

## QUALITY TOOLS IN ENGINEERING EDUCATION

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**Abstract** - *Maybe due to the success of their use in industrial companies, quality programs have been often applied in Engineering courses. These programs aim at applying basic concepts of Total Quality Management to the structure of teaching activities and to the way they are functioning. The main purpose of these programs is to select practical actions for educational process improvement. This paper tries to develop a critical analysis of these experiences, considering mainly the report of personnel involved in the subject. The quality models of some Brazilian universities (used mainly during the years 1999 and 2000) are considered. Production and industrial engineering, Mechanical engineering, Civil engineering and Electrical engineering were the main courses we have analyzed. The evaluation applied to the quality programs tries to emphasize situations where the results obtained are not the desired ones. These cases have had some failures during the application of the program. We have carried out the analysis of causes, circumstances, situations or accidental aspects that have contributed for critical problems and we propose some actions to avoid them.*

*Index terms* – *Quality programs, engineering education, quality evaluation.*

### INTRODUCTION

Quality programs have reached good results and success in industrial companies. Maybe because of that, they have been also applied in Engineering courses. As we know, the main purpose of these programs is to select practical actions for educational process improvement. These actions should fit the characteristics of the educational system they are directed to, i. e., the engineering teaching and learning process.

This paper develops a critical analysis of such experiences, based on reports of people involved in these processes. It is also considered a model of this kind of program, which has been applied in four Engineering courses at the Federal University of Santa Catarina for 3 years. Similar programs applied in four Brazilian universities are also studied.

The evaluation intends to study situations in which the results obtained were worse than expected (cases characterized as “failure” of the program application) by focusing on the analysis of causes, circumstances, situations or accidental aspects which had contributed to it.

This paper concentrates on the productivity aspects of engineering courses and what the quality programs have done to improve them. We discuss the failure notion in the quality programs and describe the quality indicators that can be used to evaluate the productivity of educational systems.

### APPLICATION OF QUALITY PROGRAMS TO EDUCATIONAL SYSTEMS

During the years 1999 and 2000, we carried out a research in 220 Brazilian organizations, specifically in terms of quality programs they have applied. Part of those efforts involved engineering teaching institutions which have been dedicating themselves to include quality programs in their activities. The relation between education and business are always interesting, as pointed out, for instance, by Limpert

In this study we have included six federal universities and six other state colleges. Production and industrial engineering, Mechanical engineering, Civil engineering and Electrical engineering were the main courses we have analyzed.

In many of these cases, the quality programs applied were considered to be unsuccessful. In spite of a certain difficulty in characterizing what comes up as failure in each case, there is no doubt that the programs did fail, for there was a consensus that “things did not work out”.

Aiming at avoiding the repetition of such situations, it is worth analyzing the failure itself as well as its causes. For sensitive programs like those ones in the educational area, the results must be visible, even in a short term, and they must also be presented in a certain understandable form to everyone. A way to facilitate this comprehension involves, unquestionably, the quantification of the results.

A critical point of the analysis of quality programs is to determine who can evaluate the program of engineering education and what determines the program failures in education.

In order to have a better idea of the failure causes in the quality programs of teaching institutions, we have applied a special classification to them. Therefore, the programs are organized in general classes, in order to relate them to the roots of the problems or to the more immediate meanings of such problems. For each group considered, the failure (or, at least, the weak results) was attributed to some causes that we study here.

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We consider that the main results of this paper concern the correct and incorrect actions and concepts adopted in engineering education by quality programs. Such results will help teachers, educational policy makers and educational researchers to avoid wrong decisions and create effective productivity in educational systems.

### WHY DO QUALITY PROGRAMS FAIL?

The main question we have heard in teaching institutions that use quality programs is always the same: “why do they fail?” Maybe all the problems in quality programs begin at the same point - to understand exactly what a failure is.

The most usual notion of failure refers simply to a situation in which we could not reach expected results or objectives. The same idea appears when desired benefits from some actions are not generated. This notion seems to be quite clear. It can be found in all the cases studied (the detailed report on the research in question can be found in [4]).

