

Formation of Professional Analytical Competence of Specialists in Maritime Transportation during the Training Process through Business Games

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The paper considers the use of gaming methods as a means to improve the efficiency of formation of the analytical competence and systems thinking of students and specialists which are among key objectives of specialists training. The actual task is to elaborate innovative methods and models for formation of the analytical competence.

A design approach and methods of game simulation experiments are the basis for organization of professional competence development. The set of professional games was worked out for this purpose. Such set is based on Organizational-Active Games (OAG), simulation models and business games. Elements of the set are logically correlated in time and space and include interdisciplinary links. The set orients both to development of the analytical competence and the professional preparedness in general. The training experiment has been conducted since 2010 at the "Transport organization" department of the Baltic Fishing Fleet State Academy. Those students who study subjects: "Transport Logistics", "Fleet management", "Port management" and "Methodology of transport processes and systems designing" took part in the experiments. An analysis of experimental results showed that the use of the set of OAG and simulation models in the training process allows to improve significantly the quality of specialists' preparedness.

Keywords: professional analytical competence, game experiments, simulation models, designing games, quality of specialists' preparedness

1. Introduction

One of the key limiting factors of the problem of improvement of the efficiency and safety of the maritime transport is the level of the personnel professionalism. The relevance of the problem is emphasized in some papers published in proceedings of various conferences carried out by such international societies as International Association of Maritime Universities (IAMU), International Association of Maritime Lecturers (IMLA), International Association of Engineering Pedagogy (IGIP), etc. [1,2,3,4,5]. Many documents (Conventions, Codes, International Standards, Recommendations, Circular letters) of the International Maritime Organization (IMO) are devoted to these problems. Even the IMO slogan sums up its objectives: "safe, secure and efficient shipping on clean oceans". The important document which is called "A concept of a Sustainable Maritime Transportation System (SMTS)" was presented at the World Maritime Day in 2013 [6]. According to the concept, the maritime transport exists in conjunction with the many shore-side infrastructures, services and personnel for cargo handling and delivery and for the financial and support services essential to maintain an efficient i.e. cost effective, reliable and seamless operation. SMTS is a vital link in an international logistics chain, moving cargo across the world at the service of global trade, economic development and growth. By the same token, all actors in the chain are equally essential for SMTS to work cohesively. The concept pays the special attention to education and training in maritime professions and support for seafarers. The document emphasizes that SMTS will require training, education and capacity-building of maritime professionals for the broader system including engineers, lawyers, port personnel, ship managers and senior policy administrators. SMTS requires properly trained and educated seafarers.

Results of the above mentioned problem' analysis show that there are contradictions between the growing volume of information, improvement of technique and technologies, the level of knowledge required for effective professional activity and limited possibilities to develop and update this knowledge within the period of study at a higher institution [7].

Business and simulation games are used for a long time in a training practice [8,9,10,11]. But most of games are focused on the development of skills and abilities for standard professional tasks solutions. Scenarios of such games are usually premeditated to a strict algorithm. In fact, they are a kind of professional training. A lot of simulators have now developed in the maritime industry in order to train practice skills of specific professional activities. The term "gamification" uses now as an educational tool for the maritime industry [12]. The maritime community is well accustomed to simulation as a feature of Maritime Education and Training (MET) and would recognize full mission simulators for competency training and assessment. But would it recognize a "serious game", perhaps played out on the decks of a virtual ship as simulator training? Or would it associate full mission simulation with serious gaming which, as noted above, is about the creating an environment in which to develop specific knowledge or skills? [2].

But to find solutions in unusual situations specialists with well-developed systems thinking are needed. They should be able to analyze such situations that requires to use knowledge in various subjects and to find solutions that do not have (in most cases) prototypes or samples. Therefore the analytical competence of specialists is considered as a basic one. Training such kind of competence it is possible significantly increase the effectiveness of specialists' preparedness and development of professionalism in the field of maritime transport.

The analysis of the current practice of specialists' training in the field of maritime transport [1,4] enabled to draw the following conclusions:

- the main attention is paid to studying disciplines of the professional cycle during the training process, i.e. to develop professional competences;
- the contradiction between the need to integrate knowledge in different disciplines and the differentiation of the teaching of the subject knowledge within each disciplines taking into account the final goals of education at a higher institution;
- insufficient level of knowledge and skills in configuration of interdisciplinary knowledge in order to analyze problems and solving complex tasks (e.g. in the field of transport logistics);
- due attention is not paid to the analytical competence formation, which is a necessary condition for the development of skills to analyze and solve complex production tasks;
- a significant obstacle for development of the maritime specialists' analytical competence is the lack of methodological training in the integration of interdisciplinary knowledge for the analysis of production situations and solving non-standard tasks.

