

# PROJECT AND EVALUATION OF COURSES IN THE QUALITY AND PRODUCTIVITY MANAGEMENT AREA IN THE UNDERGRADUATE PROGRAMS OF ENGINEERING

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*Abstract - The importance of Quality and Productivity nowadays has raised much discussion over their inclusion in curricula of undergraduate programs of engineering as well as how this is to be done. Such discussions are focused mainly on two basic aspects, namely, how the course is taught and how contents are selected in order to make up course syllabuses. Based on a series of experiences being carried out at Brazilian universities we make a proposal of subjects and courses to be included in the undergraduate programs of engineering, which address aspects related to Quality and Productivity. Firstly, an evaluation is made of the courses currently offered. This evaluation takes into account the characteristics of the courses offered and the main positive and negative points observed. Such points were listed by both professors and students at the end of each course. Grounded on these elements we build a proposal which ultimately aims at distributing basic aspects regarding Quality and Productivity into various courses regularly offered in the different engineering programs and designing specific courses for this area.*

*Index Terms – Engineering courses, quality area, productivity area, undergraduate programs, quality programs.*

## INTRODUCTION

In view of the importance of quality and productivity in recent years, the inclusion of courses in these areas has been increasingly analyzed and discussed. And a consensus seems to have been reached: it is appropriate, necessary, urgent and even essential that such courses be included in the curricula of undergraduate engineering programs. In general, at least one course in these areas is included in the undergraduate programs of Production Engineering. As a rule of thumb, the syllabuses of such basic courses comprise specific topics in Quality Control, with basic notions of quality inspection, sampling techniques, process control and some notions of in-factory quality management, in addition to, of course, basic concepts of quality.

If on the one hand there is a consensus as to the inclusion of this course in the curricula of the other engineering programs and even the inclusion of new courses in the core curriculum of Production Engineering, on the other hand we are still not sure of how this is to take place.

Based on some experiments being conducted at the Federal University of Santa Catarina (UFSC), one of the most important Brazilian universities, more specifically in the Undergraduate Production Engineering Program itself, a proposal is presented of syllabuses and courses to be included in the engineering programs, involving aspects related to Quality and Productivity. The proposal is grounded on the evaluation of previous experiences and the pedagogical projects of the courses to be included in the curriculum.

## COURSE EVALUATION

The courses offered to the undergraduate programs by the Department of Production Engineering in the UFSC have been the subject of a constant evaluation process over the past semesters. In particular, the evaluation more often considered is that which is filled out by students and whose results are rigorously analyzed by board of professors of that department. In general, the elements which make up the evaluation in question are the following:

- (a) As regards the course, students are requested to tick a number related to the evaluation of each item below, according to given indicators (for example: 1: Bad; 2: Regular; 3: Good; 4: Excellent.):
  - (1) Inclusion of this course in the program.
  - (2) Course syllabus planning.
  - (3) Course syllabus development.
  - (4) Didactical resources used.
  - (5) Approach given to topics.
- (b) As regards the faculty, students are requested to tick a number related to the evaluation of each item below, according to given indicators (for example: 1: Bad; 2: Regular; 3: Good; 4: Excellent.):
  - (6) Communicability.
  - (7) Degree of topic knowledge.
  - (8) Class planning.
  - (9) Teacher-student rapport.
  - (10) Clearness and objectivity.
  - (11) Response to classroom questions.
  - (12) Office hours availability.

(c) Students are then asked to tick a number related to each of the items below, which have to do with the evaluation for this course, according to given degrees (for example: 1: None; 2: Low; 3: Medium; 4: High.)

- (13) Personal interest in the topics.
- (14) Number of new pieces of information.
- (15) Interest raised by the topics.
- (16) Bibliography: how up-to-date it is.
- (17) Bibliography: how easily books can be found.
- (18) Bibliography: texts and course relationship.

The evaluation also involves the final score obtained by the student in the course, as well as suggestions, criticisms, difficulties and or personal remarks that students might wish to make.

