Big data in oil and gas industry. A new project base learning technique for students

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Abstract—The oil-gas and energy industry (extraction, processing, and supply of fossil and renewable resources), requires the processing of thousands of process data in short times (pressure, volume, flow, position, speed, concentration). In the context of the need to increase energy security, safety in operation and especially the obligation to ensure safe control (not affected by cyber wars), the understanding and use of artificial intelligence by students (in the management of technological processes) requires the modification of learning concepts and professional training. Starting from the increased digital skills of the students, the possibility of using PBL (Project Base Learning) in understanding chemical processes and industrial processing data was created within the technological higher education of the University of Oil and Gas. The method consists of the creation together with student teams of software dedicated to artificial intelligence, for the students to understand their role in the management of technological processes and especially in the design of security in the operation of installations. The teams were formed by the leader, critic, project manager and technologist engineer and each team described a technological installation and the problems that may arise. Thus, at the end of the semester, each team presented a security plan and economic operation of the facility, as well as the software created for this purpose. This paper presents a PBL technique in Oil and Gas University and the role of this project activity in learning engineering studies.

Keywords—PBL (Project Base Learning), oil and gas, energy, bigdata, neuronal modelling, control process, industry automation.

I. Introduction

FROM the beginning of the use of industrial plants in people's lives, they noticed that their work would be reduced if they analyzed some production data collected and then applied some techniques of automatic control of technological processes as a result of selecting, processing and processing data, collected.

If we analyze the management of technological processes in the energy industry, we will notice that like other industries, there are four levels of automatic control:

a. Manual control of the installations, where the operators receive the measurement data of the processes in the installation and especially of the quality of the final products (process temperature and constituents, their volume, concentration and density of the final products and those in the reactors, etc.), analyzes and modifies the status of the control valves (following the analysis of an operation manual), in order to bring the process within the predetermined operating limits, [1].

b. Identification of the maximum and minimum levels of the process properties of the products in the reactors and of the operating parameters and their signaling in the process. When these values are reached, the automatic system signals and usually restores the optimal state of the process by automatically modifying the valves and the techniques for regulating the technological process.

c. Control of the damage states of the installations, which consists in securing the system by opening some safety valves, transferring the gases to the flare, replacing the fluids from the steam installations, opening some safety valves.

d. Securing the system in case of catastrophe, fire or chemical or industrial accident. This state of control of the installation consists in stopping the supply of combustible gases and electricity, closing the safety valves of the installations, putting them in a state of preservation and operating the advanced protection systems of technological processes (putting into operation of fire extinguishing systems, securing the installations by flooding them with steam, protecting the employees by creating under pressures in the control rooms).

But all these levels of automation, take place after the analysis of large amounts of data (process temperature and constituents, concentration of final products and fluids in reactors, their volume and density, etc.).

The data taken by the translators from the heart of the process (following the contact between the process and the translators), are taken by a processing unit (processed for interpretation), then used for process management and subsequently stored for use as witness in a subsequent dispute.

So, in the crude oil and gas extraction, processing and treatment industry (like any industry), the data collected from the operational field can be classified into, [2]:

a. Data on the staff working or present in the installation (number of persons, age, qualification, place where they are present at a given time, state of health, level of concentration, etc.),

b. Primary process data (analysis of final product quality and constituents),

c. Data on the condition of the installation (corrosion level, state of tension of the installation wall, etc.)

d. Data on the evolution of the state of the environment in which the installation is present (air and water temperatures in the work area, the concentration of pollutants, the agitation of the fauna, the evolution of the health of the flora and human populations around the installation, etc.),

e. Data on ensuring the safety of the industrial installation (concentration of hazardous fluids, condition of fire-fighting installations, level of concentration of steam required for insulation and preservation of chemical and industrial installations, etc.),

f. Economic data of the operation of the chemical or industrial process (the level of stocks of final products and constituents, the number of products sold or delivered, the level of bank interest and the need for money for the operation of the installation, etc.),

g. Useful data in the control of the installation by the authorities and the population (state of the installation and level of pollutants).

This level of data, collected from the process at an interval usually of 3-5 seconds, must be processed by:

-Data analysis and elimination of absurd values (which may not be present in the operation of the process),

-Integration of values to reach an average of them,

-Their analysis of the maximum and minimum values prescribed by the operation of the installation,

-Operation of valves and process automation tools through a proportional-integrative-derivative regulation process, in order to restore its operation in optimal parameters,

-Data storage.

In preparing students to understand the process of data collection and automatic control of chemical plants, usually, teachers present the processes of automation of chemical plants (due to insufficient hours) and less on the analysis of data in a chemical plant (part of technological process of extraction, transport and processing of crude oil and natural gas).