It was hypothesized that the use of the set of business games and simulation models during training will significantly improve the quality / level of formation and development of the analytical competence and development of professionalism of specialists in the field of maritime transport. To test this hypothesis we have developed such a set which is focused on developing skills and abilities to analyze and solve complex situations / problems (e.g. designing transport and logistics systems without prototypes, optimization of design solutions, risk assessment, etc.).

2. A gaming technology approach

2.1 A practice of business games

In this context the issues related to the development and implementation of innovation methods and models of formation of analytical competence of specialists in a learning process, both at higher institutions and in the system of continued professional education, become quite relevant [7].

For a long period authors have been carrying out studies to assess the effectiveness of "gaming technologies" in the process of training and improvement qualification of maritime professionals [4].

In particular, business games were used for training specialists in the field of maritime transport. A content of such games was oriented on actualization of professional knowledge during the study of some subjects such as "Transport logistics", "Fleet management" and "Port management".

The main objective of the games was the development of algorithms for the solution of logically related local tasks and communication links between participants of the game.

Such an approach gave positive results in terms of learning techniques and technologies of solutions of standard situations and tasks. However, students had serious difficulties when solving the complex situations and tasks.

In particular, participants were asked to respond to several theoretical test questions in the fields of theory of ships, cargo transportation, fleet management, etc. Test results showed that they answered all the questions. Further, the participants were offered a complicated task which is quite rare in practice. A wrong solution in this case can lead to negative outcomes (accidents, cargo losses, loss of the ship). Unfortunately, only five participants (from three groups of 25 people) coped with the task. Obviously, these participants had a higher level of professional training and personal analytical skills, i.e. they had the so-called "quick mind". The paradoxical nature of this result is that for the analysis of the suggested situation and finding the correct solution of the task was enough knowledge that students have shown during testing.

This example and other results of the educational technologies evaluation have shown that the main reason of difficulties in analyzing complex situations and solving non-standard problems are disadvantages of methodological training and the development of analytical competence both of students and of specialists.

The other conclusion is that gaming technologies in the learning process are effective for updating knowledge and skills for solutions of professional standard tasks. At the same time it is necessary to develop business and imitating games with a target set for the development of systematic thinking and formation of analytical competence. Also development of professionalism is the actual goal of training.

Results of such organization - activity games (OAG) have shown their high efficiency. However, there are difficulties of such games using at the university (academy) due to time constraints in the curriculum. At the same time the use of OAG in the system of advanced training and continued education is a necessary part of the learning process.

Integrated Professional Business Games (IPBG) and OAG are among the most effective methods of formation students' and professionals' skills to integrate interdisciplinary knowledge in order to solve complex professional tasks and to develop their systems thinking.

IPBG can be considered as an integrating course and a method of intensifying actualization of knowledge. Results of such games are: the analytical competence formation; the effective method of developing professional competence and the practical experience to solve the complex, unusual situations; a method of testing and evaluating the professional competence of specialists.

The Baltic Fishing Fleet State Academy (BFFSA) trains specialists within the speciality "Organization and management of maritime transport".

The project approach and methods of game simulating experiments described above are the basis for organizing the process of the students' professional analytical competence development [4].

2.2 The set of integrated professional business games

The set of Integrated Professional Business Games (IPBG) and OAG was worked out for this purpose by authors of the paper. Such a set is based on OAG, simulation models and designing games.

Elements of the set are logically correlated in time and space and include interdisciplinary links. It means that every game has integrating character covering all the processes related to maritime transportations. It requires the use of knowledge in many special disciplines. The set orients for both the development of analytical competence and the development of the professional preparedness in general.

The goal of IPBG is development of analytic preparedness of students to solve the complex tasks in the field of transport organization and management.

Short contents of games included in the set are given below:

1) OAG "Analysis of problems of the regional transport complex development" is oriented on the development of systems thinking and studying methods of a problems' analysis. The game scenario includes the following stages:

- goals statement and game set; self-organizing game groups of participants;
- work in groups, i.e. a situation analysis, identifying and formulating problems, structuring problems and their analysis, etc.;

- elaborating the programme of the regional transport system development;
- group reports and discussions;
- summing up the game and preparing recommendations for postgame activities of students and professionals.

