19

Design of simulation games

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In the preceding chapters different games have been presented, and a "road map" was introduced in the first chapter to serve as a guide for the reader to select one or more games suitable for a specific teaching situation. The games may also have inspired to suggest an alternative game be developed, or that one of the games be augmented. This paper sets forth to present a framework for designing a game. The overall design process is described in terms of four steps, respectively initializing, design, engineering and use. The initializing step includes the specification of requirements for simple games. The elements of a simulation game are introduced which may serve as a useful checklist during the design process. The design of games leads to a game concept. Defining roles and role playing in the game is an important part of the design and engineering step.

The chapter is based on the basic principles developed by Greenblat & Duke and the authors' experiences gained from the design of a number of production management games (*). Such games are used either in teaching production management or in improvement projects in industrial enterprises.

(*)   The participants at the Workshop on Simulation Games in Production Management, University of Aalborg,
      June 1994 contributed to this chapter through a discussion on design experiences

1.   THE DESIGN PROCESS IN FOUR STEPS

Greenblat & Duke recommend four steps in the design of a simulation game: Initializing, Design, Engineering and Operation of the game.

Initializing means defining the objectives and the scope of the simulation game. Important questions are:

- Stakeholders and their special interests? The sponsors and owners of the simulation game? The "buyers" of the game and their expected benefits from using the game?

- Participants in the simulation game? Their background, skills and motivation for participating?

- What is the purpose of the simulation game? What should be communicated and taught through the simulation game? The role and context of the game?

- Subjects to be dealt with in the simulation game?

- Time frame and benefit/cost considerations for the development of a simulation game?

As in all development projects, efforts should be spent on the identification of the need for the simulation game. The analysis of the area of application should tell whether a simulation game is the right tool for learning, or whether other communication media should be applied.

What is the idea of using a simulation game? Different ideas might lead to different types of games. A simulation may illustrate the processes and effects of a proposed new manufacturing system or control procedure. A game may be an instrument for learning new rules for decision and work rules. An experiment through a game will facilitate immediate feed-back on the usefulness of creative ideas from the participants.

A simulation game is useful when complex situations are dealt with. The game model should reflect the complexity of the real world. But the game itself should be easy to play. A comprehensive game manual with many instructions and rules might confuse the participants and reduce the learning effects.

Design means development of a simulation game concept. At first the basic ideas to be conveyed through the simulation game should be defined. Next alternative ideas about the game process, game setting, game symbols and components should be gathered and evaluated. Inspiration may be found in other games, and brainstorm sessions might be useful. The task of staging the game usually is most challenging, and calls for creativity.

The simulation game process represents two aspects. One is the game process picturing the real life situation, for example a manufacturing process, a logistic system, a production control method, etc. Another is the learning process.

Building a model of a real life situation often tends to result in a minimized realistic model. The Ruler Factory is one example of a miniature manufacturing system, and the Lego Lorry simulation game illustrating a logistic system is another example of a realistic picture of a system. Animated computer simulation models are based upon the same thinking. More

abstract models and finding analogies in other worlds will sometimes serve as better "eye openers". For example the design and engineering of crossword puzzles was used to illustrate different degrees of work integration between functions and departments in new product development. The level of abstraction depends on the capabilities of the game participants and on the need for overcoming blindness and habitual thinking related to the real life system.

The learning process could at first be seen as teaching the game participants to adopt a certain behaviour, to follow certain procedures and to apply certain working and decision rules. It should be emphasized though that the learning effect usually is obtained by experiencing the relations between actions and effects (consequences). This might lead to games where the participants are allowed to change procedures and rules and even the manufacturing process or logistic process. This really urges to consider cause and effect relationships. An aspect is added to the discussion of simulation results versus reality. The simulation game inspires changes in the real life system, questioning preconceived assumptions and restrictions.

The scenarios in the simulation game and their sequence illustrating the process are an important element of the game. If the scenarios are too complex it may be too difficult for the participants to identify cause and effect relationships.