II. History learning

People have always wanted to reduce their physical activity, and that's why they invented methods to automate technological processes.

The university prepared for the young people (to working in the oil and gas industry) first course in technological process automation as early for 1955, [3].

The teaching of this subject was done according to the Soviet model (that is, the student's mind is eager to acquire information, and that is why they need to learn the course and laboratory work).

At the beginning of the teaching presented of this course, the equipment for local monitoring of pressures, temperatures and flow rates of petroleum fluids. Also was presenting the mathematical equations of data transfer.

After 1970, when the control of technological processes required, in addition to the visualization of the data, the automatic handling of the devices control, chapters on optimization of technological processes, modeling of installations with the help of Fortran software and elements of data processing have also been introduced in automation books and courses.

The courses were updated according to textbooks taken from American universities (where after 1970 Romania sent professors for specialization).

After 1990, the courses were updated at a rapid pace, depending on the introduction of automatic control and remote data transmission techniques.

At that time, the teaching techniques of the course were based on the American system of learning (we have to provide the students with the data necessary for them to manage in the search for information).

The emergence of the Internet and especially the transmission of massive blocks of data that had to be processed, operated and used for the purpose of industrial process control, led to the modification of the structure of industrial process automation courses and the renaming in the modeling and control of technological processes.

Thus, in this course the students were taught to recognize the local apparatus for detecting and indicating the physics-chemical properties of the raw material and intermediate and final products, as well as the operating data of the installation.

New chapters dedicated to data acquisition, processing and storage have also been introduced.

A special chapter was introduced to understand remote data transmission, protocols and automatic plant operation in operating parameters.

Accidents in the oil and gas industry and in the chemical industry led to teaching to the young students about to the elements of security and automatic control of petrochemical processes, emphasizing the security of human activity and the protection of the environment.

In the context of an increasing struggle to reduce the carbon footprint of industrial technological processes in the oil and gas industry, technological engineering must move to a new dimension, namely the engineering of the processing of fossil and renewable resources.

Thus, it is necessary that the new courses be dedicated to the use of energy from natural gas deposits, the creation of new technologies that use geothermal, wind and solar energy, the production of hydrogen and its use both locally (for energy compensation) and as a mixture in gases natural (up to 30% hydrogen in distribution networks).

Also needed is the understanding and automatic control of carbon dioxide injection processes in depleted oil and gas fields, natural gas storage processes in salt and abandoned gas fields, and biogas production, treatment and use.

During this time (when jobs in the oil and gas industry are decreasing), the focus of industrial process automatic control courses must be based on using the concepts of learning by example and predictive learning, providing the student with the information they need needed at the time of teaching the course.

At this moment the course is dedicated to the processing, control and engineering of technological processes from the need to use fossil energy in the transition to green energy.

Data on the equipment for taking over the quality of technological processes, their processing, transfer and storage as well as local automatic control (Process Local Control) and remote operation are also presented in a few hours of the course.

The levels of operation of chemical and petroleum facilities are described, starting from level I (local operation), level II of maximum and minimum (warning and automatic operation) and the level of danger with the intervention of the facility's security equipment.

It is also recommended to teach technological process management techniques and transfer them to software written in Python.

III. Big data in the oil, gas, and energy industry

Big data in the Oil, Gas, and Energy industry consists of the collection, processing, local and remote transmission and storage of millions of parameter readings.

It should be noted that in a refinery about 10,000 readings are collected every 3 seconds, and in an oil field for extraction and transport about 100,000 readings every 1.5 seconds, [3].

An example is the reading, processing and storage of data from the National Crude Oil Transportation System in Romania, where 5,000,000 data (files) were stored in 5 years of activity of the read data processing system.

Thus, the following data were read and processed:

- Pressures and temperatures on the transport pipelines (more than 1200 km from the pipeline),
- Vibrations of pipes and motors,
- Engine temperatures (10 readings every 1.5 seconds per engine),
- Parameters of drive systems (consumed electric current, absorbed power, etc.).

However, these millions of data are usually processed only to detect the maximum and minimum permissible values.

The processed data are not used in order to predict the production, to establish the costs in real time and especially to make a forecast.

That is precisely why students need to know these processing techniques and especially to build equations and software for predicting industrial activity.

IV. Project based learning

The concept of Project-based learning (PBL) was implemented by John Dewey starting in 1897, [4].

The basic idea of the project-based learning concept was the existence of the teacher in the school as a member of the community and not as the one who imposes his ideas. Through this concept, credit is given to learning through projects, that is, through the development of didactic skills through the discovery of not imposed but suggested issues.

