm	5 mm	2 pcs.	Yes
114 Mini	154 mm	16 mm	4 mm	1 pcs.	Yes
124 Standard	154 mm	19 mm	-	-	No
507 Ruler	154 mm	19 mm	5 mm	-	Yes

The four ruler variants are physically being produced in 17 different operations that are designed to meet the following objectives:

1. The operations must consist of both a machine time and a manual time in order to simulate real life conditions.
2. Set-ups and adjustments should be necessary when changing from one variant to another (e.g. different length, width, size of hole).
3. The machines should give an intuitive impression of a processing machine and at the same time be unpretentious in their appearance.

All production papers are identical to those of a real life production department. The production papers include drawings of the ruler variants, routing cards, work instructions for each operation, instructions for the set-up fitter, and specifications for the quality inspections.

Finally the process times for each operation are given (see table 2). All standard operation times are determined by a time element system called MOST.

Table 2
Unit process times

Ruler type:	799	114	124	507
Operation:	<i>Process time in minutes</i>			
Sawing	0,16	0,16	0,16	0,16
Planing	0,17	0,17	0,17	0,17
Cutting	0,25	0,25	0,25	0,25
Grinding/chamfering	0,64	0,64	0,64	0,64
Drilling hole	0,40	0,40	-	0,40
Chamfering hole	0,40	0,40	-	0,40
Milling ink edge	0,50	0,40	0,40	0,40
Milling non-skid groove	1,80	0,84	0,84	-
Smoothing	0,80	0,80	0,80	0,80
Painting	0,21	0,21	0,21	0,21
Stamping the scale	0,72	0,65	0,65	0,65
Stamping the logo	0,30	0,30	0,30	0,30
Mounting rubber string	0,37	0,22	0,22	-
Cutting leather strip	0,75	0,75	-	0,75
Mounting leather strip	0,70	0,70	-	0,70
Final control	0,25	0,25	0,25	0,25
Packing and sending	0,65	0,65	0,65	0,65

As indicated above the ruler game is a complete course, which provides opportunities for weighting different problems and organizational areas within the production. Before the production game is implemented, it is therefore necessary to analyze the problem areas within a given real life production situation.

In the following we shall describe an application of the ruler game which is used for teaching of production engineering students at Aalborg University.

3. THE RULER GAME AT AALBORG UNIVERSITY

At Aalborg University the ruler game is used as an integrated part of the course "Introduction to Process and Production Planning" [2]. This course is offered at the fifth semester just after the students have finished their introduction to basic mechanical, physical and mathematical subjects.

The course is the first introduction to notions like "process-time", "production economy" etc. Only a few students have specific knowledge of the conditions within a production unit.

Normally the number of students will be approximately 100 persons divided in 12-13 smaller groups. The concept of the game is made as a competition between these smaller groups. The winner of the game is simply the group which can provide the greatest surplus in the final round.

During the course the game falls in three parts:

1. The first part includes an introduction to production methods. After an introduction to the game (products, machines, forms, and rules) the group is asked to organize itself. Each participant gets a chance to acquaint himself or herself with the specified job, e.g. reading the work instruction

for the operation, reading the quality instruction, producing a few samples.

Then the group is asked to produce according to a preprepared Gantt Chart with only two ruler variants. After an initial period of confusion the production gets more stable. Now the instructor puts different disturbances into the game, e.g. machine break down, absence of workers, rush orders, or even strikes. Also the students experience disturbances because of poor quality or mistakes when reading product specifications.

The main result of this round is confusion and a lot of data for later analysis (see figure 2).

2. The second part includes reflections of the first game round and preparation for the last game round. The content of this part will be described and discussed below.
3. The last part is a game round where the students have prepared their own Gantt Chart, have chosen their own production philosophy, and eventually have made their own paper forms. The result of the last round is an account which can be compared with other groups. The winning group is the one with the greatest surplus.

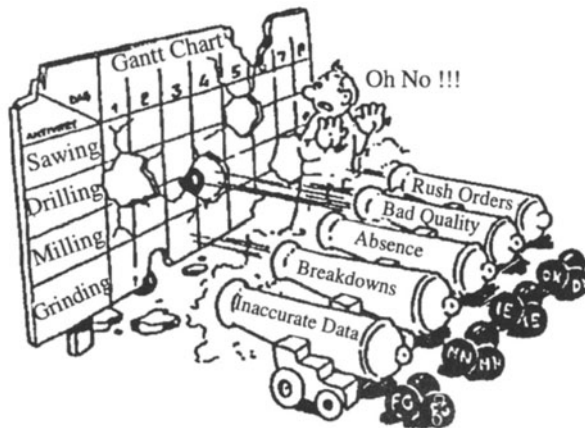


Figure 2 The students gets a more realistic view of planning and particularly the disturbing factors of it.

As input to the second part of the game the students are introduced to a sequence of potential orders (see table 3).

