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Implementing Interdisciplinary Education through Virtual Environment for Design and Professional Tasks

Gubkin Russian State University of Oil and Gas
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Adherence to the standards of the worldwide "CDIO initiatives" guarantees the shift to the activity-based training and interdisciplinarity. The present article presents the experience in implementing virtual engineering environment in High Engineering School, which meets the requirements of activity-based training. The virtual engineering environment is regarded as a system of interconnected computer workstations for the team made up of different petroleum specialists and a set of digital models of objects and technological tools.

Key words: virtual environment of professional activities, interdisciplinary training, method case-study, a simulator for the specialist, CDIO.

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The achievements of IT industry have drastically changed the way people handle all kinds of activities including educational process. New achievements continually contribute to this process. Traditionally, higher engineering education is regarded as a means of getting theoretical knowledge in university classrooms, laboratories, and libraries, while professional skills and experience are acquired by performing various practical activities and projects stated in the current curricula and by participating in internship programs which allow students to work at companies, particularly at Technology, Research and Development, Engineering and Administrative divisions. In Russia, student internship programs are usually initiated by the universities themselves, however, it is getting harder and harder to create effective internship opportunities for the growing numbers of students in the context of the market-driven economy and the absence of relevant statutory regulations for private companies. In Europe and the United States, the main responsibility for gaining experience and corresponding professional skills lies on the shoulders of students who usually try to find summer employment with the help of special university services.

Gubkin Russian State University of Oil and Gas (it is basically, Polytechnic University training of specialists for petroleum industries) is the first university to have started implementing virtual engineering environment which recreate workplace experience and project activities within the walls of the university [1]. This virtual environment is a system of computer workstation-

Fig. 1. High-tech Centers of Gubkin Russian State University of Oil and Gas (upper left – FDCC, upper right – control desk of FDCC, lower left – OGPTOC, lower right – Virtual Refinery).

simulators connected by high-speed network and imitated the operations of various specialists working in different subdivisions of the companies in the oil and gas sector: oil-production enterprise (oil field), refinery, underground storage facilities. In the case of oil field, workstations-simulators imitate the operations of such specialists as oilfield geologist, well-log analyst, well driller, production engineers, technician, power engineer, chemist engineer. Each of these simulators, on the one hand, allows imitating specialist's work, i.e. monitoring real technological complexes which are represented in virtual environment by corresponding digital models, however, on the other hand, the simulator provides the possibility to connect with the main server, use its data bases, interact with colleagues, team members and leaders. To be more precise, the simulators allow students to receive and transmit technical data, instructions, orders and etc. The situation center which is an analogue to the well-known spaceflight control center is a network core which connects all the laboratories equipped with the workstation-simulators.

Today, there are three state-of-the-art situation centers at Gubkin Russian State University of Oil and Gas: Field Development Control Center (FDCC), Center for Monitoring and Control in Refinery Process (Virtual Refinery), Oil and Gas Production and Transport Operations Center (OGPTOC) (Fig.1).

These virtual environments and related technologies allow students to study in a number of innovative ways: on-line imitation of project activity (students work as specialists of the corresponding divisions of the project company in the laboratories equipped with simulation units); on-line imitation of production operation (students work as specialists of the oil and gas production company or refinery).

One of the key issues of virtual engineering environment design and implementation is the development of digital models of the study objects - oil-bearing formation, wells, downhole equipment, and etc. To address this issue, professional software products provided by worldwide companies Schlumberger,

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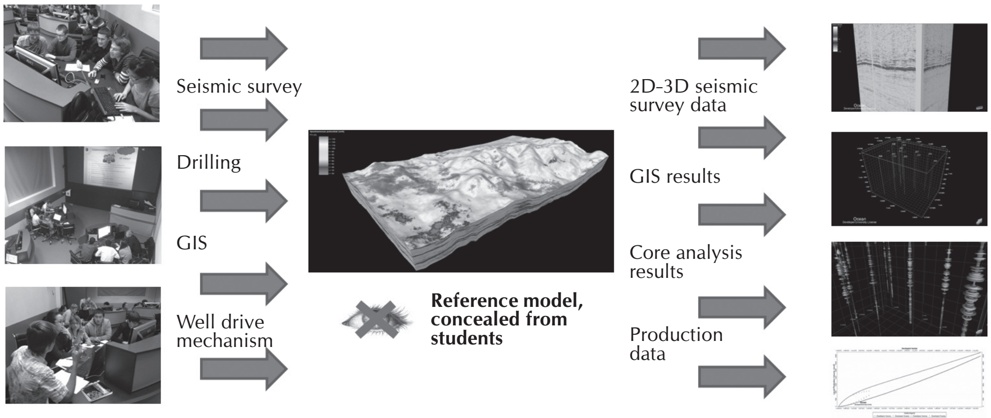
Fig.2. Performance Capabilities of Software Simulation Complex "Virtual Reservoir".



