PORTUGUESE RESEARCH UNIVERSITIES: WHY NOT THE BEST?

by

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ABSTRACT

In this paper I present certain controversial ideas and suggestions whose purpose is to help strengthen the ability of Portuguese universities to carry out first-rate research in the engineering and technology international arena, and to increase the visibility of Portuguese researchers and their institutions among their international peers.

The specific suggestions relate to:

(a) increase the productive time for serious research for faculty and post-graduate students, through changes in the academic calendar and examination procedures;
(b) strengthen the incentives and rewards for superior researchers;
(c) create a university administrative environment that fosters, encourages and rewards educational and research excellence and
(d) improve university-industry collaboration.

To implement these suggestions requires radical changes in current university rules and procedures with respect to teaching loads, examination procedures, faculty hiring and promotion policies, reward mechanisms, and accountability standards. Such changes will also require cooperative actions by the ministries of Education and Science & Technology.

1. BACKGROUND

After 38 years as a faculty member at MIT I have been fortunate to have a visiting research professor position at ISR/IST for the past 3 years. During this period of time I have had numerous discussions with engineering faculty and students at several Portuguese universities. Based on these discussions, I have become convinced that *there is an urgent need for structural reform in both the engineering education system and*

university-based research in major Portuguese universities. These changes, in my view, are imperative in order to support the strong desire of Portuguese faculty and post-graduate students to carry out advanced research and development efforts, of the same caliber and impact as those of their American and European colleagues.

I am a firm believer in the axiom that states "it is a crime to waste a fertile mind." Yet, it seems that Portuguese policies, procedures and traditions which impact university education and research have created an atmosphere that often inhibits the proper research and intellectual environment, which is absolutely essential to achieve excellence in research and education.

My own background at MIT (see Appendix A) as a teacher in both undergraduate and post-graduate subjects, as a thesis supervisor for numerous students, as a director of a MIT research laboratory, and as a co-founder of a high-tech consulting company has certainly influenced my evaluation of the educational and research climate in Portuguese universities. *My suggestions are based on my strong belief that Portuguese universities can do so much more to improve dramatically their academic excellence, research productivity and effectiveness, and industrial-university interactions.*

There is no doubt in my mind that Portuguese science and technology researchers, working within the university system, are fully capable of first-rate research and development accomplishments; and that they deserve greater international recognition. Yet, at present, such accomplishments and recognition are lacking. The million dollar question is: WHY?

I asked myself the following questions:

Are Portuguese students stupid? Of course, not! Indeed I have met numerous post-graduate students that are of the same intellectual caliber as the ones I knew at MIT.

Are Portuguese faculty incompetent? Certainly not! Most of them have excellent academic and research backgrounds.

Are Portuguese researchers lazy? No way! My Portuguese colleagues work very very hard.

Are laboratory and computer facilities inferior? Certainly not; they are often superior to those in several American and European universities.

Is there a lack of research funds? No! In point of fact, it is my opinion that it is much easier for Portuguese researchers to obtain research funding, including generous support for international scholarships and research leaves, than, say, in the United States.

So, what is the problem?

During the past year I have presented my ideas and suggestions in three different lectures[1]. After the lectures, I have received strongly supportive comments from numerous Portuguese faculty and students. Thus, it is evident that the very people that teach, and conduct and supervise research are quite frustrated with the present more-or-less archaic bureaucratic system for university research and education.

To "BE THE BEST", we must foster the emergence of Portuguese talents and credentials by modifying administrative rules and procedures that stifle individual creativity and initiative. Changes must conform with the self-evident rule:

Excellence breeds excellence, while mediocrity fosters mediocrity.

I sincerely hope that my controversial suggestions will form a basis for a national debate for university education and research reform, at least in engineering and related technology fields.

