Problem oriented teaching in electric power: some experience and new trends in Tasmania and Ukraine

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***Abstract**: The increasing power and availability of software tools used for power system analysis have already changed the way power system subjects are taught and learnt. This paper describes curriculum issues of power systems for third and fourth year power students of the University of Tasmania with an emphasis on problem-oriented teaching. It also introduces issues related to power engineering education in Ukraine. Problem-oriented teaching helps to reach a sound understanding of a broad range of topics in power systems and make the syllabus interesting and attractive to students. The impact of changes in the power industry to the problem of women in engineering is considered.*

***Keywords:** Power Engineering Education, Problem-Oriented Teaching, Computer Applications in Power, Expert System Shell.*

Introduction

The word "problem" has a number of meanings, however problem solving, in general, can be considered as finding the most effective course of action among a number of alternatives. Any condition of a given system is the problem situation when a student experiences intellectual difficulties due to the shortage of information and/or time and cannot achieve a goal applying a familiar technique. It causes a student to seek a new approach to the problem and gives rise to his or her creative mental activities. Therefore, problem-oriented teaching aims to develop the creative mentality and results in more logical and professional thinking (Gibbs and Habeshaw, 1989; Lesgold, 1978). However, any logical mentality should be based on a practical basis. It means that practical skills and knowledge should be considered as a criterion of the human professional mentality (Green, 1991).

It is of vital importance that power students acquire knowledge and hands-on experience to deal with real practical problems in power system operating and planning. They need to learn theory in order to make their own decisions in solving a particular problem.

The aim of the final year power systems course is to instil confidence and understanding of those concepts of power system analysis that are likely to be encountered in the study and practice of electrical power engineering. The approach taken is to develop critical thinking of a student in a broad range of topics in the area of power systems.

The authors have taught a variety of power system courses for students with different backgrounds and experience in electrical engineering. There have been students with extensive experience in computer applications. But there have also been students with little experience with computers. The opportunity of teaching the power systems course to students from such a wide range of exposure to computers has been a learning experience for the authors on how to best introduce students to computer applications in power.

Course Objectives

The primary objective of the final year power system course is to provide students with an opportunity to solve a number of practical problems in power systems. It is only through hands-on experience that students can obtain a real understanding of power systems.

"I hear and I forget,
I see and I remember,
I do and I understand".

This old Chinese proverb can be used as a guide for introducing students to power systems design and operation. First students are introduced to some major concept, such as load flow solutions, followed immediately with a demonstration of power flow studies in a small four-bus power system. When the students have mastered load-flow analysis, they should then perform load flow study on a five-bus power system and find bus voltages and flows of megawatts and megavars. The students are also required to study the system behaviour under different operating conditions and explain results obtained. The style of presentation of the course material which includes lecture, demonstration and actual problem solving gives students an understanding of the basic concepts.

In addition to solving small problems for clarifying power systems concepts, it is extremely important to give the students an opportunity of solving complex practical problems existing in power systems design and operation. This work is included in a course project.

It is not practical to achieve all the objectives described above with a single one-semester course unit. It is necessary to prepare students by giving them a preparatory course in power systems. In the University of Tasmania, this course unit is designated as *Power Systems 1* and is offered in the third year. The second unit, *Power Systems 2*, is offered in the final year. The two units together form the whole body of *Power Systems* for students taking the Power option. In this paper, therefore, both the course units will be described.

Major topics in Power Systems One

This basic course which is compulsory for all Electrical Engineering students is offered in the third year. The topics covered are:

- Revision of AC circuits;
- Per unit quantities;
- Equivalent circuits of power system components;
- Voltage characteristics of loads;
- Control of voltage and reactive power;
- Load flow analysis;
- Symmetrical Fault analysis;

- Safety and protection in industrial power plants;
- Harmonics and Quality of Power Supply;
- Direct Current Transmission.

Major topics in Power Systems Two

In order to achieve the previously discussed objectives, the following major topics are included in the course:

- Asymmetric Fault calculations;
- Admittance and impedance models and network calculations;
- Load-flow solutions;
- Fault calculations using the bus impedance matrix;
- Selection of circuit breakers;
- Economic operation of power systems;
- Power system security;
- Reliability analysis of power systems;
- Intelligent systems applications to power systems.

An important factor in teaching this unit is the use of Expert Systems. A commercially available Expert System software named *Level5 Object* is used by the students to simulate the operations of a power system. For example, students are required to take appropriate actions to improve the voltage profile by adjusting transformer taps, changing generator voltages and switching reactive power compensators. Thus problem-oriented teaching together with the expert system application helps to reach a sound understanding of a broad range of topics in power systems and make the syllabus interesting and attractive to students.

