Education for Decision-Making

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Abstract

In this paper it is reported the recent experience of continuous evaluation and e-learning that have been implemented in the course of Civil Engineering at the Faculty of Engineering of Oporto University (particularly in what concerns the subject of Operations Research), showing how good it fits the concepts of strategic planning and management, as well as the way it enhances a better involvement of students and teachers, and a deeper understanding of the benefits it deserves to future professional life of engineers.

Keywords: Strategic education, long-distance, lifelong and e-learning processes.

1 Some theoretical issues about strategic planning and management in universities

The strategic planning and management rationale consists in the following inter-related components:

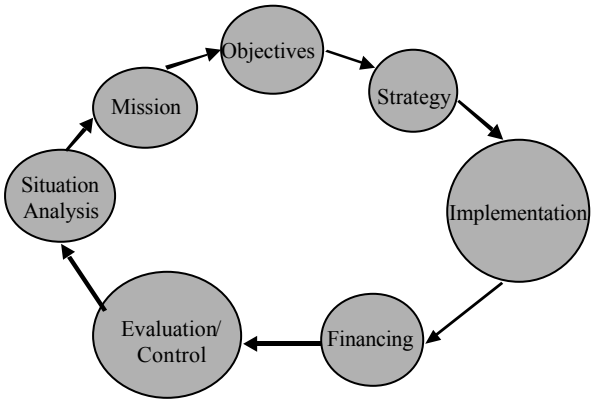

Figure 1: The strategic planning and management process.

The strategic planning and management processes [15] analyse the impact of the environment as well as the changes in the organization itself [16]. This connection between the institution and its external environment is crucial to its success. In the following diagram the main agents with whom the institution has to deal with are pointed out, considering as strategic elements the environment, the university, the existing and the proposed programs, and the abilities and plants [15]:

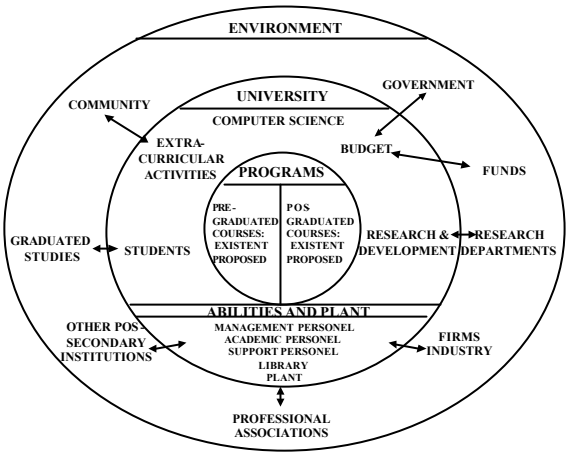

Figure 2: A strategic model of universities management.

The existence of the organization is based upon its capacity to attract individuals and groups that are willing to collaborate in mutually beneficial changes [5], [1], [18], [17], [19], [11], [4], [13], [24], [25], [23], [6], [9], [1]. These cooperation mechanisms, to which people and groups freely adhere, allow perception adjustments and the definition of frameworks common to the individuals that belong to the organisation and to those that keep straight relations with them. The legitimacy and the ability to motivate and communicate are the values assumed to be the most important in these kinds of institutions.

The most relevant elements in the strategic planning and management processes are:

- **The organisational culture** - It consists in the values and believes an organization has concerning the way it should be driven, as well as the way their human resources are expected to behave and be treated. Its role is crucial because it represents a stabilizing influence over the activities that are being performed: it allows facing the environmental uncertainties in more controlled ways. A culture with strong features allows predicting behaviours, thus preparing beforehand the appropriated answers.