2. MY IMPRESSIONS OF ENGINEERING EDUCATION IN PORTUGUESE UNIVERSITIES

A summary of my impressions related to technological education and research in Portugal can be summarized as follows:

(1). Well-trained and hard-working post-graduate students
(2). Overworked and stressed junior faculty who:
- (a) strive to create a meaningful research environment
- (b) have too many teaching and administrative duties
- (c) must prepare and administer too many examinations
- (d) get frustrated by the lack of institutional incentives and support
- (e) suffer from little available time for deep thinking and concentrated research

(3). Too few full professors, some technically obsolete, who:
- (a) often exercise undue power-politics, with no accountability
- (b) often promulgate unfair and arbitrary promotion proceedings
- (c) encourage inbreeding in hiring, an extremely dangerous widespread practice

Clearly, few people can be superior researchers. By its very nature, good research is done by an "elitist" group of people, and it is nonsensical to think of "equality among researchers". But even superior researchers require prolonged periods of time to think deeply. Intense concentration and "well-being" are essential to unlock and unleash the creative process. High-quality research cannot be done in one's spare time! *And let us not forget that even superior dedicated researchers need to work in an environment in which their efforts are both appreciated and rewarded.*

[1] April 11 2000 at the Instituto Superior Técnico, January 25 2001 at the University of Porto, and April 9 2001 at the FORUM workshop at the University of Algarve. Copies of my slides can be found at **http://isr.ist.utl.pt/~jpc/portresuniv/**

It is also important to strive to establish and administer high-quality research groups, since research groups act as "idea multipliers" and serve as incubators for research apprenticeships for post-graduate students that are just starting their research career. Also, well-functioning research centers foster discussions that lead to, and define, superior "strategic research" directions that fully exploit the intellectual resources of the research team. Furthermore, in this age of rapid technological change, good researchers also have the responsibility to translate the state-of-the-art into advanced courses, so as to maximize the time to technical obsolescence for their graduate and undergraduate students. Hence, good research and effective teaching are intimately interlinked.

Unfortunately, in my opinion, the current situation in Portugal is characterized by "too much equality" and "little promotion of excellence."

It is inevitable that in research universities education and research are intimately intertwined. *In a research university, excellence in teaching and research go hand-in-hand and they are mutually reinforcing.* Let me compare undergraduate engineering students at MIT and IST (the two institutions that I am most familiar with), although I am confident that these comparisons are valid for other institutions as well:

(1). IST students are just as intellectually gifted and hard-working as their MIT counterparts
(2). In 5 years IST students have been taught almost *twice* as many technical subjects as compared to those of an average MIT student in a 4 year engineering curriculum.
(3). The depth of technical knowledge of MIT students is superior to that of their IST counterparts
(4). MIT students excel in independent thinking and problem-solving, while IST students are "spoon-fed"
(5). MIT students have more exposure to, and appreciation of, industrial issues and are far more sophisticated about the nature of the engineering research process than their IST counterparts

In my opinion, while IST engineering students have a far greater exposure to a variety of science and engineering subjects, their skills in deeply understanding and applying fundamental concepts, in conducting independent study, and executing complex problem-solving are inferior to those of their MIT counterparts. This state of affairs appears to be the consequence of treating undergraduate engineering education, learning and testing, as an extension of Portuguese high-school practices[2]. Thus, although both IST and MIT undergraduate students start with the same intellectual credentials, IST students simply do not have the time for deep understanding and true mastery of the very large volume of the technical material that they have been taught.

[2] An example is the common practice to offer (non-hardware) "laboratory subjects" where problems are solved by the instructor. This represents, in my opinion, a time-wasteful process, reinforces an inferior mechanism for learning, and is representative of the "spoon-feeding" mentality. Portuguese students deserve better.

The ministry for Science and Technology has instituted several innovations that benefit the research climate in Portugal. These include the granting of research funds to faculty and postgraduate students, financial support for international visits and collaborations, and rewards for superior research. However, these initiatives cannot by themselves lead to the needed improvements. It appears to me that the ministry of Education must undertake similar innovations that impact the Portuguese research environment, so that a coordinated national set of academic and research policies is formulated and implemented.