In the [4], continued the application of the method, considering that learning should not focus on memorization.

In his theory, project-based learning is considered as a method that engages students to invent and view learning as a process of professional development and not as a mechanical acquisition of knowledge bases, [5].

The project-based learning technique was later developed by Jan Comenius, Johann Heinrich Pestalozzi and Maria Montessori, [5].

In 2011, Thomas Markham best defined the concept of project-based learning (PBL), a technique based on knowledge, understanding and action.

The PBL learning technique has as its objective the production of collaborative projects, which ensure the students' orientation towards experience and not the compulsory curriculum, [6].

Learning through projects is similar from a pedagogical point of view to the classical exposition, the emphasis being on search and conviction, the teacher in this case being the one responsible for formulating the questions and the essential tasks, the student being dedicated to his own research in the activities carried out in the project.

So project-based learning turns out to be a technique for involving students in investigating problems that may arise in real life, asking questions and finding answers.

Also in learning through projects, knowledge from several disciplines can be used, with the real role of incorporating them into the chosen topic, students being taught to work in a collective.

There are few studies regarding the organization of teams and especially the distribution of roles in a project.

Usually the teams are chosen based on affinities and some even if the teams are called, there are problems of removing some colleagues or giving up teamwork because the leader does it all, [7].

In the practice of project-based learning, the teacher notifies the assignments and the students seek to develop the projects by copying passages from similar works from the Internet.

Teams are rarely allowed to choose their project topic, as teachers accept known topics and a multidimensional diversity of them would create problems for them to understand them.

V. A NEW CONCEPT IN PROJECT BASED LEARNING

The emergence of artificial intelligence and its application in the oil and gas industry makes it more and more necessary to work as a team and less to choose to be an individual.

This fact is due to the need to process a large amount of data in real time and to make decisions that ensure the profitability of the activity and safety in operation.

In a market disturbed by the transition from fossil fuels to renewable resources, by the tightening of operating licensing conditions from the point of view of environmental protection and quality of life, the oil and gas industry lives its life (if it remains in the current stage of functioning) the last moments, or it can again be a vector of human development, by using fossil resources as a support for the transition to sustainable fuels.

Also, the engineering of exploitation of fossil resources can be used in the discovery of new techniques of processing, treatment and storage of industrial waste, as well as in the discovery, development and use of new sources of renewable energy.

For example, using geothermal energy from oil and gas wells is a good example of using old oil fields.

That is why they are necessary so that students can discern which of the techniques used in oil and gas engineering are used in accordance with the new techniques of using renewable resources.

For this purpose, the use of the project-based learning platform is proposed as a learning technique, but modified according to the new application conditions.

Thus, in this learning platform, work teams formed on active roles are used.

The Base Learning Project consists in creating teams of students, were formed by the leader, critic, project manager and technologist engineer.

Each team were described a technological installation and the problems that may arise.

The role of the teams is to ensure:

- technological and constructive analysis of a chemical or industrial process (chosen by the group of students from those proposed by the teacher),
- studying how it works,
- identification of databases that may arise,
- data processing,
- realization of numerical models necessary for the optimal functioning of the industrial process.

Each group of students consisted of four colleagues chosen as follows:

- in the first stage the groups were made according to the degree of affection of the students,
- after completing the groups, the students received a test to assess their personality and integration into the group,
- depending on the result, the groups have been recalibrated to ensure their functioning,
- the roles of the students in the analysis group: project director or manager (leader), system secretary or integrator (project manager), product manager or sales manager (technologist engineer) and critic or staff using this product.

Each group of students received a project evaluation grid and an evaluation grid of students' roles in the project.

The students also received a framework project for the research topic consisting of:

a. the analysis of the literature specialized in the description of the chosen technological process,
b. estimating the differences between the projects described in the literature and the researched industrial project,
c. determining the level of data required to be collected and the technology for processing them,
d. establishing the level of data retrieval and processing and numerical modeling of the technological process,
e. submission of the project for analysis to the tutor in the analyzed chemical installation,
f. presenting this project to colleagues and teachers,
g. correcting the project according to the suggestions of teachers and colleagues,
h. dissemination of results through the publication of articles and the presentation of scientific papers at some student scientific conferences.

Each team chose a name and slogan to achieve unity in research and analysis.

Students former three study class (and Groups):

Class 1. (16 students-4 teams)

Optimal operation of the technological installation

Four installations from the refinery were analyzed.

Students' teams are analyzing atmospheric distillation installation, catalytic cracking installation, catalytic reforming installation, blending finished products and supply process.

