Measurement and Control of Experimental and Virtual Lab Stands for Improvement of Quality Education

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Annotation

The paper deals with main principles of total quality management (TQM) with application to the area of university education processes, where TQM tools were used in approach to the design of new laboratory education forms by realization of physical lab model hot-air plant (HAP). Stand lab HAP presents function module of air conditioning and it is used on the experimental laboratory education for all study forms, not only on the Faculty of Mechanical Engineering VŠB-TU of Ostrava, but also on other seven technical faculties at Czech Republic. Stand HAP allows to realized by TQM principles all-important tasks connected with: - identification of static and dynamic system and sensors properties, - intuitive even experimental verification of controller synthesis results, - verification of the new control algorithms (fuzzy, neuron, genetic, ...).

Laboratory stand HAP is also used for demonstration of function multilevel control systems in environment of the program support SCADA/MMI on the Web environment (INTERNET/INTRANET). Air condition plant HAP allows to connect the approach with simulation program tools (for instance SIPRO) with physical function model, which is much more similar to real industrial plant with all its function defects (noise, nonlinear properties of sensors and actuators, disturbances, etc.).

1. Introduction

University goal is to produce high-quality graduates who are well prepared to make immediate technical contributions and to help shape the rapid change that characterizes this industry. Meeting this goal requires a "hands-on" teaching approach, in which students have the opportunity to become familiar with industry-standard design tools, processing tools, cleanroom infrastructure & protocol, and metrology & test techniques. These experiences, combined with a sound curriculum in the basic engineering sciences, will give students a distinct advantage in the job marketplace, over graduates of programs who have received a strictly theoretical education.

Fundamental part of university education creates connection of theoretical approaches with experimental or simulation methods for verification of coincidence. Illustration of practical physical (real) models is cardinal importance for engineering experimental exercises, for comparing of the computer simulation tasks with practical experiences and with real-time measured signals from the technological or lab plants. Experimental verification of the theoretical knowledge responds to need for accelerated acquisition and adoption of "best practice" techniques and methods and it increases the quality engineering education by Total Quality Management (TQM) principles. Experimental stands allow easy understanding principles of the real industrial plants parts, measurement and control devices, signals character, noise, dynamic responses and easier crossing to the real technological systems.
TQM involves a set of general principles about the fundamental culture and norms of practice of a working organization dedicated to quality. Many of the educational reforms being implemented today are based on this concept, which has been revolutionizing U.S. business and industry for the past decade. Only recently have leaders in education begun to adopt TQM as an operational philosophy.

"The role of the university in the 21st Century is to transfer technology or ideas out of our labs into the commercial world," says Michael Hooker, president of the University of Massachusetts. [Dion 1995].

One concrete example with real laboratory stand of physical model hot-air plant connected to the different types of microcomputers, PLCs and controllers for measurement and control tasks will be presented with good experiences from the experimental education on the Department of Control Systems and Instrumentation VSB-Technical University of Ostrava.

2. TQM in Education

TQM in education applies at three levels:

1. The lowest level is to the management processes of a school. The main benefit is in improved efficiency and lower cost of administration.
2. The second level is teaching total quality to students. Quality philosophy and methods/tools are covered.
3. The highest level is total quality in learning. This is a learning philosophy supported by a comprehensive tool kit and driven by students and staff in order to identify, analyse, and remove the barriers to learning.

Four pillars of Total Quality Management (TQM), which fill these levels, are:

Principle 1: Synergistic Relationships

In one sense, the student is the teacher's customer, as the recipient of educational services provided for the student's growth and improvement. Viewed in this way, the teacher and the university are suppliers of effective learning tools, environments, and systems to the student, who is the school's primary customer. The university is responsible for providing for the long-term educational welfare of students by teaching them how to learn and communicate in high-quality ways, how to assess quality in their own work and in that of others, and how to invest in their own lifelong and life-wide learning processes by maximizing opportunities for growth in every aspect of daily life. In another sense, the student is also a worker, whose product is essentially his or her own continuous improvement and personal growth.

Principle 2: Continuous Improvement and Self-Evaluation

The second pillar of TQM applied to education is that everyone in the organization must be dedicated to continuous improvement, personally and collectively. One implication of this TQM principle for education involves an increased emphasis on training, research (especially department research) and communication (with students, parents, business leaders, community representatives, and so forth).

Grading systems such as the bell curve result in one student's success at the expense of another student's failure. Many assessment reforms are focusing on "authentic assessment," which many educators believe provides a more accurate representation of a student's learning and abilities. Authentic assessment includes actual examples of students' work presented in portfolios exhibits and student competitions.
Principle 3: A System of Ongoing Processes

The third pillar of TQM applied to education is that the organization must be viewed as a system, and the work people do within the system must be seen as ongoing (continuing) processes. In the new paradigm of learning, continual improvement of learning processes based on learning outcomes replaces the outdated "teach and test" mode. Content area literacy supports this principle by emphasizing an ongoing process for learning that involves setting goals, monitoring progress with respect to those goals, and making changes based on self-evaluation.

Principle 4: Leadership

The fourth TQM principle applied to education is that the success of TQM is the responsibility of top university, faculty and department management. School's leaders set the tone for their school's teaching culture, teachers set the tone for their classroom's learning culture.

