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Business Games in Training Engineering Students

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Abstract

The article discusses solution approaches to the enhanced training of engineering students. To shape professional competences and learning motivation it is offered to use business game as an active teaching technique, which to the authors' mind, is an efficient tool to prepare students for future professional activity. Business game, as a tool for simulating various aspects of professional environment and real industrial processes, allows to train students apply the obtained theoretical knowledge and solve problems emerging in their professional activity.

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Keywords: Business game; simulator; electric power system; regime; emergency response drill.

1. Introduction

Non-conventional approaches for giving classes can be viewed as a factor motivating academic activity of engineering students. On the one hand, it is an opportunity to gain fundamental knowledge, on the other hand – to change approaches to the organization of educational forms, to improve the quality of education process, to develop students' creative abilities, which ensures high level of academic and research training of specialists (Dolzhenko & Shatunovskiy, 1990).

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Training must involve active and interactive forms of teaching (automatic training systems, interactive seminars (Lin, Chia-Yen., 2015), simulation techniques, business games and role-plays (Lynn, V., 2015), computer-aided simulations, tabletop exercises, group discussions) aimed at developing professional skills.

2. Business Games in the Educational Process

Different active-learning techniques are used to arouse students' strong interest in the subject and to meet their practical needs. This refers to business games, role-plays and trainings. Incorporation of business games in the educational process must be based on the didactic principles of demonstrativeness, activity, accessibility, combination of the theory with the practice, scientific character and involvement, which are widely used in teaching practice (Barinov, et al., 2011).

Business game is a tool for simulating various aspects of professional environment, imitating the industrial process, a simplified reconstruction of real manufacturing situations. Game-players are given tasks, similar to those they are to solve in their everyday professional activity. The tasks can be different, e.g. monitoring of electrical equipment condition (routine switching); power system state management in different regimes (steady-state, repairing, emergency). In business games there are two types of activity: play activity and educational activity. Play activity involves performing particular professional tasks, while educational activity involves developing skills and knowledge. Educational tasks are solved before playing (i.e. studying theory and analysis of the assigned problem) and while analyzing the players' activity after the game (Kalentionok, et al., 2007).

The main aims of business games in the course unit "Operational management in power engineering" are:

- mastering operational management models
- developing abilities to independently make models while meeting real challenges of the power system control
- solidifying students' professional knowledge in electrical safety, regulations and standards, characteristics of electrical equipment, functions of automatic control systems, power system states

The structure of the business game includes operation model, methodological support, simulated power facilities, system of analysis and assessment of players' activity (Fig. 1).

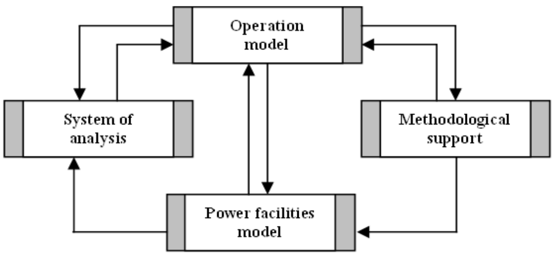

Fig. 1. Business game structure.

The key issue in the game design is the choice of the software package aimed at developing students' required operation model during the training process. The software package of the business game must reflect the next on-line control situations: steady-state, emergency, repairing.

Generally, the algorithm of a business game design for professional training of electrical engineering students includes the next items:

- defining objectives and tasks
- selection of equipment
- selection of participants (roles assignment)

- describing the initial condition of the facility and the problem situation
- developing the package for the participants to keep
- developing guidelines for studying the theory, regulations, rules and instructions
- developing guidelines for the business game analysis

The given algorithm can be modified and supplemented with necessary items in every particular case.

Business game design procedure in the course unit “Operational management in power engineering” consists of: aims and rules of the game, facilities used in the game; an entry list, a package for the participants to keep, theory to study, guidelines to analyze the game.

Usually business game rules are similar to the uniform code of the emergency response drill for the power facilities staff. The assessment system of the participants’ includes a list of the actions assessed and their quantitative indices (points assigned or cut for every game round, points for typical and non-typical actions of the staff). Generally, faulty actions, required solutions and incompleteness of solutions are assessed. Business game is analyzed with a certain algorithm which can vary in terms of objectives, time allocated for the analysis, participants individuality (Merkuriev, 2002).

Incorporating in business game real systems models enables to bring educational process closer to the specialist professional activity.

3. Tool Kit for Business Games

As a tool kit for business games of running regime a system operator regime simulator “FENIKS” was selected. It is a software package designed for emergency response drill displaying energy system current operation state. Current operation state displays power system frequency and voltage regimes, as well as operation state of permanent equipment, bus-and-switch structures of power stations and substations.

A special feature of the simulator is the ability to simulate during the game substation circuit arrangement and automatic accounting of the device status change in the regime model.

Power system operation model allows to simulate steady-state regimes, electromechanical transients and long transients.