The symbols and mechanisms will provide the characteristics of the game. Which means should be used? It should be easy for the participants to understand the simulation game itself and to learn the means and their symbols.

The simulation game concept should be described in a concept report forming the basis for building the simulation game and the basis for deciding on this step. Typically the elements of the concept report are: simulation game context, purpose and objectives, basic ideas to be conveyed, game structure and processes, means and symbols, resources required for building the simulation game and for running the game.

The design step is an important activity, because purpose, objectives and alternative means are considered before resource consuming, and costly engineering and manufacturing activities are started. A headlong jump into detailed engineering entails a risk for a less qualified game.

Engineering means detailed engineering and manufacturing of the simulation game according to the requirements and ideas described in the simulation game concept. This step comprises engineering of the elements (e.g. forms, plates, symbols, models, programmes), collection and conversion of real life data for the game, first dress-up test run.

Development of successful games seems to be characterized by:

- A certain discipline, meaning that ideas and tasks are maintained in the development process

- Obtaining a clear logic of the game

- Usable stagings and technology

- Steadiness, intuition and inspiration

- And finally, a portion of luck

It should be emphasized that games must be kept simple. There is a temptation to include too many subjects in combination to reflect the complex reality. It means that the game will be too confusing to engineer and its effect might be reduced. Managing more subjects and problems should be done through more games or versions of the game.

Operation of the game must be considered with care. The participants have an aim and a purpose with the game, but how do they perceive the process of the game? It is essential to make sure, that the participants see the game as a constructive element in the development process, or in the learning process which the game should support.

The objectives of the game itself should not confuse the purpose of applying the game to teaching situations or to situations in the business/organisation. The participants should be able to relate the game to their everyday. The game should not be considered as just fun or a needless activity.

2. THE INITIALIZING STEP

2.1 Checkpoints of the initializing step

Before spending too many resources on development and implementation of a simulation game, there could be a reason to consider if a simulation game is the right means at all in the actual teaching and development situation. Greenblat & Duke recommend some considerations when initializing the development of a game.

- *Is the game appropriate at all?* It has to be considered, why a simulation game would be a suitable media in the present situation and what justifies the development effort. When considering the development costs of a game, it has to be justified that the game is the right communication media. Other media might be used instead of or together with a game.

- *What damage might be caused by a poor game?* The game may turn the issue upside down and leave a false impression with the participants. The result may be misinformation, ignorance of important facts of the problem, confirmation of preconceived opinions, myths etc. The simulation game may fail due to poor illustration of the real problems, or because the process of a good game is disturbed by an unqualified game leader. Hopefully, such situations will be observed by the participants.

- *How important is the behaviour of the simulation game leader?* The game leader has a great influence on the game process, but it is difficult to define which behaviour will cause a success respectively a failure. There are no certain rules for the game leaders' intervention in the game process, to obtain the desired process. The game is supposed to proceed in a certain direction, but at the same time the participants should have an opportunity to experiment and to learn.

    The good game leader must consider his role and analyse the process and the results of the game, just as the participants must evaluate the game. Each game is unique - a result of interactions in a certain group of people in a certain period of time.

- *What will the reactions be to variations in the benefits obtained by the participants?* During development of the simulation game, we normally assume that all participants get the same experience, but this is seldom correct. Different roles will give different experiences from the process, and even with a good game resúmé, where experiences and opinions are exchanged, the results will hardly be the same for all participants.

- *What about participants who dislike simulation games?* You will meet participants who are not at all interested or motivated, but rather have been ordered to participate. These participants might refuse to play their role, but more likely they will be passive and they could easily spoil the game for the other participants. If they have to participate they should be allocated to roles which they accept themselves, and which cannot disturb the game. Often an observers role would be a possibility.

