“There is more than one way“ - a game about production and working environment

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Abstract

The engineering education shall qualify the students to take considerations of the working environment into their solutions of technical problems. Especially learning about the consequences of the organisational planning and socio-psychological influences seems to be theoretical and abstract for the students. In order to make use of alternative learning theories a simulation game is developed to give the students an opportunity of experiencing a situation close to reality and yet being able to include reflective loops, breaks, to ensure a thorough understanding of The Developmental Work.

Keywords

Simulation game, Tayloristic work, The Developmental Work, learning theories, reflection loops.

1 INTRODUCTION

The purpose of this paper is to present the aim and principles in a generic educational game with focus on both educational problems and pedagogical methods. The game is about production planning and working environment.

The conditions for traditional working environment courses at the engineering studies leave little possibility of using the recent theories about learning in action, situated learning, reflection in action, and reflection on action. The courses are too short, and some of the subjects, eg social- and psychological working environmental elements, are rather abstract in a technical and rational field. By the use of games it is possible to simulate an adequate part of reality to establish a learning situation which creates opportunity for learning in action as well as for reflection in action and reflection on action. In this way, insight and awareness about physical, social and psychological working environmental elements in the production should be provided.

The following describes the background of the game, the learning approach and the content of the game. Finally we discuss the use of reflection and possibilities and concerns using a game.

2 BACKGROUND

During the past 10 years the unions and the working environment experts have become increasingly engaged in the concept of "The Developmental Work". The Developmental Work is a production concept introduced by the Swedish Metal Workers' Union in the mid-1980s. It describes a new strategy for the trade unions' focusing on what they see as current possibilities of establishing consensus between the workers and the employers on development of work, flexibility, quality, qualifications, etc. - possibilities related to the new market conditions. Job enrichment and highly skilled workers to secure flexibility, involvement of employees in decision making and planning of work to increase motivation and quality, and employee influence on product and services are some of the potentials outlined (Hvid & Möller 1992).

In Denmark there is a general and increasing understanding of finding alternatives to Taylorized work. This has lately been expressed in the action programme for minimizing repetitive, monotonous work drawn up by the Danish Parliament (Busk Kofoed and Garsdal 1993). At the same time the companies have an increasing understanding of the necessity of a good working environment because of the above mentioned conditions (Andersen 1992). But still we see many and even new companies with repetitive, monotonous work based on Taylor's principles.

When new products, and therefore new production planning, are introduced designers and production engineers have great influence on the working environment (Broberg et al. 1997). Therefore the knowledge and consciousness of the working environment's importance for the health and developmental potentials of the employees as for the general capability of the companies is of great importance in the engineering curriculum. The knowledge that newly qualified

engineers have developed during their education, is crucial to the working environment in the companies (Tybjerg Aldrich 1994).

2.1 Engineering students' approach to production planning and working environment

When engineering students are admitted to the study, they often have an idea of engineering as an isolated technical development and production in which they find it rather difficult to plan with perspectives from The Developmental Work in the design and planning task. Most of the students can see the possibilities and the advantages of establishing a good working environment in the company. They also consider the necessity of making a reliable, economical production plan. The problem is to integrate working environment and production planning.

During the production planning courses the different levels of a product's working up will automatically mean that the flow of the processing has to be broken up into a number of single elements. When planning the production flow it is of course important to know and understand how to handle the specific operations to be able to plan for machinery, tools, manning, cycle times, etc. In a theoretical planning approach a production will look profitable when it is planned from a technical and rational point of view with focus on all segregated machines, processes and functions. It is our experience that this necessary fragmentation affects the work organization and thereby the social and psychological elements when the manning is planned. Those elements (the "irrational" elements) which we by experience know are important for lead time, quality, time of delivery etc. and thereby for the profitability are often underestimated or non-existent in the production plan. This gives a wrong impression of e.g. the possibilities concerning employee motivation, responsibility for quality, and the ability for employee interventions in unexpected situations.