The simulator can be used at all preparation stages: initial training, self-study, training for the position of operating employees, specialist training (proficiency maintaining of operating and accident response personnel), professional retraining for a new position, specialty knowledge tests, emergency response drills of the operating shift aimed at developing corporate actions skills. The simulator can also be used to develop management skills in standard situations, in pre-fault and fault conditions, to study system behavioral analysis in particular cases (regime analysis, working with requests to take the basic facility out of service for repair, Emergency Control Automatics check, forecast regimes security assessment).

The simulator is integrated in the local computer network and includes instructor’s workplace and some trainees’ workplaces. Software package of the simulator includes a system operator interface, an instructor interface, a power system model, a control center model.

The system operator interface displays the power system operation state during the operating personnel training and power facilities management.

The instructor interface manages the power system simulating model during training, introduces modifications into substations switch positions, changes power system state regulating voltage, power station loading-de-loading, tap-changing of transformer. An instructor supervises the training session and acts as a subordinate operating personnel, executing the system operator’s instructions interacting with the power system simulator via his interface.

The power system model in “FENIKS” simulator has two levels: a patch-board of substation circuit arrangement and a dynamic study model of the power system. The power system substation circuit arrangement includes circuit arrangement of the power system electrical annex and topological analysis and development algorithm of the equivalent circuit. The circuit arrangement includes single area power systems, substations, bus-bars, circuit breakers, disconnecting links, power lines, autotransformers, generators, reactors, capacitor banks, and electrical ratings of equivalent circuit elements. The algorithm of topological analysis generates the power system equivalent circuit, considering the current state of the switchgear devices at power stations and substations.

The model calculates a full operational mode determining node voltage, frequency, active and reactive power flows in system elements, power stations loading. The mode calculation is performed with an original computation algorithm for long-term dynamics in power system which enables to simulate modes with off-nominal frequency and voltage, power systems division into parts and other emergencies. The power system model can also specify system and emergency automation. Before training the auto-execute script of the lesson can be specified (e.g., emergency evolution). The control room model enables to employ operating data display facilities, used by system operators at normal operations. These are dispatching desks, wall diagrams, and alarm annunciators (Tyan & Budovskiy, 2013).

4. Methodological Support and Implementation

As an implementation example a fragment of a business game courseware "Blackout of 220 kV power line Tsentralnaya – TPP-2 with automatics of power station unloading in case of de-energizing two power lines of TPP-2 in the network maintenance diagram" is presented. The game is organized on the basis of Training power network. The Training power network includes a Regional Dispatching Office with the next facilities: Svyatogorskaya SDPP and Yuzhnaya SDPP, Svetlaya HPP, TPP-1 and TPP-2, TPP station units of petroleum processing plant and an integrated iron-and-steel works TPP, three 500 kV substations, eighteen 220 kV substations, and five 110 kV substations. An operation diagram segment is presented in Figure 2.

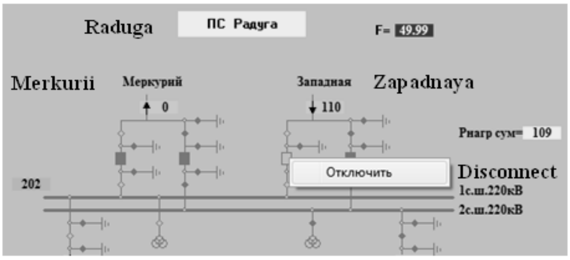

Fig. 2. Interaction pattern of business game participants.

Participants are furnished with the next data: a power system reference regime; a standard pattern deviation and emergency disturbance; a leading-in and assignment; an optimum solution to emergency disturbance elimination.

A training session can be divided into five stages:

1. Study of terminology, diagrams and equipment.

2. Initial operating mode and regime state clarification. A student who is a Dispatcher actively uses Dispatcher interface of the regime simulator and calls Instructor to specify the operation mode and power system equipment condition, when current information is not displayed on the Dispatcher interface, and to specify the mode state.

3. Emergency development period based on the business game scenario involving emergency automation. During this period a trainee makes an assessment of the situation and plans emergency operating procedures. Situation assessment is based on the data obtained through the Dispatcher Interface and messages announced by the instructor.

4. Emergency management and power system restoration. A student who is a Dispatcher executes emergency management plan in accordance with the optimum solution to the problem. He gives instructions to the facilities, which instructor puts into the model managing the power system model (Tyan & Budovskiy, 2013).

5. Evaluation of emergency response business game. The commands given are registered in the record of decision by one of the participants. The business game is evaluated with reference to the record of decisions and the process list with demerit and bonus points for completing the regime task.

5. Conclusion

Therefore, business game can be efficiently applied to develop students' abilities to plan standard operating conditions and promptly respond to emergency situations initiated by equipment failure. It proves advisability of subsequent use of business games as an efficient tool for student training to prepare them for future professional activity at power system enterprises.

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