This evaluation model made possible to draw an outline of both faculty and courses as a whole. In particular, it made possible to analyze regular courses (such as 'Quality Control') and experimental ones (as is the case of a course called 'Special Topics', which approached 'Total Quality Management'). The same evaluation model showed the weak points in the undergraduate program as a whole – many of which stemming from the absence of courses regarded by students as essential for them to have a good performance in the market, however not listed in the undergraduate program curriculum.

Two sets of courses arose from the analysis of the evaluations carried out initially: specific courses the area of quality and, next, complementary courses in the same area.

### **SPECIFIC COURSES**

In broad terms, the general objectives of the basic courses in the area of quality are to provide students with techniques, strategies and tools to effectively develop ways of consolidating efforts towards production, maintenance and improvement of quality in all sectors of a company, in an organized manner, so as to allow such efforts to settle down in consistent levels. This has to do with the production of cost-effective, high quality products and the evaluation of such products according to scientific bases.

Since it is a common procedure to enhance the personnel's level of consciousness as well as to improve their skills as a basic strategy to reach the objectives mentioned above, such courses tend to stress the participation of the workforce in the quality process, by discussing elements of motivation, consciousness raising, qualification, etc.

A complementary objective of such courses involves students themselves as the target of the quality production process. Therefore, a positive attitude is expected to develop in relation to quality, making them aware of its importance as well as the relevance of the activities planned and organized in order to achieve it.

A further relevant objective has to do with building a statistical basis for quality analysis and evaluation, based on data correctly collected and recorded. This objective

includes aspects related to the evaluation of quality systems described in the technical literature or in use in companies which can be visited by students.

Finally, it is necessary to discuss the management process deriving from quality implementation actions [as proposed by [1] and [3]], new concepts and policies (as proposed by [2]), and also the changes quality brings to companies (see [5]).

The basic areas proposed for the new courses are three, as follows:

1. Quality Production (Concepts, Consciousness Raising, Motivation, etc.);
2. Statistical Process Control;
3. Quality Evaluation.

Each area has its own activities, which require specific topics. Thus, we have:

### **Quality Production**

The inclusion of courses in this area must have as a final result of its application in organizations effective workforce consciousness-raising processes, creating suitable ways of motivation for work; standardization of quality concepts, quality control and related areas, and the development of motivation strategies for training and for the program itself. Such courses must also approach management topics, planning techniques and the organization and structure of quality systems as well (topics proposed by [4]).

The courses must show that the inclusion of such activities in companies should yield specific results, such as the identification of attitude changes of the workforce involved, as regards their daily routine at work and the program itself.

Two courses with 15 contact hours each (or one with 30 contact hours, bringing the two together) are proposed:

- (1) Quality – Concept and Relevance, and
- (2) Quality Planning and Management.

### **Statistical Process Control**

The courses in this area must present the general bases of the methods of Process Capability with their most common tools. In particular, the course must introduce tools and strategies through which a statistical evaluation of the productive process can be carried out, analyzing its real capacity (what we have) in view of its process specifications (what we want). Such tools and strategies must allow the definition of effective ways to control the process during its development, by analyzing relations such as material, equipment, workforce, methods, etc. As a course in the Quality Control area, the bases for action in preventive control must be introduced here ('to be ahead' of production problems).

Two courses are proposed:

- (1) Process Planning and Control, and
- (2) Statistical Quality Control.

The former centers on the diagnosis of the process and usual tools to analyze it (such as cause-effect diagrams, for instance). Now the latter shows usual activities of Process Control developed by variables and attributes. Emphasis must be placed on the procedures of implementation and interpretation of control charts and of the tools themselves for controlling the process as a whole. The number of contact hours suggested for each course was 20. Alternatively, both courses can be brought together into one 40-contact-hour course.