The students are inclined to man the production corresponding to the stages in the machining, for instance in the assembling: "one man one task". This means that the work organization is based on the different levels of processing rather than on the elements which altogether create developing and qualifying working conditions for the employees. The students often end up with a production plan which, so to speak, programmes repetitive, monotonous work.

The challenge therefore is to design a simulation game that illustrates the consequences of fragmentation and a too narrow focus on the manufacturing operations versus the possibilities of an integration of working environmental aspects in the production planning. The purpose of the game is to show that production can be planned in several ways, one of which is to integrate the working environment and with aspects from The Developmental Work: production process planning with an anthropocentric approach.

2.2 A simulation game with an anthropocentric approach

The game is based on a case that describes a company situation and the product. The game is designed to have two scenarios. One in which the game is played with

a production sequence based on a Taylorized production planning, and one scenario based on an organization containing elements from The Developmental Work.

By using two scenarios, awareness should be established about the different focuses in production planning and the different consequences for the working environment. Furthermore, the two scenarios should lead to a discussion of important aspects of establishing and developing a good working environment and the benefits for the productivity.

The game process in the two scenarios can widen or reduce the scope of actions, because the players are not given any personal instructions connected to the role. The role is only presented as that of an operator and a task to be fulfilled.

During the game process it should be possible for the game leader to make interventions, either by adding some unforeseen situations to the game or to stop the game because a specific situation needs reflection.

3 THE LEARNING APPROACH

The learning approach has to fill out the gap between the abstract working environmental aspects and the more concrete subjects about production planning which the students have to work with. The approach is based on Kolb's learning cycle. (Kolb 1984). Kolb's learning cycle shows that learning, especially the type of learning which is required in relation to non-technical working environmental issues, takes place through a series of phases in a cyclic process which can be described as:

Figure 1. Kolb's learning cycle encompasses two significant areas: one which covers action to reflection and one which covers the transition from concrete to the abstract.

Kolb is talking about problem-solving as problem-oriented learning, where the problem represents both the motive and the content in the learning model. When

the context of learning is technical issues in relation to better working environmental performance, Kolb's learning theory is relevant, as problems often are the background for the necessary learning, and additionally his learning concept is based on 'learning by experience' and 'learning by doing'.

For many years John Cowan has worked with the significance of reflection in relation to learning especially when and how in the course of the learning process the reflection is placed and performed. Cowan's concept of learning is based on how learning based on experience takes place, and especially how learning is performed together with others in a group (Cowan 1996). Cowan in this way introduces an approach to the collective aspects in the learning concept, and he modifies the Kolb cycle to encompass the following words as illustrated in figure 2.

Figure 2. The Kolb cycle with words paraphrased by Cowan. (Cowan 1996 p. 32)

The words in Cowan's Kolb cycle are discussed in the following.

Experience: As a basic approach one can say - in the context of a specific learning process - that all participants have their own individual experiences. The participants' experiences in a learning process may be categorized into three types. Among these experiences some are more interrelated than others.

One type is experiences which are shared by everybody participating in the learning process. This experience is often to a great extent concordant for all students in the group. Such experiences may typically be the function and the structure of the university's management, the social structure in the university, and the culture of the university. These experiences are fundamental to the common language and understanding in the group of learners in the initial period of the learning process.

Another type of experiences is based in the individuals' daily working situation and problem-solving methods. These experiences may be shared by some in the

group, but not by all. This type of experience may contribute to a specialist in-put into the learning process from individual participants.

A third type of experience is external input from others such as lecturers, other students, etc. In this way the participants in a learning process have access to an infinite number of experiences, a fact to remember and consider when planning a learning process.