All the analyses of quality programs we have done consider that both the general and the specific objectives of the programs play an essential part in their evaluation. And here we can frequently observe the first problem in quality programs applied to the educational process: the incorrect definition of the objectives. There are evidences of some errors and conceptual confusions in the following situations (all of them identified in practical cases studied):

1. The quality programs generate only long-term results, but immediate benefits were desired. Example: the program emphasizes some alterations of teacher’s behavior – they seem to have no participation in the university decisions. The local culture, however, has never valued this participation. The educational system has never generated mechanisms to change this situation. So the common sense in that given school is that this participation is not productive or desirable.
2. The objectives of the quality programs seem to be poor or too restricted. Example: the actions are limited to some groups of teachers or students (since the others cannot reach them).
3. The objectives were not feasible for the institution reality. In most cases, the feasibility depends on some resources and they are not provided. Example: Some institutions have altered the teaching methodology, by using computational support. Nevertheless, the computer devices did not fit the chosen methodology.
4. During the application of the quality program, we could see that there was not a direct relationship between the results desired and the actions chosen by the program to generate them. Example: Some important changes have been made in educational programs, but they still remain “old”, i. e., the changes do not seem to be useful.

The action taken “to alter” the educational program finds an end in itself. Any action proposed, however, should have very well defined objectives.

5. The objectives seemed subjective and so there is no way to quantify them. Example: we know that it is difficult to measure how much a group of students has understood some information or acquired some knowledge. It is also difficult to define exactly what are communication degrees, content domain, class planning or relationship with teachers. But there are acceptance levels for these elements.

So we can identify here the first difficulty to be outlined: to define correctly the objectives of the quality programs. If general or specific objectives are not correctly defined and considered, the quality program may lead to a situation that cannot be seen as a failure but, rather, the result of a mistaken expectation.

There is a second important point to take into account when defining failure in quality programs: sometimes we do not know the actual situation of the educational process or of the educational system, i.e., when planning the quality program to be used, some important pieces of information are missing, or such information is not representative of the situation, or, finally, it is not enough to have an exact idea of the environment. In the educational institutions analyzed during this research, the lack of information is the first deficiency we have detected (and often the most indispensable requirement).

### ANALYZING QUALITY PROGRAMS IN EDUCATIONAL SYSTEMS

The analyses of quality programs show that there are two main sets of difficulties:

- (1) What is the main objective of the quality program?
- (2) What is the environment that the quality programs are included in?

This means that: (1) it is usual to have incorrect objectives in quality programs and (2) it is common to have incorrect information about the educational system reality.

Having this situation in mind, the methodology used here has considered the use of quality indicators, which happen to be the basic elements of evaluation. These indicators should have some characteristics. To the study of this paper, the following ones are critical: *Visibility*: the indicators show visible and unquestionable results of the programs; *objectivity*: it means measurable indicators; *representativeness*: the indicators show the reality of the institution now; *viability*: the indicators cannot require information that the system cannot have at this given moment or that is not available now; *precision*: The indicators cannot allow double interpretations; *wideness*: the indicators allow a large visualization of the situation.

The first point is very important. For fragile programs as those in the area of education, the results should be, above all, visible. They have to be reached in a short term. They should also be presented in some comprehensible form for everybody. The best way to facilitate the understanding of quality programs involves, without any doubt, the quantification of these results. This last element perhaps is the greatest difficulty to take into consideration.

In fact, a basic purpose of quality programs in education is to show - to all the students and teachers in the system - elements that allow an effective evaluation of the entire quality process and the benefits the application of these programs can have for them. In this situation, to list some results on a notice board or to apply some questionnaires cannot be enough. So, a critical action to evaluate quality programs is to define correct indicators.

The next point to discuss in the evaluation methodology has to do with determining who can evaluate the quality programs. Considering basic quality concepts, we have defined the first principle of the quality program evaluation as follows: every evaluation of quality is centered on customer's satisfaction. In the case of quality programs used in teaching institutions, or, in general, in educational systems, the first question to consider is who is the customer of the program.

There is a great mistake here. Most of the programs considers the students as customers of the process. Actually, the students are the "raw material" to whom all the efforts of the systems are directed. *Raw material* here means the following: the students are the elements under transformation during the educational process.

So we consider the students as a part of the *in-line* quality process. Being the main support of educational systems, teachers are included in *off-line* quality environment.

In order to define the *on-line* quality environment it is necessary to establish the real customers of the educational system. We consider that the customer is society as a whole. In fact, the actual objective of universities is to shape good professionals to the society. Therefore, society can evaluate the educational process results. In terms of quality programs, the role of society is precisely that of evaluating the results of the efforts for the improvements of educational systems as a whole.

We consider a serious mistake not to include alumni in the evaluation process, as well as the companies, organizations and, finally, the working environment where the alumni are acting now.