    We have met this situation several times, e.g. as game leaders for the production simulation game The Ruler Factory. The Ruler Factory was for several years used at an introductory training course at The Institute for Production Management at The Technical University in Copenhagen. 12-14 groups were playing simultaneous games. Every semester a group of students performed especially bad. There were several reasons, but lack of interest and motivation, negative attitude to simulation gaming and insufficient individual preparation were typical explanations. Especially the preparation was important. The participants' knowledge about the purpose of the game was limited because they did not attend the introduction to the game. In many cases a more individual introduction changed the attitude and the general view of simulation games.

- *Can simulation gaming be overdone?* A good question. Of course it can. Games should be meaningful and suited to the size and importance of the problems.

2.2 Specification of requirements to simple games

In the initializing phase, you should consider the general problems to be solved through the simulation game, consider the participants and the practical limitations and derive special requirements to the game.

Games are developed for different purposes, but generally two main purposes are seen, i.e. education and demonstration. The purpose can be detailed, (Morry van Ments)
- to describe - illustrate or demonstrate an issue, a situation or a process
- to demonstrate - a method or a technique
- to practice - training and education
- to reflect - experiment and obtain response
- to prepare - increase or direct the attention towards a specific situation

A good piece of advice: Do not formulate the purpose of the simulation game too wide - do not kill two birds with one stone.

If the game is used by different groups or in different situations it should be considered if this will raise problems and special challenges, like running the game in different ways.
- Who are the participants?
- Do they represent different educational situations and different degrees of motivation to participate?
- What is the aim and purpose of using the game?

Development of simulation games is always limited by resources and by equipment.
It is important to explore such problems from the beginning :
-     Which alternative types of games could be considered?
-     What is the cost limit for the game?
-     Time limitations for developing, respectively running the game?
-     Could the simulation game be run within or outside normal working hours?
-     Is the game equipment to be transported and used in other places? Is it supposed to be kept for later use?
-     Will instructions be required for the provision of game materials for each game?
-     Will the game use standard materials?

The game must be developed according to a psychological line of thinking. General demands are:
-     Game focus must be clear. Games with many issues may have reduced teaching effect
-     The game should be adjusted to the learning levels of the participants
-     The participants should learn how new methods work and they should be allowed to experiment
-     The game should reflect the real life and context of the company - to an extent enabling the participants to assign the experiences to their daily lives
-     The level of abstraction of the game should match the line of thought of the participants - symbols must be unambiguous and have a clear message
-     The result of the game should be measurable. Quantities are preferred
-     The game should contain driving forces like excitement, challenges, competition - and some stress

In simulation games for production management attention should be paid to illustration of the consequences of missing or inappropriate management, illustration of different management principles, and illustration of different production systems and production structures.

2.3 The elements of a simulation game

A simulation game can be described in different ways. However, it is possible to identify some elements of a game. Duke & Greenblat describe a paradigm for the development of a simulation game with 12 elements: model, scenarios, pulse/events, game process, game periods, roles, procedures, decisions, results, indicators, symbols and materials. These elements are summarized below.

- *Model:* Simulation games are figurative models of a delimited reality. The model could be implicit - for example the effect of a quality improvement campaign. This means that the participants should explore cause and effects relationships. The model could be explicit and be presented to the participants at the beginning - like in chess where all the rules are known.

- *Scenarios.* A story is told, framing the game, and introduced to the participants at the beginning of the game. In simulation games related to a company, the players/participants

will easily learn the "game reality". The detailed instructions of the game are the descriptions of the process and the roles

- *Pulse and events.* An event will release activities and effects in the game. Events could be used for opening the game periods and to ensure attention to special issues. Events are released by the game leader or by coincidence. Events in production management games might be material defects, machine break down, urgent orders etc.

- *Game process.* The typical game process includes introduction, a number of game runs (consisting of several periods) and finally a game résumé. A clear and visible game process will provide an easy task for the game leader.

- *Game periods.* A game may have a number of periods, each with a sequence of activities.