Reflection is by Cowan considered the central issue in the learning process, and this is why he describes his learning concept as 'reflective learning'. A distinction between three possibilities for reflection may add valuable understanding to the concept of reflection. Cowan indicates that Schön (1987) distinguishes between reflection related to action and reflection related to experience, called reflection-in-action and reflection-on-action. These types of reflection are mostly retrospective in their attempt to make an analysis with the purpose of using the results in future learning situations. Cowan therefore add a third learning distinction which is reflection-for-action, in which the participants reflect upon which types of problems they hope to be able to solve more successfully in the future than they have been and are at present. Reflection-for-action is described like this:

"It is a reflection which directs subsequent learning by identifying needs, aspirations and objectives which are then kept almost constantly in mind". (Cowan 1996 p.37)

Figure 3 illustrates the process with three reflection loops: reflection for, in and on action.

By reflection-for-action it is understood that in the first stage of the learning process it is considered and rendered visible why the learning process must be performed, what it shall contain, and how it is to be carried out and evaluated.

In order to ensure, that the learning process is 'on track', a planned reflection (reflection-in-action) is included in the process. During this reflection it is contemplated whether or not you as a teacher or a student are working in the right

direction and whether or not the thoughts, scope and goals for the learning process you made in the first place are still valid or if it is necessary to revise and adjust the planned process. Furthermore the preliminary outcome is considered and afterwards what you want the students to learn later on in the process. After the learning process has finished another reflection loop, reflection-on-action is instigated. In the reflection-on-action phase you consider what has been learned, why the outcome of the learning process turned out as it did, and how the outcome may be applied in the future.

Generalization and test. After the reflection loop is finished the results of the reflection are generalized, and based on the generalization a test is planned with the aim to verify or falsify the generalized results, or to build on/challenge them.

The Cowan diagram as showed in figure 2 is a simplified representation of what happens in real life, and a complete round in the Kolb cycle is not always made in the learning process. In real life, Cowan states, you may begin with experience - reflect on the experience and make a part-generalization to which you add another related and relevant experience - reflect on this, make another part generalization and so on until you add the part generalizations to an aggregate generalization, which is subsequently tested.

Figure 4 shows the modified Cowan Diagram.

The Modified Cowan Diagram illustrates that a series of minor reflection loops are made between the three planned reflection loops (reflection-for, reflection-in and reflection-on cf. figure 3). These small reflection loops are attached to the 'here and now' learning situation. The small reflection loops are typically without test, as described above, while the 'big' reflection loops represent complete learning cycles cf. figure 1.

The ideas in reflective learning seem to present an operational approach to obtain objectives and goals set for the learning process. Goals and objectives are

necessary in connection with common learning processes of the type suitable for our purpose, as it is the periods of reflection which particularly contribute to the depth and durability of the learning within the cognitive as well as the affective area.

The ideas of reflections support the pedagogical goals in the game. The game has to create awareness about different approaches of production planning, and to illustrate working environmental aspects of the production as well.

4 DESCRIPTION OF THE SIMULATION GAME

The game simulates two production situations to be played successively during two scenarios in a plant, LUDO A/S.

Scenario 1: A line production indicating repetitive, monotonous work.

Scenario 2: A production where the group organizes their own work.

The production is a fully documented production of a windwheel. Documentation is made according to the quality management standards.

The product, a windwheel folded in paper, is chosen from several criteria: cheap raw materials (paper, wooden pins, distance sleeves and needles), few auxiliaries, the possibility of Taylorized production, only a little training required.

Total playing time is four hours.

4.1 Scenario 1

The participants are divided into two groups, one group of 7 members participates in the game, and one group that observes the game. If possible we form two groups of players and two groups of observers.

Scenario 1 is organized with a very strict Taylorized organisation with no initiative left to the workers.

A foreman and a floor man (serviceman for filling in materials, relief, etc.) are appointed in the team. Five members are blue collar workers.

The game leaders arrange the layout of the plant beforehand. Five tables are placed on a line with some space between them in order to illustrate an assembly line where it is impossible for the workers to communicate. The foreman's table is placed at some distance from the line, and so is the floor man's table for the storage from which he fills in for the production line at the tables.