Class 2. (16 students-*4 teams*)

The future of the oil and gas industry

The themes of the second class and the 4 teams were dedicated to:

- Analysis of the implications of reducing greenhouse gases on oil plants (reduction of oil losses and environmental impact),
- Impact on employees the emergence of green cars,
- Use of new technologies in technological processes (green H_2)
- CO_2 storage and, chemical reduction.

Class 3. (16 students)

Neuronal data network in Python Modeling

The established teams analyzed:

- The use of neural networks in the transport and distribution of natural gas,
- Ensuring development models through the use of Artificial Intelligence,

- Use Python software to write code of modeling,
- Use of neuronal data in security and safety of process.

VI. Project description

The teams will work for one semester, (12 weeks) as follows:

a. In the first week, the main aspects of the course and the role of the teams in carrying out this project are presented. Teams are also organized and the choice of topics begins.

b. In the second week, the psychological testing of the students will be carried out and the teams will be regrouped according to affinity, the type of leader, the role that suits each student. The initial research and development data will also be presented for each project proposed by the professor.

c. The third week is dedicated to understanding the roles in the team and the results expected by the professor. At the same time, the forms that must be completed in order to ensure a proper grading, both for the team and for each student, will be presented.

d. The next four weeks are used in covering each topic with theoretical data (presented at the beginning of each class by the professor) and the practical aspects of the projects (researched by the students).

e. For two weeks students will be in technological practice, visiting facilities that may be part of their projects and talking with field managers about new facilities proposed by the project. At the same time, they will ensure the technological design and optimization of the installation chosen to respond to the project.

f. For the next two weeks, each team will present the project from the point of view of process engineering, feasibility and cost. The team critic will present the strengths and weaknesses of the project as well as its opportunities and constraints.

g. Last week the critics from the three teams will simultaneously present the problems identified in the projects, the teams answering how they are solved.

Within this project, teams are encouraged to publish results in journals indexed in international databases and at student conferences.

Each project is completed with two articles written by the students under the direct supervision of the teacher.

At the end of the course, the teacher together with the team leaders notify each member and provide diplomas for participating in the project.

At the same time, the teacher will present together with specialists from the industry his opinion about the realization of the projects and especially the way of integrating the students into the team and its response to the challenges of the projects.

After finishing this project, we expected:

- Understanding industrial processes,
- Obtaining numerical models to simulate the technological process,
- Analysis of data collected from the project and their processing,
- Understanding the deletion of data that does not impact the process,
- Ensuring good collaboration between students.

VII. Conclusion

In the future, the analysis of databases by PBL methods can be applied in the oil and gas industry to ensure the energetic supply security, all these processes being providers of data necessary to be analyzed, processed and stored.

The use of PBL in understanding chemical processes and processing industrial data is the best teaching method, as it ensures the introduction of the student in the roles of productive employees and in the handling and processing of the properties of the analyzed technological processes.

The specialized analysis of the courses supported by the PBL method led to the conclusion that exceptional results can be obtained in the training of students.

The use of a feedback questionnaire showed that 90% of the students understood the processes supported in the classroom through the presentations and software made.

Also, the software remained the property of the University, being useful for students and teachers.

The fact that a psychological assessment was used regarding the composition of the study groups and subsequently the role of each student in the created team was emphasized, made the understanding of the chosen theme well expressed in the final presentations.

Moreover, for the final presentation of the project, an identical methodology was chosen for each team and consisted of:

a. Presentation of the theme (by the team leader),
b. Analysis of specialized literature (presentation made by the Project Manager),
c. Presentation of the work technology and the resulting products (described by the process engineer);
d. Critical analysis of this project and what are the shortcomings of the team (supported by the critic in the team).

During the presentations, each team asked questions and got answers.

Each team also had a framework score, for each individual project (the scores being entered based on the presentations and answers).

The final results consisted of:

a. Scoring of teammates, for each team member,
b. Grading the teams for the presented projects,
c. The teacher's rating for each member of the team,
d. Teacher grading for each project.

The average obtained was over 8.50, which represents a success in learning technological processes.

The success of a project depends on the sharing of criteria and constraints from the beginning.

Students and teams must know the roles and grading criteria from the start, each being able to choose their degree of fulfillment of the criteria and default grades.

Also, the teams can choose their work pace and especially the understanding of the role of each member within the team.

Opponents of project-based learning are wary of the results, stating that projects are usually not focused on learning but on copying, and lessons are not taught in a traditional classroom format.

Since PBL revolves around the autonomy of the student, his motivation and ability to manage his work time during the realization of the project are the main problems in achieving expected results.

But the balancing of the teams, the staged realization of the project and the psychological analysis of each member of the realized teams, makes these impediments to be successfully removed.

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