3. SUMMARY OF RECOMMENDATIONS

In this section I outline the essential elements of my suggestions. The initial motivation arises from the need to create more time for uninterrupted research and to improve the university environment for serious research. However, such changes cannot be either separated from, or accomplished without, the need for additional changes in the educational process. Furthermore, these changes require modifications in current policies and procedures that impact the formation of research groups, the introduction of new blood and ideas into the research process, and the orderly and timely transfer of technology to industry.

GOAL 1: Create more uninterrupted time for research by:

(a) reducing course requirements in the 5-year undergraduate engineering curriculum
(b) conducting all teaching and all examinations from ***September 15 to June 15***
(c) eliminating current practice of multiple examinations at the end of each semester for each subject

GOAL 2: Provide better career incentives and fair rewards for Portuguese researchers by:

(a) increasing the number of full and associate professors (inversion of the present academic pyramid)
(b) establishing regular promotion timetables and methods, following strict but fair evaluation of teaching and research excellence
(c) improving financial rewards for superior researchers

GOAL 3: Improve evaluation mechanisms and accountability in both the educational and research process by:

(a) continuing use of international evaluation (visiting) committees for ranking and evaluation of research centers
(b) initiating use of international evaluation (visiting) committees for ranking and evaluation of academic department educational practices and policies
(c) strengthening university administration

GOAL 4: Improve university-industry collaboration

In the remainder of this paper I shall expand on each one of these suggestions.

4. GOAL 1: CREATE MORE UNINTERRUPTED TIME FOR RESEARCH

As I remarked above, good research requires periods of uninterrupted time for deep thinking. *Portuguese faculty members simply do not have such uninterrupted time, because of heavy teaching loads and the insane practice of the current examination system.* To create more time it is necessary to modify the present practice related to both undergraduate and post-graduate educational system.

Suggested Changes In Undergraduate Education

(1). Classes and examinations should take place only from mid-September to mid-June, with no formal lectures or examinations during the summer
(2). Undergraduates should only take 3-4 technical subjects each semester. At present there are too many classes and "non-hardware laboratories"
(3). Eliminate the wasteful practice of repeated examinations at the end of each semester
(4). Expose undergraduates to the research environment, as early as possible
(5). Provide serious academic and career counseling to students by faculty
(6). Encourage undergraduates to obtain summer jobs in industry

My suggestions for creating more time for research reflect the best practices of well known American universities (such as MIT, Univ. of California at Berkeley, Stanford, Univ. of Michigan, Univ. of Illinois, Carnegie-Mellon to mention just a few).

Current undergraduate education in Portugal appears like the continuation of high school teaching methods. For five years, undergraduates are expected to enroll in 5-7 technical subjects per semester and spend more than 25-30 hours per week in the classroom and problem-solving "non-hardware laboratory" subjects. As a consequence, there is very little available time for serious learning during the semester and there is no feedback mechanism (such as regular graded homework and midterm exams), to either the student or the faculty, to assess the quality and depth of learning during the semester. Thus, the students are forced to try to learn and assimilate the semester-long technical material during the 1.5 to 2-month examination period and they are also given 2-3 opportunities to pass a final examination. *It follows that the quality of learning, the proper assimilation of prerequisite material before advanced concepts, and independent thinking suffer.*

Contrast the Portuguese system with that of first-rate US engineering schools. In a typical 4-year undergraduate engineering or science curriculum the student is expected to take only 3-4 technical subjects each semester, typically accompanied by a non-technical humanities course. Graded homework, quizzes, mid-term tests and a single final examination are used to monitor and evaluate, continually during the semester, the quality of student learning. The fact that there are fewer required technical subjects allows the US student to assimilate the material in an orderly manner, encourages independent thinking and study, and alleviates "panic learning" just before the final examination.

I favor a 5-year undergraduate degree program, with drastically reduced technical subject requirements of 3-4 subjects per semester. The student should not be expected to spend more than 12-15 hours per week in lectures, and the current practice of supervised problem-solving should be ended. Graded homework and mid-term tests should be instituted. Following the end of the course, a week should be allowed for the student to study and then during the following week he/she should take a single examination per subject with no recourse to a second or third try. Such changes will allow the student to properly learn in-depth the material in a timely manner, foster independent study and thinking, and improve the quality of the educational process.