The production is divided into 5 operations followed by very detailed work instructions. The game leaders deliver the documentation to the groups. A description of the plant, the product and the production system is distributed to the team. The documentation of the production is delivered to the foreman ie part lists, layout, work instructions, production orders, sales orders, etc. Instructions for evaluation are distributed to the observers.

All the participants are informed about the company situation and the product. While the foreman is reading the instructions, the game leaders practise folding of

the windwheel with the workers to ensure that the production is running at full speed from the first batch.

The production chart is based on the sales orders delivered from the game leaders. Around 6 sales orders (1 to 8 windwheels in each batch, 4 variants) make about 1 hour's production.

The production begins with a one piece batch to avoid too much spare time. After the first batch the team is on their own lead by their foreman according to the instructions.

4.2 Scenario 2

In scenario 2 the foreman is asked to join the observers. This leaves a team of 6 workers to produce the orders.

The team receives the documentation from the game leaders and they have 10 minutes of initial planning of layout and production.

In scenario 2 the new work instruction is describing a full production of a windwheel while the sales orders are the same as in scenario 1. The production order is prepared for the full production of a windwheel. Again the playing time (production time) is maximum 1 hour.

4.3 Game materials

All the documentation and materials for the game are gathered in two boxes to enable unexperienced game leaders to run the simulation game without help.

A script is explaining how the game can be carried out from beginning to end. An important point is, however, that the participants should be left to define their own personal roles.

A folder contains all the documentation for the production together with models of the product and various descriptions and instructions to be copied for the game. The content of the folder is:

- Case description of the plant and its situation on the market
- Sales orders
- Formula for production process planning
- Work instructions for all participants
- Quality control instructions
- Layout map
- Evaluation instruction for the observers
- Evaluation instruction for the players
- Script
- List of all the materials needed for the game

4.4 Two types of intervention in the game

To illustrate unforeseen events during the production, the game leaders intrude in the game.

Examples of interruptions can be: a telephone call for one of the workers, sick leave, lack of raw materials. The interruptions will illuminate the flexibility or lack of flexibility of the production system. The same interruptions are made in scenario 1 and 2.

During the game, interventions are made to facilitate reflections on the experiences. The interventions are sometimes planned beforehand and sometimes derive from the focus of the process of the game.

5 RUNNING THE PLAY

5.1 Running of scenario one

The game developed very differently due to at least two circumstances:

- different knowledge/background of the teams as to production process planning, and
- freedom to define the personal characters of the operators and foremen.

The teams' backgrounds seem to be very important for the outcome of the game. One team was studying production process planning, their production was running instantly in an efficient way with few delays but they obviously focused on quantity rather than quality. The team worked hard to minimize the lead time and this caused rejected products due to low product quality.

Another team was less familiar with production planning and consequently they had difficulties in getting the production started and with maintaining a balanced flow that kept all operators equally busy. As a consequence the operators had several boring delays.

We have consciously avoided to define the personal characters of the players in order to make the roles open for interpretation. This led to very different progresses of the game as the participants did not hesitate to give a personal interpretation of the roles, playing authoritarian, reluctant, helpless, etc.

During scenario 1 the repetitive, monotonous work very soon felt boring and the players began teasing each other or the foreman, making jokes and making errors on purpose. Thus the participants themselves experienced monotony. An authoritarian foreman typically provoked infantile or demotivated behaviour.

5.2 Running scenario 2

When scenario 2 was running, an interesting discussion took place in one group as to whether the group should have a leader or not. The members of the group disclosed very different attitudes to planning and implementation ranging from "let us make it perfect from the beginning" to "if it does not work we will just change it". The group ended up with an agreement that they would try to run the game collectively. As to the organisation of the production there was a discussion of how many operations each operator should take. The team agreed that each member should produce a complete product from bringing the raw materials, doing the

quality control to delivering the finished product to the storage. The team set up the layout so that everyone would be in contact with one another and so that everyone had access to the documentation and the sales orders. They distributed the first sales orders among the team members and the rest of the sales orders were left according to priority.