- **The structural organisation -** An organization consists in a consistent group of people within an organised system in evolution, whose co-ordination efforts are targeted to the attainment of certain goals, in a dynamic environment. The specific features of universities require a structural organisation that Mintzberg [16] names as "professional bureaucracy". Professors have a considerable autonomy, which allows a concentration of power in the lower layers of the hierarchy. This power is based in a specialised knowledge that is too much complex to be supervised by managers or patterned by analysts, and on the production of patterned services. The two fundamental mechanisms that allow the co-ordination of the work of the professionals are the "**pigeonholing process**" (that consists in the division of the activities of an organisation in a collection of components or patterned programmes, which in turn are applied to pre-determined or contingent situations), and the **standardization of knowledge and abilities** (that occurs along the learning and training process of the specialists in their areas, making up expectations about what they are supposed to perform in their professional work). These processes of co-ordination allow the professionals to concentrate in the performance and improvement of their activities near their clients/students, far away from the supervision from colleagues and hierarchical superiors.
- **Mission -** The organisational mission expresses the fundamental reason for its existence, and establishes what it wants to perform in order to satisfy the society expectations. Its formulation involves two facets: the **explicit expression** (that defines the core of its operations in terms of its product/service and its market, and supposes a decision-making process related to the clients as well as to the responsibilities and functional compromises - which are its basic institutional values - and allows the identification of a certain institution by its own specific characteristics), and the **implicit expression** (that consists in a set of values shared by all within the organisation, which shows the basic reason for its existence, and also provides a common framework for the decision-making and for the management process).
- **Objectives -** the objectives set the specific targets to be attained. In these kinds of institutions the objectives are not clear, in opposition to what happens in firms. The management of educational institutions focuses in broad objectives, values and mission, and it follows a set of qualitative and quantitative approaches. It is rather important also a good fit between the institution and its environment.
- **Strategies** - In universities, the strategies are patterns of decisions and actions that emerge from a variety of interactive processes [16]. There are two opposite extremes in the process of their formulation: the **intentional or deliberated strategies** (that are performed according to the planning models of their leaders), and the emergent strategies (that consist in patterns or consistencies performed without, or besides, the intentional reasons).
- **The decision-making process -** The powers of the traditional administrators concentrate in the defence of the interests of the different internal components of the organisation, in what concerns its relationships with the external environment. Their involvement in the strategic planning and management processes is, thus, crucial. In these institutions emerge four different implicit models of decision making: the **analytical model or model of the rational actor** (where it is made a choice between the various possible alternatives, through the rational evaluation of their respective consequences in what concerns the attainment of the organisational objectives); the **"dust-bin" model** (that has clearly irrational features and centres in non-intentional behaviours that provide a random perspective of the decision-making processes, and consists is a set of choices that seek problems, the appearance of theme matters and feelings that look forward to decisional situations, by proposed solutions to values to which they can answer, and by decision agents that search for work [22]); the **collegiality model** (that approaches the decision-making as a consensual process in which participate different individuals that, although playing different roles and keeping different specificities, share common objectives to the organisation); and the **political model** (that consists in the turning up of processes of power resulting from differences between the different groups inside the organisations, that lead to the constitution of coalitions and to exert pressures over the decision agents, a great deal of decisions in these kind of institutions are clearly political ones).

  There exists also a great diversity in the decision-making agents: the decisions concerning the teaching activities are the responsibility of the professors, because they are the only ones that supervise their speciality areas; the administrative services, such as the financial management or the treasury or accounting system are assured by the administrative agencies of the institution; the potential students and external parts decide upon the attitudes to adopt towards the institution, and the global institutional decisions are the responsibility of the government and the organisation itself, and play important roles that contribute to their success or failure expectations. The decision-making process is frequently characterized by a general lack of coherence because the decision taken result from a variety of interactive processes. The compromises can be established based on negotiation processes or upon a conflict between interests.