### Quality Evaluation

This third group of courses aims at defining real parameters for controlling product quality characteristics, as well as analyzing the rules for quality inspection and sampling techniques. Such courses include concepts regarding inspection and sampling techniques so as to standardize them and also the presentation of quality evaluation models which, by complying with desirable safety standards, minimize their application costs. In broad terms, this group sets out to conduct a statistical analysis of quality evaluation.

Likewise, two courses are proposed here, each of them consisting of 15 contact hours (alternatively, both courses can be brought together into one 30-contact-hour course):

- (1) Quality Evaluation – General Aspects, and
- (2) Sampling Plans.

The former deals with methods and models for quality evaluation (it means, evaluation of an organization as regards quality); how to measure quality improvement; quality evaluation based on elements like customers, productive processes, workforce, process support and objectives; the evaluation of quality programs themselves and the difficulties in quality implementation. The latter approaches the structure, development, project, use of technical specifications, implementation and evaluation of sampling plans both for analysis by attributes and for analysis by variables.

### COMPLEMENTARY COURSES

Similarly to what is already done in Graduate Specialization Programs of Quality and Productivity, the introduction of the list of courses below is proposed, divided into three basic modules. Each course has 30 contact hours, which makes possible to combine two courses into a regular four-credit course:

(1) Module 1: Quality Systems Project.

Proposed courses: Basic Quality Concepts; Introduction to Statistics, Productivity Concepts and Evaluation; Productivity Philosophies and Techniques.

(2) Module 2: Quality Systems Implementation

Proposed courses: Strategic Planning for Quality; Quality Systems Organization and Management; Quality Implementation Strategies; Human Resources Training for Quality; Marketing and the ISO 9000 Series; Quality and Productivity from Project to Product.

(3) Module 3: Quality Systems Evaluation.

Proposed courses: Quality Evaluation; Consumer Rights; Introduction to Reliability.

Specific topics not covered by the courses above can be delivered in the form of 'Special Topics'. Such courses, as is the case for the undergraduate program of Production Engineering, will replace technical courses to be condensed, in the areas of Electrical, Civil and Mechanical Engineering. For the other engineering programs, they can be offered as elective courses.

The syllabuses for each of the courses proposed are listed below:

- *BASIC QUALITY CONCEPTS*: The basic concept of quality. Conceptual approaches of quality. Design and product quality. Defects and their classification. Quality control. Quality assurance. Total quality control. The quality of products and services.
- *INTRODUCTION TO STATISTICS*: Probability. Random variables. Discrete probability distribution: Binomial, multinomial, hypergeometric, Poisson. Continuous probability distribution: Normal and exponential. Binomial normal approximation. Descriptive statistics. Data collection and treatment. Sampling theory. Sampling techniques. Statistical inference. Confidence intervals. Hypothesis test. Parameter estimate. Adherence tests. Correlation and regression.
- *PRODUCTIVITY CONCEPTS AND EVALUATION*: General concepts of productivity. Effectiveness and efficiency of productive systems. Productivity evaluation. Productivity performance measures (Workforce, materials, equipment, systems, etc.). Productivity evaluation tools. Development of models for productivity evaluation.
- *PRODUCTIVITY PHILOSOPHIES AND TECHNIQUES*: The just-in-time productivity philosophy (JIT). JIT principles. Performance objectives and measures. Organizational models. Departmental structures. JIT implementation and philosophy. Industrial techniques of productivity. Kanban. Lead time reduction. Set-up reduction. Operation standardization. Cellular layout. Autonomation. JIT inter-company programming (see [6]).
- *STRATEGIC PLANNING FOR QUALITY*: Strategic planning basic concepts. The planning system.

Strategic planning fundamentals. The strategic planning process: diagnosis, defining objectives, strategies, control and evaluation. Productivity planning. Practical models: experience curves, life cycle and Porter's approach.