By having a semester of 14-15 weeks for all teaching and examinations, it becomes feasible to free three summer months for both students and faculty. Thus, *I suggest that all academic activities take place, say, from September 15 to June 15, freeing the three summer months for research.*

Eliminating the current practice of repeated examinations will result in a major time-saver for faculty. A typical faculty member who teaches 3 technical subjects must make 9 different examinations each semester! *This is a great waste of time, because it is next to impossible to design three high-quality different exams for each subject.* This time could be better utilized to improve the quality of teaching and/or to do serious research.

In science and technology, and especially in engineering, technical obsolescence can occur in as little as 10 years. To safeguard against such technical obsolescence, undergraduate students must "learn how to learn" and "learn how to think" so that they are prepared for the inevitable life-long continuing-education requirements. It is far better to learn fundamentals well and in depth, rather than to fire-hose the students with a myriad of technical details, many of which may well become obsolete by the time the student graduates. In short, stop the current practice of having undergraduate engineering education mimic that of high-school; it only encourages mediocrity.

I also suggest that undergraduate students be allowed to sign-up for an "undergraduate research opportunity project (UROP)" in which they are encouraged and expected to interact with on-going research groups and mingle with post-graduate students, professors and post-docs in a research project. Such an educational experience provides a major input to the student to appreciate the relevance of technical subjects, expose undergraduates to research practice and ambience, and further encourages them to think deeply and independently[3].

By freeing the three summer months, students will be able to work in industry during the summer months, apply and sharpen their technical knowledge and also earn some money. Others may want to continue with their UROP during the summer, perhaps with a small salary stipend. Others may simply choose to go to the beach and that is OK as well. *It*

[3] UROPs were introduced at MIT in the 1970´s and were soon copied by most major US research universities. MIT undergraduates consistently cite the UROP experience as one of the most important aspects of their undergraduate education!

will be very worthwhile if the Portuguese universities take the initiative in bringing students and industry together for possible summer employment.

Suggestions for Post-Graduate Education and Research

(1). Postgraduate students are an essential element of the research process. They should be provided with an adequate salary (conditioned on satisfactory research progress) and they should alternate between teaching and research assignments

(2). A strong Masters thesis in engineering is essential. The Masters degree, however, should not take more than 1 1/2 to 2 years. Moreover, the current jury system for the Masters degree should be eliminated, since it is a waste of time and faculty resources. The Masters thesis supervisor should be entrusted in qualifying the quality of the Masters thesis

(3). The doctoral thesis should be completed in 3-4 years; at present, it takes too long to get a Ph.D. in engineering. There should be tough qualification criteria (written and oral exams) for the doctorate. A doctoral thesis committee should be established early and the candidate must provide frequent progress reports, as well as future research plans, to the entire doctoral thesis committee. This will streamline and enhance the final thesis defense to the jury.

(4). Doctoral students should have NO expectations for a guaranteed academic career, especially in the same university, thus avoiding the very serious problem of inbreeding

(5). All Masters and Ph.D. theses in engineering should be written in English. Defense of the Portuguese language at this level is completely counterproductive.

There is no question that post-graduate education and research is a key and crucial element of the overall university research process. Post-graduate students, and especially those pursuing the Ph.D. degree, are probably the most important future national intellectual resource. At present, it is my impression that it takes too long to get a Ph.D., and every effort must be made to streamline the overall process. Ph.D. students must be encouraged to develop and exercise their creative process, become true experts in their research topic, publish their research in well-known international research journals, and cultivate as early as possible strong ties with international peers and research groups in their area of specialization. Most important, Ph.D. students should not be treated as "slaves" in the hands of certain powerful "academic dictators", as is sometimes the practice in some Portuguese academic departments.