- **The strategy implementation process** - In what concerns the implementation of strategic patterns in universities, different planning proposals stress the **flexibility**, which is the capacity the institution has to adapt to non-predicted and permanently changing circumstances. It allows the organisation to give convenient answers because there exist high levels of uncertainty in its external environment, and the ability to control them is rather incomplete. Thus, the flexibility mechanisms that are proposed by the different planning concepts are [22]: the **incremental planning** proposes the decisions should lead to the resolution of specific problems, and to the accomplishment of little changes, instead of great deep reforms; the **communication and transaction planning** suggests that the different opinions and organisational positions should be integrated in the decision-making through dialog processes that allow the social learning, and lead to consensual positions; the **cybernetic planning** defends that the different cells in the institution should use their own images, symbols, values and self-conduction abilities in order to avoid the failure of the whole organisation and proposes that decisions should be delegated in the units or individuals that have a deep and detailed knowledge of the situations in which the planning process should occur; the **processual**, the **mixed inspection**, and the **adaptative planning** propose the introduction of accompanying systems at the different levels, as well as the consideration of "feedback" circuits, and the postponing of more deep decisions, which allows a continuous evaluation process and a re-direction of the planning process fitting it better to changing circumstances.
- **The decision-making process** - The main problems that emerge in these kind of institutions depend directly upon its characteristics of autonomy and democracy, and reflect the lack of conscience of the professionals in relation to the co-ordination, discretion and innovation questions [16]. The co-ordinatiom mechanism in which the professional bureaucracy is based is the "**standardisation of knowledge and abilities**". This process occurs through the long theoretical and practical formation and the training of the specialists. The co-ordination mechanisms usually applied in other kinds of organisations, such as the direct supervision, the mutual adjustment, or the standardisation of work processes and outputs, cannot be applied because the work is highly complex, their results are uncertain, and there is a deep approach between the professionals and their clients.

  However, the standardisation of knowledge and abilities has many restrictions when it deals with many of the problems of higher education institutions. The kinds of problems that can emerge are the following ones:

  - Co-ordination problems between the professionals and the support personnel, that results from the contradictions between them: the vertical power of the authority line, and the horizontal power of the professional specialists.
  - Co-ordination problems between the professionals themselves, that results from the "pigeonholing" process application. Professional bureaucracies, indeed, are not integrated entities, because people who work in them only share the search for resources and support services, and the allocation of the needs and programs to pre-defined contingencies is artificial.

  The design of the professional bureaucracy considers that all the professional tasks uncertainty is clearly away through the "pigeonholing" process. But the discretion problems appear because this process, when concentrates power in the hands of singular professionals, doesn't consider only their complex capacities and the standardisation of work, but also believes in their constructive criticism. Problems may turn up because incompetent or unconscious professionals may not want to update their knowledge, may concern more with the income than with the students, may overvalue their abilities over the needs of the pupils, or may want to oppose their pairs.

  In the professional bureaucracies, the professionals´ unwillingness to work co-operatively with one another may lead to the appearance of innovation problems. These organisations present performance structures that, although well adapted to the resolution of the existing problems (deductive rationale), do not fit difficulties previously predicted (inductive rationale), and that will require the re-arrangement of the existing "pigeonholes".

  The power to perform changes is diffused, as a result from the operator's autonomy, and the inversion of the decision-making power. Their implementation requires the accordance of everyone, and it is a slow process, characterized by a succession of tiny negotiated adjustments.

  A background of interactions among different subjects is needed to deal with the dynamic environmental conditions. Also it is required a deep change in abilities, and the development of a co-operative spirit

2 Case study: recent trends in teaching and learning processes

The new learning processes – e-learning and long-distance teaching/learning - which are currently being implemented at the Faculty of Engineering of Oporto University, particularly in certain subjects of the course of Civil Engineering, have allowed to surmount a great deal of difficulties related to the

structural organisation, to the implementation of strategies, and to the decision-making processes, not only at the different layers within the faculty, but also at the level of the courses, subjects, as well as in what concerns the agents involved: professors, students, and line decision-making agents.

The **mission** of the engineering education is not only to teach students the theoretical and practical backgrounds strictly related to their future profession, but also to develop abilities that allow them to solve the different kinds of practical problems they will be faced with, most of them requiring a prompt answer, or that will imply important consequences. As Gault [12] settles in a very interesting way, it is *"necessary to distinguish between teaching and learning. In referring to teaching, the focus is placed upon the teacher who teaches. In seeking education from this perspective, the student is regarded as a secondary, passive figure. Such student may be termed a pupil: a pupil is a person who is taught. Discussions of education will then concern matters such as teaching methods, teaching aids and even teaching machines.*

By contrast, when discussing learning, it is the student who is the central and principal figure. As the person who learns, he or she must be seen to assume an active role in the process, and will be termed the learner. The person conducting the learning process will be referred to as an educator. The educator then becomes the person who assists learning."