- *Roles.* Description of the roles in the game is an important part of the formulation of the game idea. A role characterizes a person or a job in the simulation game. To the role is connected interests, subsidiary goals, attitudes, opinions, expectations and special problems. Each participant or eventually a group will get a role. Depending on the game the role can have more or less degrees of freedom, including implication of the participants personality.

- In production management games, most often a role is equivalent to a job function. Very seldom a player is asked to play the role of a certain person with prescribed personal characteristics

- *Procedures.* Procedures or game rules will ensure connections between the roles and will proceed the game. The less rules the faster the game can take off.

- *Decisions.* Decisions and the way decisions are made will usually be the important part of every game. The result of the game comprises the consequences of the decisions made. That is the basis of a good debriefing discussion. By letting the participants explain their experience of the game process, they form a positive forum for the exchange of ideas. Even when the participants will be accountable for their decisions and get the chance to explain their reasoning most of them are willing to be criticized. It is natural too, to criticize colleagues and leaders within the content of the game. That is often much more difficult in the everyday situation. In the game, the

- *Result statement.* The accounting system of the game, i.e. the way the performances are made up, is important for emphasizing the behaviour of the participants. That is in the learning process and in the presentation of the game process at the game résumé.

- *Indicators.* In addition to the statement of the total game performance, there is a need for different measurements of the game progress. Status diagrams, plans, deviations, modifications may be used.

-   *Symbols.* Production orders, goods/items, machines and work places, progress and performance indicators etc. have to be represented through symbols, which will ease the game, facilitate quick understanding and add some fun.

-   *Materials.* Different accessories and equipment are used in games, for example dices, jetons, coloured cardboard pieces, lego bricks, watches etc. Specially built miniature machines, wall plates, flow-diagrams, game plates are seen too. Only fantasy and economy will limit the possibilities.

3.   THE DESIGN STEP

For determination of the game issues and purpose, Duke suggests [*] :

-   Interview key persons as a starting point for determination of the issues and as a primary check of the suitability of simulation gaming for solving the problems

-   Inspiration from literature and existing games, to get ideas for the illustration of the actual issues

-   Brainstorming in a group of interested and creative people. A cardboard method can used for example. The ideas are written on carton cards or "post-it" notes and arranged on a board. It is easy to rearrange and to define suitable structures. All participants in the brainstorm have an overview.

The generation of ideas provides a basis for drawing a preliminary rough outline of the simulation game. By producing plates describing purpose, game participants, scope of the game, etc., it is easy to explain the ideas of the game. The game process is often shown in a flow-diagram, which illustrates the game model, parallel activities, roles and performance measures.

4.   THE ENGINEERING STEP

4.1 Engineering elements
The next step is the detailed engineering of the elements of the game. Duke suggests a matrix illustrating the real world and the game world. The issues to be illustrated via the game are shown horizontally and the elements of the game are shown vertically. Each crossfield in the matrix is filled in with ideas for the game. It might be a good idea to consider one crossfield at a time, not to get lost in detailed relations and conflicting ideas.

(*)   Richard D. Duke: Short Course "Development of role playing games for production management", Denmark, June
       1988

Elements of the game	Issues First game run	Second game run
Model	Actual management principle - flow model	New management principle - *kanban*
Scenarios	Initiated from sales	Initiated from sales
Pulse/events	Weekly requirements	Customer orders
Game process	15 weeks of production	15 weeks of production
Periods	1 week	1 week
Roles	Own roles	Own roles
Procedures	Different distribution models and rules for flow of material	Same distribution model at all operations
Decisions	Centralized issue of orders	Wanted production volume locally
Result measurements	Capability of delivery. Work in progress	Capability of delivery. Work in progress
Indicators	Delivery difficulties and stocks	Delivery difficulties and stocks
Symbols	Pieces of cardboard. Process layout on table	Pieces of cardboard. Process layout on table
Other materials	Dices	Dices

Table 1: An example of an element matrix for a production management simulation game

Working with a matrix, like for example the one shown in table 1, can be done from a top-down point of view, i.e. according to the issues to be illustrated, or from a bottom-up point of view - i.e. based on the single game elements.