5. GOAL 2: PROVIDE BETTER CAREER INCENTIVES AND FAIR REWARDS FOR PORTUGUESE RESEARCHERS

Many of my Portuguese research colleagues, especially young ones, work an 80-hour week with minimal professional recognition from their institution and without significant financial rewards. No wonder they feel frustrated. *It is so tempting for them to contemplate giving up the hard work and the demanding hours that research requires, and to degrade to a comfortable "acceptable mediocrity" status of just teaching the same old subjects and not being involved in thesis supervision and research.* After all, their

salary will remain the same and the administrative system does not seem to either care about or reward excellence.

Portuguese research universities must strive to encourage "research superstars" and to provide them with the intellectual, administrative and financial resources so as to foster faculty research productivity.

Suggestions for Research Incentives

(1). Provide extra salary, up to 3 summer months, paid by research contracts (no contracts, no pay). Treat the current 14-month salary as a 9-month salary.
(2). Allow faculty one day per week for industrial paid consulting, while retaining full-time faculty status.
(3). Promote faculty according to a fixed schedule, with tough but fair criteria of excellence, and establish multiple professorial ranks to reward excellence in research and teaching
(4). Reduce teaching loads for superior researchers; 2-3 subjects per year (not per semester), averaging ±6 hours per week, should be normal load. Credit should be given for thesis supervision.
(5). Establish annual departmental and institute-wide awards honoring superior achievements in research, teaching and thesis supervision for both faculty and students
(6). Provide adequate technician, secretarial and accounting support for administering and execution of research contracts. Researchers, thank God, make bad accountants!

The suggestion of "extra pay" for the three summer months (freed by the recommended changes in the academic calendar) may appear to be a radical recommendation. *The funds for this summer pay must come from external research grants and contracts.* If such funds cannot be raised by the researcher, or his/her research team, there should not be a financial reward. Professors who are not good researchers, and cannot obtain research funds, are not penalized since they still receive their 14-month salary, and they can use the summer to (hopefully) improve their research and/or teaching credentials or work in industry or go to the beach, as they see fit. *I firmly believe that salary equality is a major cause for educational and research mediocrity.*

The biggest disincentive, especially for young Portuguese faculty members, is the fact that promotions are based on "openings" rather than merit, and not according to an established timetable. I believe that there are too few full professors and too many assistant professors in the current Portuguese university system. Figure 1 illustrates this point, showing that in typical US research universities the "academic pyramid" is inverted.

There are about the same number of faculty members in the DEEC/IST and EECS/MIT departments. At MIT there are many more full professors (65) as compared to IST (18)

while the number of assistant professors (20) at MIT is much smaller than those (75) at IST. Similar patterns exist at all major US research universities.

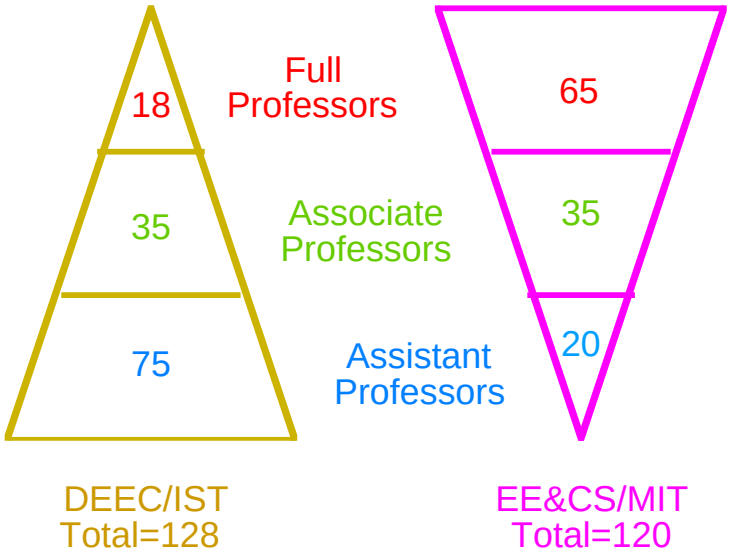

Figure 1. A comparison of academic ranks at the department of Electrical and Computer Engineering (DEEC) at the Instituto Superior Técnico (IST) and the department of Electrical Engineering and Computer Science (EE&CS) at the Massachusetts Institute of Technology (MIT)