## EVALUATING THE QUALITY PROGRAMS OF THE EDUCATIONAL SYSTEMS

This study was carried out in six Brazilian universities and six state colleges. All of them are in the same situation: by 1995, they started a quality program to improve engineering courses (we consider here the courses of Production and Industrial engineering, Mechanical engineering, Civil engineering and Electrical engineering).

We have applied evaluation indicators to these courses, with the characteristics described above. Other sets of indicators were used, like the ones from [2] and [5]. Thinking in terms of quality, some interesting studies like that of [1] should also be mentioned..

These indicators have pointed the failure causes in the quality programs of the educational institutions we have studied.

The research was developed in four main steps:

- (1) First we applied some data collection techniques. We considered students, teachers and other elements in the educational system. At the same time, we have studied the environment where former students of those institutions are working now. Finally, we interviewed some areas of society.
- (2) Statistical treatments were applied to the data collected, i.e., we organized the information and gave a quantitative approach to the educational system evaluation.
- (3) All the conclusions were tested in the same institutions where the data had been collected.
- (4) The final conclusions were tested in other institutions and then we have extrapolated them.

As a result of step 4, we organized in general classes the causes of failures in quality programs applied to educational systems. Hence it was possible to relate quality programs to the roots of the problems or the more immediate contexts of such problems.

Four groups of causes have been identified. They are shown below with the frequency of occurrence: (1) Structure of the quality program itself. (72%); (2) Activities of the human resources (61%); (3) Management actions (49%) and (4) Quality program Management (39%).

For each considered group, the failure (or, at least, the weak results) was attributed to the following causes:

### 1. Quality Program Structure

- (1) *The program did not present clear directions or defined objectives.* In this case, the program evaluation cannot be done. This is already a tremendous damage: we cannot know if we are doing the right thing or not. Furthermore, we cannot know where to concentrate more efforts or resources nor can we know where to allocate more people. In some cases, nobody can account for the high dropout rates in certain courses. In a specific situation, four teachers of a same discipline have presented eight different explanations... And all of them were involved in the quality program.

- (2) *The structure of the program did not reach its own objectives.* Example: The structure of the organization (to support the program) did not bring an integrated view of the different areas of the engineering course, neither did it create conditions for interaction between them. Thus, there is constant conflict among teachers of different areas or of different centers. It is normal to have different points of view but it is not acceptable that this divergence hinders the quality process. In all of the cases studied we observed that the program is overlooked on behalf of the peace and of the harmony inside the institution.
- (3) *Lack of participation of the High Administration of the school in the program.* The most common situation is the following: the High Administration agreed with the program but they did not partake of it or did not give support to it. Absence in events of the program (seminars, meetings, congresses etc.) and indifference to some positive results obtained were cases where the poor participation of the Administration in the efforts for quality could be noticed. The idea that the program is actually not so important always reminds. An old notion must be considered here (and always): "the example should be set by the top".
- (4) *There was no long-term planning of the quality program.* Example: the planning did not envisage all the necessary resources. The time required for certain actions was not enough. There was no integration between steps. In general, we noticed lack of specific technical support, whose existence was not correctly evaluated and it was not available when necessary. A simple but illustrative case: the program foresaw the modernization of contents in the disciplines, but the acquisition of new bibliographical references did not take place.
- (5) *The quality program did not attribute a correct role to the teachers or to the students.* Example: There are specific roles for each segment in the process of quality improvement of the institution. If one of them is missing, the whole program will be affected.
- (4) *Restrictions to some actions.* Example: to prohibit students of discussing a certain issue under the excuse that they do not have enough qualification for such area.
- (5) *Lack of adequacy of the activities designed to some teachers or students.* Example: Physical sciences teachers do not always have aptitude for tasks that involve subjective aspects.

### 3. Management Actions

- (1) *Fast results were expected.* Example: immediate improvement of the student's satisfaction.
- (2) *The Administration of the institution seems to want to produce quality, when actually other objectives were in mind.* Example: the real objective of the institution was just to impress some students in potential.
- (3) *The Administration did not have clear objectives in terms of the quality.* Example: The program included many items at the same time. And the impression we have is that the program was too large, imprecise and rather vague...
- (4) *The Administration understood that the program would not bring costs for the school.* Example: the program began to fail when the administration did not provide funds for the purchase of microcomputers or material to keep the laboratories functioning.
- (5) *The Management of the educational system has adopted a quality program because many other schools are doing the same (it was "fashionable").* This is the most common case. Many educators that talk about "quality in the education process" do not know anything about quality.