When the matrix is filled in with ideas, the group has obtained a comprehensive set of ideas, which should be sorted and discussed to create a coherent game. That is the basis for the preparation of a game concept report.

4.2 Arrangement of roles

The roles of the game can be arranged in several ways, and they can be described through the following elements: functions, goals, background, education or abilities, expectations and personality (Morry van Ments). These elements are described below.

- *Function.* Status, authority and power as usually linked to a certain position in the organisation.

- *Goals.* Goals and motives which the participants have to keep up with in the game.

- *Background.* To add some more colouring to the events in the game, the background of the game could be specified.

- *Qualifications.* The role often implies that the participant is holding a specific education and special skills or experiences. At the same time, the participant should use his own experience when interpreting the role.

- *Expectations.* Roles may be described in general terms or through titles, for example "production planner". The participant hereby may express his own opinion and expectations to the role.

- *Personality.* The participant can always add some personal aspects to the role.There may be quite some degree of freedom to add ideas and a certain behaviour. The situation could be rather impossible, though, if the participant cannot sympathize with the aspects of the role, or if the role is to extensive.

The roles of the game can be split into three types: Main roles, secondary roles and extra roles. The issues of the game are defined through the main roles with a significant influence upon the process of the game. The secondary roles support the main roles. They may act as sources of information or perform more practical activities, for example production, dispatching or receiving orders or transport of materials. In many situations, it can be convenient to be able to adjust to the number of participants through extra roles. If the extra role should have a real meaning, it must be conceived in advance. If it is of no importance it might disturb the game, be boring and disappointing to the role-player. This will usually influence the evaluation of the game.

At the beginning of a game, the participants are allocated to their roles. This allocation will influence the game results and thus the experiences gained from the game. Motivation and skills are important criteria for allocation. Deliberate allocation of another role than the daily job may be valuable, for example a salesman may play the role of a production manager.

Principles for the allocation of roles:

- at random
- the participants choose roles
- role rotation
- roles similar to or close to the participants' real life job
- roles different from the participants' real life job, often meaning a role representing a counterpart job

Some important aspects to be aware of when developing roles are (Morry van Ments):

- Roles should not be too stereotype, but have a real purpose in the game.

- Role specifications should be clear and understandable - in the way the role-player would express himself

- Use role rotation.

- Use "time-out" and game resume to discuss the process and performance. The participants may defend the way they played the role - and afterwards they can express their personal opinion of the role.

- It must be ensured that the performance measurement system will reward correct or wanted behaviour by the participants. Otherwise the participants will be demotivated.

4.3 Role play in simulation games

Role play has advantages and disadvantages. Morry van Ments points out different types of role plays and experiences, some of which are similar to ours. Some of the most obvious advantages and disadvantages are listed in table 2.

Advantages of role-playing	Disadvantages of role-playing
Participants are able to express feelings	Game leader cannot control the learning process
Facilitates discussion of personal opinions and problems	Simplifications could be misunderstood
Strengthens the exchange of opinions	Is time consuming
Shows general social problems and the dynamic interplay in a group and between groups, formal and informal	Consumes resources - personal time, room and equipment
Adds colour to the descriptive material	Learning will depend on the qualifications of the game leader
Non-verbal reactions and feelings are involved giving less articulated participants better chances for participation	Learning will depend on the skills of the participants
Motivating because the participants are activated	Participants will influence the effects of the game
Rapid feed-back on actions and decisions	May be "over-played" - just entertainment and fun
Meets the needs of the participants. They can control content and speed	Can disturb the purpose of the game
Bridges theory and practice	
Affects and will change attitudes	
Enables the training of behaviour	

Table 2. About role-playing

4.4 Role of the Game Leader

The simulation game may be self explaining if it is to be used for training purposes. It calls for good instructions, help functions, supplementary questions for reflection, references to literature, etc.