Table 3
Potential orders for the ruler factory

Order number	Ruler variant	Batch size	Price pr. pcs.
5	507 Ruler	32	1080,- dkr
10	114 Mini	18	1256,- dkr
15	507 Ruler	32	1080,- dkr
20	799 DeLuxe	20	1598,- dkr
25	114 Mini	18	1256,- dkr
30	124 Standard	12	985,- dkr
35	799 DeLuxe	20	1598,- dkr
40	507 Ruler	32	1080,- dkr
45	114 Mini	18	1256,- dkr
50	124 Standard	12	985,- dkr
55	799 DeLuxe	20	1598,- dkr
60	507 Ruler	32	1080,- dkr
65	114 Mini	18	1256,- dkr

Based on their experiences from the first round the students must now plan the production of these orders. By means of a simple Gantt Chart technique the delivery times are calculated. However, a number of problems experienced in the first game round must be solved. These include e.g.:

- Some of the given process times are inaccurate.
- Quality control needs to be reorganized, e.g. integrated as a part of the operations.
- Some operations can be redesigned and/or optimized.
- Some production papers give insufficient or unnecessary detailed information.
- Etc.

During the theoretical course the students are given techniques to solve these problems. At the end of the planning period each group of students determine specified delivery times of each order. These delivery times are calculated on the basis of a production planning philosophy decided by the groups individually.

On the last day of the course the last part of the game is run. During this game round a number of rules must be followed:

1. The given product specifications and work instructions must be followed.
2. All communication must follow the hierarchy. The workers speak to the foreman. The foreman speaks to the fitter and the production planner.
3. The production planner is placed in a separate room and is allowed admission to the shop floor during the production period.
4. Adjustments and set-ups must only be done by the fitter.
5. There are no restrictions in the number of workers to be employed. However, each worker can only operate two different operations (cf. table 2). Each worker's specialization must be decided from the start of the game.

6. For late delivery a nominal fine of 150 dkr/minute is incurred.
7. The customer completes a 100% inspection of delivered rulers. For rulers which fail the requirements the ruler factory is to pay 100 dkr as a compensation for the time spent on inspection.
8. The duration of the game is 150 minutes.

During the game the students individually acquire a very different experience depending on their roles:

- The workers are very focused on their own operations. They knew the original production plan but shortly after the start of the game the plan has changed because of disturbances (rush orders, machine breakdowns, etc.) Some workers are extremely busy while others seems to have plenty of time (see figure 3).

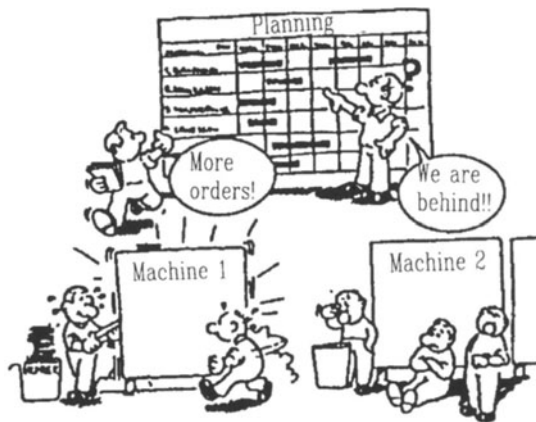


Figure 3 The students experience the paradox of planning.

- The fitter experiences the same lack of overview as the workers. Many problems occur regarding product quality but often it seems difficult to choose the right priority.
- The foreman is under pressure from all sides. He is the only person who has an overview of both the production plan and the actual production progress.
- The production planner is placed outside the production room. When rush orders arrive he is totally dependent on the foreman to keep up with the status of the production.

After the game period the final account is established (see table 4). This gives opportunity for a final reflection period and the recognition of the winning group.

Table 4
The final account

SALES				
Sales type 114	54	pcs.....	67824 dkr	
Sales type 124	48	pcs.....	47280 dkr	
Sales type 507	96	pcs.....	103680 dkr	
Sales type 799	60	pcs.....	95880 dkr	314664 dkr
VARIABLE COSTS				
Materials				84641 dkr
Wages				113400 dkr
CONTRIBUTION MARGIN				201264 dkr
ADDITIONAL				
+ addition for products in production				25750 dkr
+ addition for materials on stock				0 dkr
- minute fines for late deliverance				4500 dkr
- quality inspection costs at customer				2500 dkr
GAME RESULT				220014 dkr

4. EXPERIENCES AND CONCLUSION

The learning principle in the production game is learning by doing. The participants should get involved with real problems from a daily production situation. That puts pressure on the instructors of the game. They must be able to relate the problems of the game with the problems from real life. Also, the instructors must orient the related exercises to the actual group of participants.

The concept of the game has proven to be useful to different groups of participants, e.g. unskilled workers, engineering students. A number of Danish companies use the ruler game as an established tradition when training new unskilled workers. In this application the focus is primarily cooperation, quality assurance etc.

The application used at the university focuses on the production planning process. In this application the game facilitates visualizing the interdependencies of problems in production, and furthermore provides an experience of a dynamic planning situation. An expanded application of the game provides the possibility of testing different production planning philosophies, e.g. Just in Time, Kanban.

After having used the game for four years in teaching of production engineering students we can summarize our experiences as follows:

1. The game should be used as a part of a teaching program to supplement the teaching of factual subjects. It is essential that the game management guide the discussion according to the objectives of the teaching program.
2. The game is able to give engineering students a realistic impression of the planning conditions in a production situation.

3. The price of the game is app. 100,000 dkr (app. 17,000 \$) and needs one or two instructors for the game management. Compared to traditional educational modes (e.g. class room instruction) the game is intensive and costly. However, compared to the traditional educational modes the game represents a new effective means for training workers, foremen, engineers, and students in the functioning of a manual production system.

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