Successful implementation of TQM principles requires a great deal of patience, because TQM is not a quick fix. It can take as long as ten years to implement and produce documentable results. TQM represents a system whose rewards begin to emerge when its ideas and practices become so embedded in the culture of the organization (i.e., the day-to-day work of its people and systems).

3. Design and Application of Experimental Real Lab Stands

It has become widely accepted that the computer and numerical control systems are an indispensable tools in the practice of science and engineering, thus, in recent years the science, engineering, and engineering technology education communities have been adopting and adapting the computers as a tool in ever new and innovative ways of teaching and research in science, engineering, and technology. Likewise, the importance of the availability of a variety of computing environments to undergraduate students of science and technology is widely agreed upon.

Basic demands for design and education application of experimental stands for laboratory exercises are [Smutny 1999]:

- Similarity of physical laboratory model with real industrial devices (plants).
- Miniaturization of dimensions, power input, etc.
- Good dynamical responses of output signals (quick reaction, short time constants).
- Unified input and output electrical signals (U = 0-10 V, I = 4-20 mA).
- Good possibility of connection with miscellaneous computers or alternative numerical unit (Programmable Logic Controller - PLC, Industrial PC - IPC, Industrial microcomputer - IMC).
- Availability of model function parts and their reasonable price.
- Easy production in condition of Department Mechanical and electronic workshop.
- Cooperation of students on design and production of laboratory stand (on the subjects, for instance Part project, Final project, Diploma thesis).

Experimental verification of theoretical knowledge responds to need for accelerated acquisition and adoption of "best practice" techniques and methods and it increases the quality engineering education.
4. Experimental Laboratory with Hot-Air Plants

On the Department of Control Systems and Instrumentation of VSB-TU Ostrava were designed and produced a set of laboratory experimental stands, models and education aids [Smutny 1999]. They are utilized for practical exercises in department specialization subjects, mainly connected with group of "automatic devices subjects" (Measurement and sensors, Means of automatic control, Microcomputer measurement systems, Design of process systems, etc).

On the next few figures we can see examples of lab plants, which demonstrate the connection of real laboratory plant with computers on the Web environment as a multilevel approach for operators with different access rights.

On the Figure 1 is the block schema of experimental laboratory model HAP (hot-air plant) as a physical model of air-conditioning. On the Figure 2 is an output graph of measured and control values – temperature, power to the heat source, and disturbance of temperature by ventilator airflow. Laboratory stands HAP are used in more courses for bachelor and master branches (for instance Automatic control, Automatic control devices, System identification, Design of process control systems, Final project, etc...).
Fig. 2. Output graph of measured and control values of HAP model

On the Fig. 3 we can see the detail photo of the two experimental laboratory models HAP with external microcomputer measurement unit CTRL connected to PC.

Fig. 3. View of the experimental laboratory stand HAP with external microcomputer measurement unit CTRL connected to PC and program support WinCTRL.
Fig. 4. Block schema of stand HAA with smart sensor of temperature (STS) and software support with SCADA/MMI program InTouch.

On the Figure 4 we can see block schema of lab stand HAP with smart sensors of temperature (STS) and software support with SCADA/MMI program InTouch connected to the LAN and Internet/Intranet environment.

Fig. 5. Experimental Laboratory of Process Control with eight plants HAP connected to the LAN.

On the Figure 5 we can see the other photo of the experimental Laboratory of Process Control with eight plants HAP connected to LAN and using SCADA/MMI support on the INTERNET/INTRANET environment.

On the Fig. 6 is experimental laboratory stands with LAN-Web support (other three plants – hot-air plant HAP, small robot model and washing machine model connected with
PLC Modicon). These stands focus on the creation of an integrated, interdisciplinary, design-oriented, lower-division curricula that emphasize broad concepts, student discovery, cooperative learning, problem-solving processes, and design.

![Experimental laboratory stands with LAN-Web support (other 3 plants – HAP, robot model, washing machine model connected with PLC Modicon)](image)

Fig. 6. Experimental laboratory stands with LAN-Web support (other 3 plants – HAP, robot model, washing machine model connected with PLC Modicon)

5. Conclusions

Verification of theoretical findings is important part of education process as part TQM principles. Although increasingly significant methods are computer simulations, now typical with simulation programs aid (for instance MATLAB-SIMULINK), experiments with real physical models are not interchangeable. Experimental stands allow easy understanding to principles of industrial plant parts, measurement and control devices, signals character, noise, dynamic responses and easier crossing to the real technological systems. The courses from area of automatic control provide students with a comprehensive understanding of the automation industry and knowledge of industry automation hardware and software, so they can progress to automation careers within the local manufacturing industries.

LAN-Web properties benefit a new possibility of multilevel control and measurement systems mainly with SCADA/MMI program support. Experiences from practical lab exercises and Final Project on the Department of CSI confirm increasing motivation of students, better interconnection of theoretical knowledge with practical experiences and skills. Currently, our lab plants are to involve students of industrial control systems and computer science (applied informatics) in team projects and better connection of theoretical knowledge with practical experiences.

The decisive role of the laboratory experimental stands with computers for quality engineering education was confirmed also in very good results of Diploma thesis and yearly hold Student Creative Research Competition.
6. Acknowledgments

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7. References


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