The difference is that MIT promotes (or kicks out) faculty members on a fixed schedule. Promotion from Assistant to Associate Professor typically takes place after 4-5 years following the Ph.D. degree. Such promotion requires excellence in teaching, research and thesis supervision; the candidate must meet these high standards to be promoted, or otherwise is fired. The tenure decision is 1-2 years later; once more, there must be convincing international evidence, documented by *confidential letters of recommendation* from peer researchers all over the world, that the candidate is near the top of his/her international peers at the same age bracket. The tenure decision is the most important decision in the academic ladder, resulting in the termination of employment of inferior educators and researchers. Promotion to Full Professor is considered 2-3 years later; the candidate must demonstrate additional educational and research achievements (i.e. books, key journal articles, professional honors) beyond those considered in the tenure decision; otherwise, the promotion case is delayed for 2-3 more years. Salary compensation increases with each promotion, but there are additional merit-based rankings among the different faculty levels resulting in significant salary inequality, so that excellence in teaching and research always results in financial rewards to the faculty.

The American university hiring and promotion system is designed to avoid personal favoritism or nepotism and to reward fully-documented excellence. Typically, each department has a personnel committee, composed of a dozen or so full professors from each field. The department chair solicits highly-confidential recommendation letters, from both inside the department as well as from international peers (the higher the

promotion case, the larger the number of "outside" letters). A member of the personnel committee is assigned to be the "champion" of the candidate, but extensive discussion of both the strengths and weaknesses follows, and a decision is reached by secret vote. Next, all promotion cases are fully discussed, and voted upon, in a School of Engineering personnel committee, composed of the Dean and the department chairs. Finally, all cases go to a university-wide personnel committee, composed of the president or provost and the deans, for final disposition. It should be self-evident that the system rewards only fully-documented achievements and excellence. The probability of "favoritism" is essentially non-existent.

Unfortunately, the situation in Portugal is very different. Assistant and associate professors must wait, for many many years, for a "faculty opening" and a chance for promotion. More often than not, and in spite of a (ineffective) jury system, their promotion hinges on the whims of powerful "academic dictators" and depends on the past pattern of obedience and subservience to them. Academic dictators often manipulate the jury, especially since outside confidential recommendation letters are not commonly used. Merit-based salary increases are, for all practical purposes, nonexistent. Salary increases are based on years of service rather than upon documented research and educational excellence.

The tenure system in Portugal does not carry out the exhaustive examination of the candidate's educational and research achievements required to guarantee a lifetime faculty appointment. It appears that tenure is granted routinely[4], often to undeserving candidates. The tenure process does not appear to require documented achievements and outside confidential letters of recommendation are neither required nor used. Current tenure policies must be drastically modified. Otherwise, mediocre faculty will dominate the educational and research system for decades to come, and inevitably the axiom "mediocrity breads mediocrity" will prevail.

The current "aggregation" procedure requires the candidate to produce an exhaustive outline of a course, on a lecture-by-lecture and problem-by-problem basis. A promising faculty member wastes 2-3 months to write such a detailed report, which is completely void of intellectual promise, documented research credentials or effective teaching (more shades of high-school mentality). These 2-3 months could have been better devoted to improving educational quality and innovative research.