Thus, besides the transmission of all the theoretical and practical issues that have characterised the most part of the engineering courses, it is necessary to stress the importance of the active participation of the students in the decision-making aimed to solve real problems. These decision processes have the potential to generate the student involvement in the learning process, where they should play an active role.

The project and production components of the professional activities of the engineers should, thus, become the core of the learning processes.

The overall mission of the subject of Operations Research is settled, precisely, as consisting in the development of decision-making abilities.

The objectives for the teaching/learning process are clearly settled beforehand in the subject -sheet, which is available to all the students enrolled in the subject, from the beginning of the semester, through the internet e-learning tool. The **objectives**, settled by Costa [8] are [21]:

- To contribute to the development of capacities (methods) to solve problems in an analytical way (to teach a consultancy process/rationale).
- To apply the strategic analytical process to the resolution of a problem (situation analysis, definition, schedule and quantification of goals, settlement of alternative courses of action, implementation processes, financing modes, and evaluation/control measures).
- To use operations research as a tool to support change, what means its use to improve or change real situations.
- To implement operation research-based measures as a science of the real things: implying reality rationales as well as reality policies.
- To understand Operations Research as a continuous process of developing knowledge. It means that Operations Research should encourage the resolution of problems, because it is a direct application of education to the development of capabilities.

The **strategies** that have been recently applied consist in:

- Problem-solving through case studies.
- Budget games simulation.
- Use of e-learning tools and the Internet.
- Co-operation with firms and other institutions.
- Use of optimisation methods and scenario analysis.
- Integration of engineering students in multidisciplinary teams within firms.
- Organisation of exhibitions and conferences.
- Development of research projects required by firms and other institutions.
- Simulation of real situations that require quick and efficient decision answers.

In what concerns the **strategy implementation model**, the most recent trends in planning respect the cybernetic one, where the flow cycles (situation analysis → mission → objectives → strategy → implementation → financing → evaluation/control) are continuously refined and re-defined during the planning process.

The planner develops an information system that is continuously updated whenever changes turn up. This rationale is going to produce different alternative scenario projections, or simulations corresponding to different future dates, supposing the application of different policies (the main goal always consists in making this process as flexible and changeable as possible, in such a way that allows the consideration of all the possible paths for action to allow the firm to develop and incorporate changes.

Then the different alternatives are compared and evaluated within a framework of reference values derived from the objectives, what is aimed to produce recommendations about a system of evaluation and control policy measures that, by its turn, is changed according to the re-examination and re-definition of objectives, shown up by the information system. In other words, it is a system of continuous formulation of objectives, continuous projection and simulation of future

evaluation alternatives, and continuous choices and monitoring [14].

The different kinds of problems an engineer can be confronted with on his professional life are often unstructured. There is frequently the feeling that something is wrong, but before the solution is found it is clearly important and challenging the identification and definition of the problem. Engineers are constantly receiving information, trying to discern patterns in this information, and taking action based on their perception of these patterns [20]. A case study provides the student with a similar situation. There is a great quantity of information that must be digested and sorted into problems to be solved. Thus, the student must be aware that some irrelevant information will be included in the case, on the one side, and also that some key facts are not available, and the time and cost involved in obtaining those facts may be prohibitive. Consequently, he needs to direct the problem solving in order to define and equate the problem, surmount the difficulties, and find a quick and feasible solution to it. Case studies deeply help engineering students not only to integrate a great variety of science and engineering subjects, but also improves their skills in understanding and applying fundamental concepts, in conducting an independent study, and in executing complex problem solving [3].