2) Simulation models "Forecasting probabilistic estimates of the state of the transport system", "Organization and evaluation of the port terminal activity", "Evaluation of the investments effectiveness in strategic planning" are oriented on the development of skills of analytical works. These models have been successfully used to study the behavior of transport systems in terms of a change of probabilistic parameters and factors affecting the functioning and development of the system;

3) The business game "Designing Transport and Logistics Systems (TLS) of goods delivery" is carried out with the purpose to give students practical skills of interdisciplinary knowledge integration to solve integrated design problems, to develop skills of an analysis and design solutions optimization. Figure 1 shows a block diagram of the game.

First stages are traditional for business games, but stages 2.7 – 2.18 have specific transport-logistic contents.

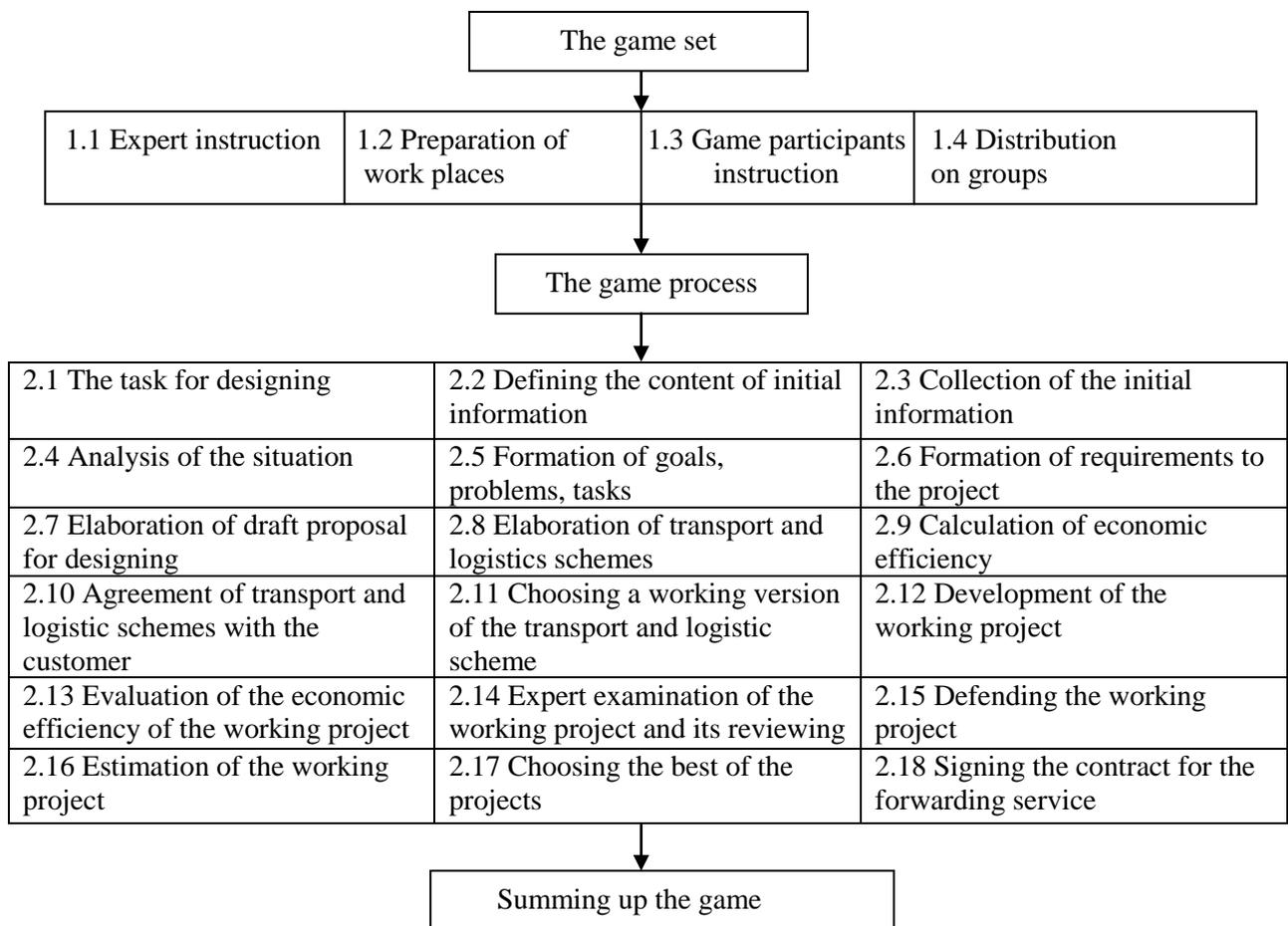


Figure 1 Structure of the business game "Designing Transport and Logistics Systems (TLS) of goods delivery"

4) Integrated business game "Development of Transport and Production Logistics System (TPLS)". This game was work out by authors taking into account the special field of training in BFFSA. The game is based on a simulation model of the fishing and fish-processing system.

2.3 The simulation model

This model simulates the following processes:

- transportation fish/bioresources from fishery grounds to the port;
- unloading and warehousing cargo in port refrigerators;
- delivering fish/bioresources to the processing plant;
- warehousing and storage of raw materials stocks;
- production of fish products;
- warehousing and storage of finished products;
- shipment and delivery of finished products to the domestic and foreign markets.

The structure of this simulation model is presented in Table 1. The production processes which will be simulated are considered at each stage of the structure and appropriate simulation methods are suggested.

The integrated simulation model includes several modules interconnected between themselves and the external environment. Modules are designed on the principle of community processes.

These modules: transportation; production; storage and stocks management; sale and delivery of products to consumers; information and analytical support for the design and management of transportations and basic tasks that have to be solved are presented in Table 2.

Volumes of raw materials transportations and production of fish products shipments to the domestic and foreign markets; the capacity of technological lines and cargo handling are considered as the controlled variables in the simulating model. Probabilistic estimates of the products demand, the impact on the transport processes of natural factors, probabilistic assessment of failures of vehicles and technological lines are considered in the model as uncontrolled variables.