A game leader might have different roles serving as a facilitator, taking care of the practical arrangement and providing practical assistance to the participants. As a moderator he will conduct debriefings and discussions, and as a coach he will advise, ask questions and conduct the discussions leading to learning and conclusions.

5. OPERATION OF THE GAME

5.1 Evaluation of the game developed

Evaluation and test of the game is a separate activity. Games to be used by many participants or several times should be tested thoroughly, whereas a game to be used only once might be reviewed only.

Duke recommends that games are thoroughly tested by using "The Rule of 10". This means 10 tests, and the final 3 tests should not lead to major changes. He also considers the first simple runs of the game as tests.

The game should be evaluated from the defined purpose. Three aspects should be considered:
- Which test conditions should be applied?
- How will the success of the game be measured and stated?
- Who should evaluate the suitability and the value of the game?

- Get input from customers and users
- Formalize instructions
- The simulation game should be self explaining
- Increase complexity through the game
- The development team should be multi-skilled and reflect various attitudes and experiences
- The game should be tested in an environment different from the user environment

Table 3: Hints from the participants in the Workshop on Games in Production Management, May 1994, Aalborg

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5.2 Preparation of the game process

Before playing a game an introduction of the play to the participants should take place. The following questions could be considered:

- How are the participants invited to the game, and how are they introduced to the game?

- How are the participants supposed to prepare for the game? Should they read part of the company production management procedures, answer a questionnaire or consider certain problems or issues?

- Should the participants receive and read the simulation game documentation in advance? Description of the game, role description, manuals, etc.

-   What is expected from the game participants?

-   How can the participants find time for the simulation game? Usually it depends on the number of participants and the degree of disturbance of the daily work in the company.

-   How should the simulation game be arranged as an element in a training process?

-   Who will be responsible for the game?

-   How should the game leader prepare himself?

-   Accommodations and materials should be prepared. Some games make a mess and some are noisy. Could it take place in a laboratory, a classroom or in the company?

Instructions and manuals should be ready at the start of the game. Instructions for simple games may be given verbally.

The game should be introduced with the purpose and the background and a presentation of the participants, if they do not know each other in advance.

-   How should the game introduction take place? Could a trial game be run or could the game start slowly?

-   What happens if one or more participants do not show up? Alternative distribution of roles or no play?

-   How are extra roles to be used if a group of participants is larger than presumed?

-   Is there extra material available at the gaming place?

-   How should the players evaluate the game? Should the normal procedure for debriefing and evaluation be used, or do the actual circumstances call for a special evaluation form?

It is important to follow up on the game. Besides the game résumé and evaluation (which is a part of the game) it is necessary to ensure that the participants see the simulation game as an element in an educational or a development process.

A note about the game process, including a discussion of the issues and the questions raised, is a way of maintaining the statements and opinions from the participants. In this way, the discussion contributes to the development process, in which the game was an instrument. Such note will require some consideration:

-   What kind of experiences did the participants acquire?
-   Which statements were typical?
-   Which expectations were created?
-   How to follow up on these expectations? How to fulfil them?

5.3 Evaluation of the game process
Will the game process and the discussions and comments during the game motivate changes in:
- Assumptions concerning external conditions?
- Management principles, stock locations, lot sizes, calculation models, etc.?
- Description of the production control concept?

Will the simulation game be appropriate later when the production process and management system has been changed? Would the same participants benefit? Should the game be repeated for other groups of students or in the company?

6. CONCLUSIONS

The development and engineering of a simulation game is a creative and challenging job. In this paper we have presented a design process in four steps: initializing, design, engineering and operation of the game. Furthermore we presented a set of rules, hints and methods for the design and engineering work

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