The future engineer should be deeply aware of the importance of the accomplishment of the costs and terms previewed in the production budgets. Thus, as part of an overall balanced engineering education system, several teams in different engineering schools should be confronted with the need to manage budgets through the use of the "budget games". It allows not only the confrontation of results among groups of students from distinct schools in different cities/countries, but also points out the importance of the economic aspects in the engineering management processes, carried out by engineers.

The co-operation with other institutions has been performed through the following initiatives:

- Short seminars presented by those firms/institutions, aimed to students in order to show the basic economic and financial mechanisms, pointing out the benefits for both parts involved.
- Exchange of information needed for leading out studies not only at the academic level, but also at the firms level.
- Collaboration of students in studies lead by those firms/institutions.

The subject of Operations Research is a crucial one in the process of engineering decision-making processes, particularly in what concerns optimisation methods and processes of decision making and implementation.

The scenario analysis is a methodology currently used in order to simulate different situations that may emerge in practical life. Generally there are considered a pessimistic, an optimistic and a more likely scenario, where the values of the decisional variables vary while the values of the deterministic ones remain stable. Risk and uncertainty are accessed in a probabilistic way, giving the students numerical tools that allow them to quickly and objectively face and solve problems.

A closer interaction and co-operation among university and the industry is currently being implemented, what is highly favourable for the whole parts involved, because it reinforces the flows of people and ideas. It betters high-technology capacity of firms, improves productivity through technology, and also strengthens the international competitiveness of firms. The interchange of ideas between the universities and the industries result in co-operative venture with great economic benefits [3]: *"spin-offs from universities, often spearheaded by academic entrepreneurs, create new high-tech employment opportunities and increase natonal helth"*. The integration of students and professors in multidisciplinary teams at the industry level, where they can apply as well as sharpen their technical knowledge, with the additional incentive to earn some money, and effectively contribute to the production processes is promoted through the interface institutes, that simplify and enhance this co-operation, rationalizes the use of resources, and manages the correspondent budgets.

It has also been organised conjointly by professors and students various exhibitions and conferences centred in specific practical problem solving. Engineers and managers dealing with projects and production processes may expose, in very interesting ways, problems they face in everyday professional life, and the solutions they have proposed and implemented in order to solve them.

"Competitive pressures in an increasing open (...) market have been demanding better quality standards, faster production cycles, and lower prices. The emergence of the Internet and of Internet based business processes, in particular e-procurement throughout the supply chain, company Extranets and Portals, has also increased the pressure on companies to adopt "common languages". All this requires the adoption of national and international standards for products, services and for business processes. It also requires, with utmost urgency, that governments and each national standard organisations discuss, adopt and impose such standards, which should obviously include aspects relating to security, quality and comfort of the constructed environment. However important are the local and national efforts to improve "local common languages", they must also be co-ordinated with international efforts, in particular for regions (...) where integration is increased due to ever opening markets." [10].

The disseminated knowledge engineering students possess, concerning the use of Internet and his potentialities can add a considerable value to firms as well as to municipalities and other public entities. In fact, students and young engineers can help to embed Internet technologies in the business and production processes [2].

In order to familiarise the employees within the firms with the possibilities of the technology (which also allows the standardisation of procedures inside the firms and suures better co-ordination processes), Internet technologies can be, thus, implemented. Besides, by means of the Extranet, the co-ordination with related firms throughout the value chain is assured. Especially important in this process is the potential development of web-based platforms aimed to support procurement processes [2]. It is also relevant the use of the Internet tools in order to improve and standardise the information tools that are used in a certain country, and in different countries, concerning the engineering fields [79.

The Erasmus program encourages students to spend some months of their engineering studies in other universities, either in their countries or abroad, because this will bring new ideas in research areas. They can implement these new ideas and methods not only in the learning process, but also implement them in firms/institutions where they can become future professionals.

The **evaluation/control** process has three main facets:

- Evaluation of the students by the professors.
- Evaluation of the matters taught/learned by the students.
- Evaluation of the professors by the students.