The suggested inversion of the academic pyramid will provide valuable incentives to deserving young faculty and, in addition, it will also help to dilute the political power of few full professors. The presence of several full professors, within the same field, simply does not allow a particular faculty member to reward mediocrity. Even more important, if the number of assistant professors is small, full professors will typically champion young ones to entice them to collaborate in their teaching and research duties. This recognizes the indisputable fact that in engineering and technology young faculty are those that have mastered the state-of-the-art, and are in their most productive phase of

[4] I have been told that in the DEEC department at IST only one faculty member was denied tenure during the past 15 years or so!

their research career. Being nice to assistant professors, rather than dealing with them as glorified slaves to full professors, represents a very powerful mechanism to strive for excellence and avoid mediocrity. Furthermore, it encourages the formation of research teams, with a variety of talents and ages, which are essential in this modern technological era to provide "idea multipliers", serve as training ground for undergraduate and graduate students starting their research, defining relevant long-range strategic research directions, establishing a research-team spirit and loyalty, and securing long-range financial support for the research projects.

The financial costs of "inverting the pyramid" by increasing the number of deserving full and associate professors is minimal. There is a very small spread among the salaries of full and assistant professors in Portuguese public universities. The small financial cost will be more than justified by the increased productivity and quality of teaching and research.

It was shocking to me to note the absence of any institutionalized academic awards for excellence in teaching and research in Portuguese universities. It is common practice in US universities to have a variety of awards at the end of each academic year. They are given both at the departmental as well as the university-wide levels. These awards recognize excellence in teaching and/or research accomplishment for postgraduate students, junior faculty and senior faculty. These awards are presented at special, well publicized and attended, departmental/university-wide faculty meetings and reinforce the much needed reward mechanisms to recognize excellence in teaching and/or research.

6. GOAL 3: IMPROVE EVALUATION MECHANISMS AND ACCOUNTABILITY IN BOTH THE EDUCATIONAL AND RESEARCH PROCESS

The successful implementation of the changes in research and education discussed above require changes at the local university level as well as at the national level. Portuguese universities enjoy autonomy, but it is not clear how accountability is monitored and how excellence is assured.

University Policies

(1). International departmental/research-center visiting committees should have major impact and real power in assessing educational excellence and research accomplishments[5]. Visiting committees should meet every two years.

(2). Visiting committees should be composed of high-caliber international academic and industrial leaders (no politics!). They should conduct confidential individual and group sessions with students and junior faculty, evaluate the fairness and quality-control standards regarding hiring and promotion, help isolate "academic dictators" from the mainstream process, and promulgate full public disclosure of evaluations and recommendations

[5] These visiting committees are different from those that carry out curriculum accreditation.

(3). University administrators must be required to pay attention to, and have the power to act upon, the recommendations of visiting committees

(4). Remove politics from the university administration! Only faculty should decide educational and research policy, because students and support staff simply do not have the required strategic long-term vision (student committees can and should provide input to faculty decisions). Also, as far as educational and research innovations are concerned, university administrators (chairs, deans, etc) must be responsible only to the faculty, rather than be constrained in pleasing students and support staff in order to get elected or re-elected.

(5). Enforce fair, tough and impartial tenure and promotion procedures. Promote on fixed schedule, not based on openings. Document international research reputation.

(6). Faculty inbreeding should be discouraged; hire only the best!

(7). Strive for improved university-industry collaboration. Establish mechanisms for life-long learning.

One of the best mechanisms for enforcing accountability is the use of "visiting committees" or evaluation committees. In every US research university each department and each research center has a visiting committee. The members of these visiting committees are faculty members from other universities (including international ones) and respected members of industry. The membership is controlled by the university administration with input from the respective departments or research centers.
Visiting committees meet every two years and their recommendations are publicized and provided to university administrators (department chairs, research center directors, deans, provosts etc). Visiting committees monitor and evaluate the degree of compliance and changes by departments and research centers of prior-year committee recommendations.

In the past few years, the Portuguese ministry for Science and Technology has successfully instituted the use of such visiting committees for evaluating and ranking numerous research centers. The members of these committees are international researchers (some of Portuguese origin) whose knowledge matches that of the research centers. Their evaluations and rankings are publicized and their findings form the basis for allocating R&D funding to the research centers by the ministry for Science and Technology. Thus, excellent research centers receive more research funding than mediocre ones[6].