Before production start the team worked on how to make the product by helping one another.

Once the production was running it seemed to be very efficient. One of the game leaders' interruptions was to ask for a rush order and this was instantly taken care of. Each operator still produced a whole windmill and the whole batch was finished very quickly. Afterwards the ordinary batches were produced.

As the team members were in contact and could talk during the production they proposed improvements and rationalizations of the production methods during the play, improvements which could be implemented immediately.

Thus, to the satisfaction of the game leaders the team itself spontaneously demonstrated the advances of The Developmental Work.

6 DISCUSSION - LESSONS LEARNED

We would like to discuss the game at two levels:

discussion of the game

discussion of reflection

6.1 Discussion of the game

In the first scenario the simulation game is a good illustration of the limitations in a Tayloristic production - especially concerning flexibility. Another visible point is the amount of time wasted when a problem occurred on the assembly line, and the role of the foreman. If the foreman takes the role as dictator, the students who play operators respond negatively to his attitudes become demotivated, find excuses for leaving the workplace, cut their fingers, etc. An interesting thing was that no one was told to put any individual characteristics in their role, however, everyone shaped their role in a way which they presumed would fit the game situation, ie how they thought people with this kind of work conditions would behave.

In the second scenario no one put on a role except the one which was in the script. Everybody did their best to fulfill the tasks, and everybody used their experience about cooperation and group work. The production was a common responsibility.

We find that the simulation game is an effective participative learning method. All the students are actively involved in the game either as players or observers. The question is what the students learned. Based on the evaluation of the game we can say that the students are now aware of some consequences stemming from a Tayloristic and an anthropocentric production planning approach. Different approaches have different consequences for the working environment.

The game could be an excellent starting point for a discussion of The Developmental Work.

6.2 Discussion of reflections

It is very important but also very difficult to make reflections during the game. Many events which are very relevant for evaluation and dialogue take place during both scenarios. The wanted events obviously will take place but it is very important that the observers and the game leaders concentrate very hard on picking up things to be able to support the reflection that will lead to learning. The game leaders' awareness seems to be very important to make it possible for them to put facilitating questions for reflection instead of giving the solutions to the problems.

The game leaders have to take the time to facilitate learning when unforeseen episodes occur during the game, and to make the new knowledge "visible" so the students get the "oh" experience. Furthermore the observers' role should be emphasized, primarily because feed-back from "one of your own" is more powerful and secondly, because a seriously elaborated feed-back provides observers as well as players reflection and knowledge.

Interruptions during the game cause certain problems so that the game leaders must be aware of the balance between a spontaneous running of the game and the reflection as the base of a more long-termed intellectual learning. The spontaneous course of the game will give the students a possibility of feeling and experiencing a situation far from the conventional learning situation. The purpose is to give the students an impression as close as possible to the real working conditions and to make them feel on their own bodies what monotonous work is like. By combining an experience close to the "real life" and the intellectual reflection in the game, we intend to implement holistic learning. The task is to let the game run spontaneously and at the same time have creative reflections on what is going on and why things turn out the way they do.

When the students in scenario one show signs of boredom from doing repetitive monotonous work the game leaders might interrupt and put facilitating questions. The questions must not give the answers but should make the students think and put questions to themselves, like: "how come that operator 2 reacts to the foreman is this way?", "when did operator 4 start to tease the floor man?" and "when did the decrease in the product quality appear?"

In scenario 2, one of the participants suggests an improvement of the production process. The game leaders interrupt and facilitate a discussion of how the organization and layout influences the communication between the employees.

After the game the reflection should increase to a new level where the students reflect on what they learned from the game and what made them learn from the game. It is also essential to emphasize that the game should not illustrate results of the production e.g. different lead times and improvement of product quality. The point is to make the students see that there are other ways than Tayloristic production planning.

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8 BIOGRAPHY

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