Table 1 Structure of the simulation model of transportation and production systems and methods of the processes simulation

Stages	Simulated processes	Methods of the processes simulation
1	Transportation of raw materials from fishing grounds to the port.	Mathematical methods and heuristic techniques of the types of ships and routes selecting.
2	Unloading and storage of raw materials at the port	Technological schemes of cargo unloading and storage.
3	Transportation of raw materials to processing plant	Mathematical methods and heuristic techniques of determining the rational delivery routes.
4	Warehousing and storage of raw materials stocks at the plant.	Warehousing technological schemes of finished products. Technological conditions of products storage. Optimizing stocks.
5	Production of fish products.	Methods of optimization of production plan.
6	Warehousing and storage of finished products.	Technological schemes of warehousing finished products. Technological conditions of products storage. Stocks management.
7	Shipping and delivering products to the domestic market.	Methods of optimization of routes delivery of products to consumers.
8	Shipping and delivering products to the foreign market.	Designing transport and logistics systems of products delivery.
9	Paper work.	Information technologies.

Development of the simulation models for various activities of specialists in the field of the transport organization is the quite complex and time-taking task.

In this regard, it is considered two main approaches to the creation of practice-oriented simulation models:

Table 2 Simulating modules and basic tasks

№	Module	Basic tasks
1	Transportation	Optimization of ships types selection; Optimization of transport routes; Optimization of loading and unloading; Minimization of transport costs; Risk minimization.
2	Production	Forecasting the demand and proposals on the products market; Optimization of production plan (e.g. fish production); Calculation of the need for raw materials, technological and other kinds of supply; Production quality management.
3	Storage and stocks management	Optimization of products warehousing; Stocks management of raw materials and finished products; Quality control.
4	Sales and delivery of products to consumers	Concluding contracts for products delivery; Selecting transport modes and optimization of supply routes; Minimization of transport costs; Designing TLS of products supply to the external market.
5	Informational - analytical support of designing and management of transportations.	Monitoring market, transportation and production; Forecasting the demand for transport services and products; Solution of optimization tasks given by customers (transport, production, warehousing, sales and delivery of products); Formation of databases; Conducting research.

1) a method of scenarios with reference to computer programs for tasks solving that can be formalized;
2) designing an automated system transport and production logistics systems, which may be used as the simulation model.