Power engineering education in Ukraine

A decline in the popularity of power engineering education has been observed in Ukraine during the last several years. The main reason for this general decline in the enrolment of power engineering departments is the slowing-down of the power industry sector of the national economy.

The power sector of Ukraine has 50.9 gigawatts (GW) of installed capacity. It is capable of producing twice its electricity needs. Nevertheless, only 163,600 GWh of electricity was produced in the last year. (For comparison, according to published data (The Electricity Supply Association of Australia Limited, 2003), the total electricity generation in Australia last year was about 199,000 Gwh, while power generation plants installed capacity was only 42 GW). Total electricity consumption in Ukraine has reduced from 216,700 GWh in 1992 to 123,300 GWh in 2002. This trend in the power industry has had a significant impact on the labour market. Unemployment among power engineering graduates has increased.

However, Ukraine still plays an important role as a critical transit centre for exports of cheep Russian electricity to European energy markets. Russia inherited a powerful high voltage transmission network from the Soviet Union. The network includes a backbone of 220-750 kV transmission lines with overall length of about 21,700 km and 131 substations with total installed capacity of about 76,785 MVA. However, due to the network's inefficiency, especially in the area of automation, a significant amount of transmitted power is wasted via

line losses and outages. On the other hand, the onrush of communication technology and the latest developments in digital equipment allow us to renew an old-fashioned domestic automation. The world biggest producers of industry-oriented digital and communication equipment, like SIEMENS, ABB, ALSTOM have come to Ukraine recently. They have brought new technology, and with that introduced new prestigious job opportunities for Ukrainian well-educated electrical engineering graduates.

In these conditions, most Electrical Engineering Departments and Schools of Ukrainian universities try to enlarge their educational frames by new courses. In particular, these courses are related to modern digital protection systems, new intelligent electronic devices, communication industry protocols and equipment, new interconnection standards, state of the art computer applications in power systems, Computer-Aided Design (CAD) systems, Internet Protocol (IP) technologies, artificial intelligence methods and tools.

Traditionally most electrical engineers graduates from Ukraine universities in three main specialties: power systems, power plants and power delivery. They have some small differences in the forth and fifth years courses. In order to compare power-engineering programs with University of Tasmania we describe the main courses, which are taught in the most prestigious universities in Ukraine.

Second year courses:
- Chemistry;
- Theoretical mechanics;
- Engineering Drawing;
- Physics;
- Theoretical Principles of Electrical Engineering;
- Higher Mathematics.

Third year courses:
- Fundamentals of Law;
- Industrial Electronics;
- Applied mechanics;
- Power Engineering Mathematics;
- Power Engineering Economics;
- Algorithm Presentation of Power Engineering Problems;
- Power Engineering Installations of Power Stations;
- Electrical Machines;
- Transients in Electrical Systems: Part 1.

Fourth year courses:
- Transients in Electrical Systems: Part 2;
- Programming and Application of Electronic Computers;
- Electrical Systems and Networks;
- Safety Measures;
- Electrotechnical Materials;
- High Voltage Engineering;
- Electrical Instruments and Electrical Measurements;
- Models of Optimising Development of Power Engineering Systems;
- Power Engineering Systems Operation;

- Electrical Part of Station and Substation;
- Electrical Systems and Networks;
- Protective Relays and Automation of Power Engineering Systems;
- Programming and Application of Electronic Computers.

Fifth year courses:

- Principles of Scientific Research and Engineering Creativeness;
- Organisation and Planning of Production. Business Management;
- Student's Scientific Research Work;
- Fundamentals of organisational and educational work on the work Collective;
- Special Questions of Electrical Systems;
- Long Distance Power Transmission;
- Student's Scientific Research Work;
- Optimising Conditions of Power Engineering Systems;
- Automatic Control of Power Engineering Plants;
- Organisation and Planning of Production. Business Management.

Before 1990, the power industry in Ukraine was relatively strong. As a result, many jobs in power engineering were related to the design of new power plants, power substations and transmission networks. This may explain the fact that about half of power engineering students were women. Design-engineers and draftswomen were a popular choice among women at that time. Unfortunately in the last decade, due to the decline in the power industry, the overall demands for such jobs are decreasing. The majority of job opportunities are now related to servicing and supporting existing equipment and mainly are man-oriented.

Conclusions

In the last decade, there has been a general decline in the enrolment of power engineering students both in Australia and Ukraine. Some of the universities have closed their power engineering disciplines. The University of Tasmania has attempted vigorously to beat the slump. To stimulate student interest, problem-oriented teaching has been introduced. An introduction of artificial intelligence on the course has created some additional interest. The course structure geared to problem-oriented teaching should have a positive influence in the turnaround of the existing trend.

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