In what concerns the evaluation of the students by the professors, in the current year it was introduced a new formula, based on continuous evaluation: instead of a final exam, it was substituted by two intermediate tests, each one covering about half the matter taught, and two works were introduced: one performed individually and a case.-study solved by group, with great possibilities for creative answers related not only to matters taught (at different subjects), but also to their own good judgement, and capacities to reflect about a problem, collect the necessary information, and propose a justified solution.

In what concerns the evaluation of the students by the professors, the average classifications of students in the school year of 1998/99 where around 10 values, and in 2001/2002 jumped to 13,7.

The matters taught/learned have been evaluated each academic year and for the past five years, both on an absolute and on a relative basis: for each subject, and the average values for the whole subjects in a certain course year.

The items evaluated (5 levels of evaluation, from 1- bad to 5 – excelent) are the following ones [26]:

- Adequacy of the matters to the context of the course.
- Difficulty level.
- Level of work and time required.
- Interest of the pupils by the studied themes.
- Adequacy and accessibility of the recommended bibliography.
- Quality of the co-ordination between the theoretical and the theoretical/practical lessons.
- Quality of the laboratory support (if applicable).
- Adequacy of the evaluation methods.
- Difficulty and work level required in comparative terms.
- Global appreciation of the subject functioning.

The introduction of the new ways of teaching/learning lead to a significant improvement in the appreciation of the subject of Operations Research: from a value of 2,83 obtained in 1998/99 for the subject in comparison with an average value of the 3,45 for the subjects taught in the 3rd year, in 2001/2002 the correspondent values for Operations Research jumped to 3,25, whereas the average value only jumped to 3,68.

In what concerns the evaluation of the professors by the students, it depends mainly upon each professor, but the issues evaluated are:

- Clearness in the presentation of the objectives, program, working methods and evaluation criteria of the subject.
- Clearness and logical sequence in matter presentation.
- Ability to motivate and concern pupils.
- Assiduity and punctuality.
- Availability and accessibility to receive pupils and elucidate their questions.
- Matter mastery and certainty in its exposition.
- Preparation, organisation and structuring of lessons.
- Global appreciation of the professor.

The main conclusions of these analytical results show not only the importance of the ways of learning/doing, but also the increasing consciousness students have about learning processes and the impact in their future professional lives, and enhances the importance of the evaluation processes in the achievement of the strategic teaching/learning goals.

3 Recommendations and conclusions

Technical obsolescence occurs often in science, technology and, particularly in engineering subject areas. Thus it is crucial the development of the ability to “learn how to learn” and “learn how to think” [3]. The long-distance, lifelong and e-learning processes allow students and engineers to be permanently up-to-date in what concerns recent developments in their areas all around the world. Besides, they keep them permanently prepared for the inevitable requirements of life-long continuous education, it allows the exchange of information and the establishment of an opinion forum, which

results in a considerable improvement of flexible and open-minded-oriented knowledge.

Long-distance, lifelong and e-learning processes of teaching/learning allow surmounting many of the problems the traditional organisational structures of universities, courses and subjects impose:

- It fits the global tendencies to use Internet facilities to disseminate knowledge and overall communication all around the world, particularly among engineering students
- It corresponds to the best fit of cybernetic planning processes and the ever and ever increasing rates of environmental and institutional changes.
- It allows a broad mission definition and internalisation of global education processes.
- It facilitates the learning processes all world around, surmounting physical difficulties of being present in a certain place at a determined time.
- Conjointly with other teaching/learning methods, it enhances the involvement of students and professors, rendering easy the cumulative and directly applicable ways of structuring the solution to problems and their respective implementation.
- It enhances the development of research processes based upon the most recent developments in engineering and scientific areas.
- It standardizes and harmonises matters, scheduling timetables and evaluation methods, making easier the overall mobility of engineers in general, and students in particular.
- It allows a better fit within the strategies of the different decisional and functional layers in the institution.
- It grants the permanent up-to-date of the knowledge of people all around the world, and with the most various education areas, professional lives, gender and age.
- Finally, it contributes to the overall improvement in quality of life, through knowledge and culture.

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