In the case of the first approach it becomes possible to create a simulation model and then to use it in the training process. All the modules are sequentially checked by the practice, a material (positive results, shortcomings, guidelines, etc.) is accumulated for analyzing the content of the module structure and methods of conducting gaming simulations. The results of such analysis will be useful when creating an automated system/imitating model.

The simulation model and some its modules are used in the training process to study such subjects as "Transport logistics", "Port management", "Fleet management", "Design methodology of transport processes and systems". Monitoring the effectiveness of the use of simulation modules in the training specialists in the field of organization of transportations and transport management shows a steady tendency to improve the quality of learning and the ability to apply interdisciplinary knowledge for solving practice-oriented tasks.

2.4 The training experiment

The training experiment was conducted at the department of transport organization with students of the fourth and fifth years. They study above mentioned subjects. Students were divided in two groups: the first is "a control group", the second is "an experimental group". Classes were held on the following methodological schemes:

- 1) students of the first group have to solve tasks by traditional methods (in accordance with the lecture material);
- 2) students of another group carried out gaming simulations using models of the modules:
 - "Transportation of raw materials from the fishing ground to the port",
 - "Unloading and warehousing of raw materials at the port" and
 - "Delivery of raw materials to the processing plant".

An input testing of each subject in both groups was conducted in the beginning of the study. Tests included questions on different subjects, because knowledge of them is needed to successfully solve the practical tasks both students and future professionals. Then each group worked on its program of classes. After completion of the subject "Transport Logistics" study both groups received the task to design a transport and logistics system (TLS) of the goods delivery.

The results of verifying the implementation of the task by students of the 1st (control) group showed:

- the work was carried out without a proper analysis of the situation and factors affecting the transport process;

- the internal logic of the work not clearly expressed;

- routes optimization, a choice of transport means and technologies of cargo processing at ports have not been conducted;

- alternatives TLS were considered perfunctory;

- an influence of risk factors was not taken into account.

The results of the work of the (experimental) group that used the simulation modules have shown:

- the task was fulfilled almost twice as fast the 1st group;

- students performed an analysis of the situation and formulated goals and optimization tasks;

- TLS of goods delivery was developed and several alternatives with optimizing design solutions were considered;

- the project was examined on the steadiness when the values of controlled variables are changed and the influence of random factors.

The training process for students who have studied subjects "Fleet management", "Port management" and "Design methodology of transport processes and systems" was the same, but the composition of the solvable tasks was changed.

Solutions of tasks in the "control" group were made on specific examples.

In the "experimental" group using simulation modules, the statement of the general problem was initially formulated. Then an analysis of the situation was performed, "problems of bottlenecks" were defined, goals and structure of tasks including optimization ones were formulated.

Further the plan of the game simulation experiment and designing TLS were developed.

During the game simulation experiments the main attention was focused on optimizing the design solutions and the research of "behavior" of the system when changing the inputs, controlled and random variables, on the analysis of risk factors and their minimization.

The final estimation of this students' practice-oriented work made by consideration of the course projects on the above mentioned subjects. The experiment is carried out since 2010. Comparative assessments of the level of students grounding are: "experimental" groups – 5.0 (excellent); "control" groups - 3.3 (a bit more than satisfactory). Thus, the use of integrated business games in training gives a possibility to develop analytical competence of participants in the experimental groups and their readiness to solve complex practical problems. There was no such effect in the control groups.

The analysis of the experimental results showed that the use of simulation models and integrated business games in the training process allows, ceteris paribus, to improve significantly the quality of specialists grounding.

Conclusion

1. Using the traditional approach to classes' organization students who solve particular tasks get only "samples" of knowledge, abilities and skills. It does not develop enough the analytical component of knowledge. Students do not know how to configure their knowledge and skills to solve complex problems of organization of transportations, as well as problems related to the analysis and research of problems of the transport management.

2. Elaborating simulating models and integrated business games and their implementation in the practice of specialists' training allows to solve such important tasks as:

- development of analytical abilities of students / professionals and their preparedness to make the analysis of complex systems and problems of the transport processes management;

- development of skills for designing transport processes and systems, optimization of design solutions;

- formation of skills for research of "behavior" of the system in the changing conditions.
- 3. Using simulation models in the design of transport and production systems allows to optimize many decisions and to improve the quality of projects.
- 4. Methods of simulation models and integrated business games in training processes can be successfully implemented in the advanced qualifications and the distance education systems.

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