### 4. Quality Program Management

- (1) *The decision about the quality program actions come from the Administration.* They do not want to listen to anyone. They do not accept suggestions. Example: In a lot of situations, we observed that the program seemed to have "a big boss". Teachers and students did not want to take part in a program with which they did not agree. In fact, we noticed that the Administration's actions (without considering any other action suggested, e.g., by the teachers) inhibited participation and restricted personnel's involvement. The natural consequence of the process is an attempt of sabotage against the program.
- (2) *The program was intended mostly to generate expectations than to generate results.* We have found this situation in a lot of institutions. In these schools, it was observed that the real goal of the School Administration was to promote its own actions. So the program generated a large expectation, without having any concrete action to create concrete benefits for

### 2: Activities of human resources

- (1) *There is no motivation process.* Example: underpayment or unsatisfactory wages.
- (2) *Many restrictions to personnel's participation.* Example: sometimes, only Ph. D. professors' participation is requested. As if the others did not have anything to say or contribute...
- (3) *The idea that willingness per se is enough to produce quality.* Example: the school understood that there was no reason to train teachers (they are undoubtedly competent - however in their specific areas and not in quality...)

teachers or students. The discovery that the program was created to “make a fuss over” and not to produce effective benefits generates a considerable frustration.

- (3) *The program seems to break the formal structure.* Example: Some changes in the Engineering courses have been made by the High Administration. The teachers’ positions about the changes are not considered. So they stay out of the process. Two positions are adopted by the teachers then: indifference or aggressiveness. In the first case, they refused to collaborate; in the second, they boycotted the program. Both situations are fatal for quality programs.
- (4) *The program does not have a continuous structure but only isolated facts.* There are two common situations here: (a) the program is meant to reach to a specific objective. Then a great deal of attention is channeled into it. When the problem in question is solved, all the efforts towards quality production cease. It is the case of the efforts to have a given course accredited: once the course is accredited, the efforts to maintain and enhance quality are put aside until the next evaluation process. (b) The program is designed to assist critical aspects of the school. It is the case of the computerization of the school. It is noticed, in several cases studied, that actually the efforts to buy some computers have been made and such a fuss over it is made. The real usefulness of the computers for the teaching-learning process was never analyzed indeed.
- (5) *The quality program involved some improvements that do not seem to be beneficial.* It is the case of improvements generated by new equipment - if the school Management justifies the benefits using only this one reason: they are better just because they are new.

### CONCLUSIONS

It is important to have in mind that this paper is specific to Engineering courses. So the quality program evaluation above and also the conclusion below are related to this area. Therefore, they might not be applicable to other courses.

In broad terms, it is possible to summarize the causes of failures in two items:

- (1) (1) A quality program cannot be successful if (the concept of) *quality* is not correctly understood;
- (2) A quality program cannot be successful if we invest in *forests* but we neglect the *seeds*.

In the first case, it is important to observe that many educators discovered in the total quality mechanisms to become famous (and, maybe, even rich...). Professionals of the quality area are unanimous affirming that many of them are absolutely ignorant of the concept of quality. In some

cases, books about total quality in education carry gross mistakes as regards basic concepts of quality.

At the same time, barely any notice is given to teachers (who will play an important role in the program) in terms of showing them the correct concepts of quality. This conceptual flaw almost always has critical consequences for quality programs in any kind of institution. As a result of that, we have observed poor understanding of the importance of quality; lack of priority for subjects that are really important (for example, the correct definition of who is the customer of the program); lack of a clear perception that quality depends on a number of factors (multiplicity of items) and not on only one that, for any reason, has been emphasized; lack of resources; lack of investments in adhesion, motivation, formation and personnel qualification (this involves teachers as well as the whole supporting staff involved in the course).

In the second case, the following must be noticed: the forest has a big area, volume, size, presence. It is precisely because of these elements that it is impressive. The seed is small and is not as noticeable (above all, because it is placed below the earth). But in the forest we never know exactly the base. This is different with the seed. When it sprouts, it produces consistency. The forest-oriented programs are good for situations where the quality is a factor of self-promotion for the high administration. The seed-oriented programs are good for situations where we want to implement quality indeed. For educational processes, the forest-oriented programs die away in 100% of the cases. The seed-oriented programs, however, have a high probability of giving good results.

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