- *QUALITY SYSTEMS ORGANIZATION AND MANAGEMENT*: The systemic concept of quality. Quality systems in the company. Quality control organization. Quality control functions. Quality administration. Quality policies. Quality management models. Strategic quality planning. Quality and marketing. Quality control basic relations: internal (quality and production control) and external (customers and suppliers). Quality economy: quality costs and benefits.
- *QUALITY IMPLEMENTATION STRATEGIES*: Quality implementation. Strategies for the production process. Reengineering. Simultaneous engineering. Just-in-time. Quality implementation Strategies in the products and markets level. Value analysis. Benchmarking. QFD.
- *HUMAN RESOURCES TRAINING FOR QUALITY*: The involvement of the company's human resources in effort towards quality. Quality motivation. Motivational approaches and their strategies. Motivation factors. Training and qualification of human resources for quality. Formal training programs. Consciousness-raising strategies.
- *MARKETING AND ISO 9000 SERIES*: Marketing as the basis for quality excellence. Normalization in the company level. Normalization in the country level. International normalization. The ISO 9000 system. Quality assurance system based on the ISO 9000. The ISO 9000 norm as a tool for quality systems implementation.
- *QUALITY AND PRODUCTIVITY FROM PROJECT TO PRODUCT*: Quality requirements. The real and the perceived quality. Quality from the relation between design and costs of the product. Taguchi's method. Product evaluation. Seeking defects in products during the design phase. Solution outlines. Defect elimination. Optimization. Integrating design and product with process planning.
- *QUALITY EVALUATION*: Introduction. Statistical process control. Process capability studies. Control charts. Control by variables: Development. Interpretation. Practical implementation processes. Control by attributes: Development, interpretation and practical implementation. The concept of quality inspection. The relevance of inspection for quality control. The nature of the inspection process. Reliability of the inspection process. Inspection by sampling techniques. Sampling techniques for inspection by attributes: Sampling Plans. Operating characteristic curve (OC curve). Structure of the sampling plans. Sampling techniques for inspection by variables: Basic plan. Basic elements. Decision criteria. Basic norms for inspection by variables. The basic model of inspection by attributes (Norms NBR 5425,

5426, and 5427). The basic model of inspection by variables (Norms NBR 5429, 5430).

- *CONSUMER RIGHTS*: Civil responsibility for the product. Basic legal concepts. Negligence. Judicial and extra-Judicial actions. Producer's rights. Publicity: nature and consequences. Brazilian Consumer's Rights Code. National Quality and Productivity Program.
- *INTRODUCTION TO RELIABILITY*: Reliability engineering. Reliability concepts. Failures. Life cycle. Failures. Reliability estimate for components and systems. Analysis by Failure Tree. Reliability Management and quality inspection.

## CONCLUSIONS

The implementation of the first group of courses (specific courses) is taking place on an experimental basis at the Federal University of Santa Catarina, with the courses of Quality Assurance (curriculum regular course) and Special Topics, which began to be introduced in 1997 (by four faculty at that time) and today is regularly offered every semester, for students in the 10<sup>th</sup> semester of the undergraduate program of production engineering.

The first experiences with these courses resulted in students who accept them but at the same time point out restrictions regarding the number of contact hours of each course (they deem there are not enough hours). The level of interest in the courses is high and most of the students who took such courses recommended them to their peers.

The main positive points raised involve the students' interest in the topics, up-to-date concepts, exercises done during the course, practical use of the contents, the notion of objectivity that the statistical approach imparts to Quality Control, and the interest caused by the historical moment the country is living, appropriate to efforts towards quality.

The main negative points raised during course evaluation are related to the number of hours given to each topic; course pace, which seemed to be intense and to involve a variety of items; some methodological failures in terms of class planning and development; unavailability of up-to-date bibliography in the library; and a few specific questions (such as the way questions are designed and presented in tests).

As for the second group (complementary courses), the courses were implemented in graduate specialization programs. A specific program in this area, namely Quality and Productivity Management, is already in its third edition at UFSC. The idea consists in taking advantage of the experience gained in order to implement similar courses in undergraduate programs. So far, however, only a few topics have been taught alone and

there are not enough data as of yet in order to carry out an effective evaluation.

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