Roxar, Landmark, Honeywell, etc., potential employers of the university's graduates, are applied. To date, Gubkin Russian State University of Oil and Gas has set up cooperative relationships with the leading service companies which participate actively in developing and implementing simulator complexes imitated the processes of oil and gas field development, hydrocarbon transport and processing.

The most vivid example of such innovative solutions in developing computer simulations is the software simulation complex "Virtual Reservoir" developed in cooperation with Schlumberger. It is a rather complicated data entity which allows imitating reservoir response toward computational activity that corresponds to the real reservoir stimulations or realistic reservoir modelling carried out during oil and gas field exploration and development, i.e. seismic survey, core sample analysis, well logging and hydrocarbon production [2].

The proposed computer simulation complex is incorporated into the educational process through the interdisciplinary project intended for the Master and four-year students. The project has implications across disciplines and with learners having different background knowledge that enables to make up interdisciplinary students teams, each of which represents a certain company or organization aimed at effective hydrocarbon field development due to the optimal solutions in reservoir properties study, production well drilling and hydrocarbon recovery (Fig.2). The economic indicators of project implementation are automatically calculated in accordance with the cost of the arranged activities and the price of the extracting hydrocarbons.

This virtual engineering environment enables to implement the standards of the worldwide "CDIO initiative" which is based on the principle that the model of the entire product lifecycle, i.e. "Conceiving-Designing-Implementing-Operating", is the appropriate context for engineering education.

Thus, project activity simulation is introduced as key training courses throughout the curriculum, particularly in 7 and 8 semesters of the education calendar [3, 4]:

- Oil Field Development Modeling in Virtual Engineering Environment;
- Gas Field Development Modeling in Virtual Engineering Environment.

These training courses involve students with different background knowledge and in any major, which allows them to perform the roles of geophysicist, geologist, driller, reservoir engineer, production engineer and economist. It is essential that half of the whole class hours allocated within the curriculum are given over to these training courses aimed to address controversial issues and find appropriate solutions in a teamwork setting.

The main goal of the training courses in Oil and Gas Field Development is to give students experience and a feeling of participating in a big specialist team striving to find the solution for a complicated problem – selecting the most optimal field development scenario. The general concept of these courses is based on the corresponding reservoir engineering regulations and procedures which are under the legislation of the Russian Federation.

Involvement into the interdisciplinary project allows students, having different background knowledge, to explore the entire cycle of the technological operations included in the field development starting from well logging and reservoir modeling and ending with the calculation of development parameters and economic analysis (Fig.3).

At the end of the course students must defend their projects before the relevant evaluating committee under the same conditions and regulations which are established by the corresponding government bodies of the Russian Federation in relation to the defense of the reservoir management plan.

The proposed virtual environment is implemented by means of a "case-study" method within interdisciplinary setting.

Application of the "case-study" method in combination with the interdisciplinary approach within high engineering education is regarded by the authors of the article as a crucial and relevant task based on the following reasons:

- absence or inadequacy of the current conditions for introducing practice-oriented courses into the education programs offered at Russian universities;
- need to develop in future specialist, bachelor or master the ability to respond adequately to various standard and emergency situations;
- need to develop the ability to work in a team setting;
- need to provide a student with the deep understanding of his/her role in the technological process and responsibility that must be assumed for the decision being made.

The interdisciplinary training course "Oil Field Operations Management" designed for the first-year Master students pursuing degree in Geophysics and Petroleum Geology, Oil and Gas Field Development, Machinery and

Fig. 3. Full Cycle of Technological Operations Involved in Educational Process.

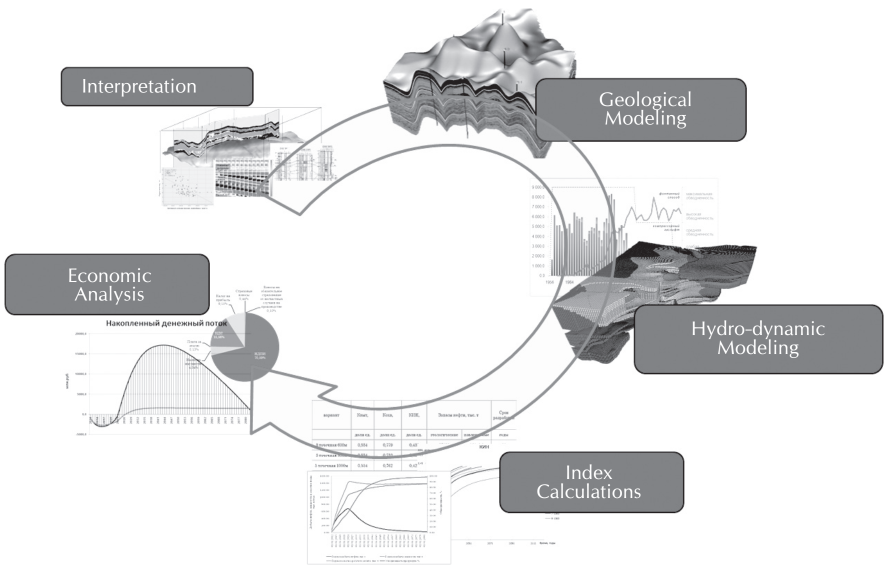


Fig. 4. Master Students Work as Staff-Members of Oil and Gas Production (FDCC).

Equipment, Economics and Managements is the best example of implementing "case-study' method in the learning process of Gubkin Russian State University of Oil and Gas [4].

The content of each class (case) contains the problems which can occur in the day-to-day realities of managing the oil field development and which can be solved not only by deep insight into the real setting, but also by making adequate and immediate decisions.

The fundamental aim of the proposed system of teaching is to provide students with the experience of team work when it is necessary to be able to analyze the problem from different perspectives, discuss the intermediate results and make the decisions within strict time constraints (4 classroom hours).

Depending on the engineering task, the student teams can be built up in the two following ways:

- 1 –based on the interdisciplinary principle, i.e. each team is comprised of 5 Master students having different background knowledge.
- 2 –based on the professional principle, i.e. each team is made up of the students in the same Master program.

Each of these ways defines the further class plan. The first variant allows imitating the operation of five competing oil production or service companies, which, in its turn, instills the sense of competition into the educational process. The second variant imitates the operation of different subdivisions of an oil production company, which helps to train teamwork skills in the corresponding divisions of the company (Fig.4).

Each team has one member designated as a team leader (company executive or head of the division) whose main task is to distribute the responsibilities according to the assigned task.

The content of each case contains the following sections: engineering situation outline; engineering situation analysis; presentation and discussion of the results; making one or several grounded decisions; evaluation of the obtained results (Fig. 5).

Each engineering or project task is set up in such a way that it is impossible for students to solve it working independently because of the differences in the initial data and the necessity to apply special software and interdisciplinary discussion.

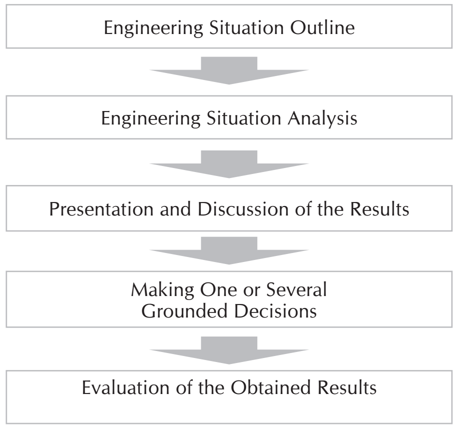
For example, the class is devoted to the analysis of a definite problem that has occurred in the oilfield, precisely, a rapid water encroachment. Each member of the team has equal access to all initial data and together they are trying to identify the reason for the occurred problem based on their knowledge, professional and teamwork skills.

Depending on the reason revealed, it is required to recommend the corresponding plan of actions aimed at enhancing production and improving lift efficiency. To elaborate the optimal plan of actions, students carry out the economic efficiency assessment. At the end of the lesson, student teams present their projects, defend their results and justify the decisions.

The result evaluation criteria applied to the students' projects include: relevance of made decisions, definite economic benefit from the proposed solution; team activity and commitment.

In conclusion, it can be stated that Gubkin Russian State University for Oil and Gas has developed and successfully implemented in the learning process an innovative teaching environment composed of a set of workstations, simulators and Situation Centers interconnected through the local network. This virtual environment allows students to simulate the work setting in order to enable them to experience those professional skills which would be required for future engineering activity, social interaction, team and independent work.

Fig. 5. Case Content.



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