Unfortunately, a parallel system of visiting committees for academic departments has not been instituted by the Minister of Education. It is suggested that this practice be initiated as soon as possible. The visiting committees should consist of national and international academics, include industrial representatives, and should be integrated (or at least coordinated) with those evaluating the research centers. *Such academic visiting committees should evaluate the strengths and weaknesses of each academic department; including hiring practices and inbreeding, fairness and quality of tenure and promotion cases, listening to concerns of undergraduate and graduate students regarding the*

[6] The proof that these research visiting committees are effective is that administrators of poorly ranked centers bitterly complain that the committee members are "biased."

quality of teaching and examinations, listening to the concerns of faculty members (especially young ones), and departmental issues. The findings, evaluations and recommendations of these academic visiting committees should be publicized and referred to the appropriate department chair, dean, provost as well as the Minister of Education. *These university administrators should have the will and the power to act accordingly so as to implement any changes recommended by the visiting committee.*

An important byproduct of the interaction and coordination of the research and academic visiting committees will be the definition (and wide dissemination) of university policies and procedures related to the requirements for excellence in teaching and distinguished research for hiring, promotion and tenure cases. In this manner, politics pertaining to personnel issues carried-out by "academic dictators" will be mitigated, if not completely eliminated. In this manner, *the universities become accountable to these blue-ribbon international visiting committees.* This is why the Minister of Education must be the end recipient of the academic recommendations of the visiting committees.

In my opinion, *one of the most serious problems currently facing all Portuguese universities relates to inbreeding.* It should be noted that many of the present senior faculty at Portuguese engineering schools received their Ph.D. degrees in the USA or Europe. This has brought a welcomed diversity of research ideas and technical subjects to the education and research environment. At present, there is a large number of post-graduate students that will soon get their Ph.D. and, by the quirks of the current system, will remain as assistant professors in the same department. *Such inbreeding is highly undesirable, because few future fresh ideas will be introduced into the research system.* Urgent measures must be found to discourage and avoid this type of inbreeding. For example, the current generation of young Portuguese researchers should be strongly encouraged to spend a research leave (from 6 to 12 months) in a high-quality research university outside of Portugal. In the absence of tough promotion and tenure decisions, this inbreeding may also lead to a serious mediocrity in the Portuguese educational system for the next 30-40 years. In addition, it should be noted that current practices that encourage inbreeding cut-off deserving and talented Portuguese students, currently working on their Ph.D. outside of Portugal, from even being considered for a faculty position in Portugal! *The continuation of current inbreeding practices will unfortunately become a vivid proof of the "mediocrity breads mediocrity" axiom.*[7]

7. GOAL 4: IMPROVE UNIVERSITY-INDUSTRY COLLABORATION

At present, there is minimal interaction between universities and Portuguese industry. Closer cooperation will be beneficial for both. The potential benefit is to increase the high-tech capability of Portuguese industry, improve productivity through technology, and increase the international market share of Portuguese industrial products and services.

[7] Unfortunately, some "academic dictators" encourage hiring their mediocre students and employ inbreeding as a means of hiding their academic incompetence and inferior research capabilities.

It is no accident that in the United States and some European countries industry has blossomed in the vicinity of strong research universities. Examples include the abundant industrial parks in the vicinity of universities such as MIT, Stanford, Michigan, Duke, Texas to mention just a few. In this information age the transfer of ideas between universities and industries results in cooperative ventures with immense national economic benefits. Spinoffs from universities, often spearheaded by academic entrepreneurs, create new high-tech employment opportunities and increase national wealth.

Clearly, university-industry cooperation centers about the flow of people and ideas. At present, undergraduate students have no exposure to industrial practices and needs prior to graduation. The suggested changes in the academic calendar will allow undergraduate students to obtain summer jobs in industry, reversing the current situation. Also, some faculty members may choose to work in industry during the summer. Exposure of industrial needs to faculty and students can be very beneficial in the formulation of relevant research projects.

Figure 2 summarizes the nature of desirable interactions. To be effective there must be a two-way flow of people and ideas. Some are discussed in the sequel.

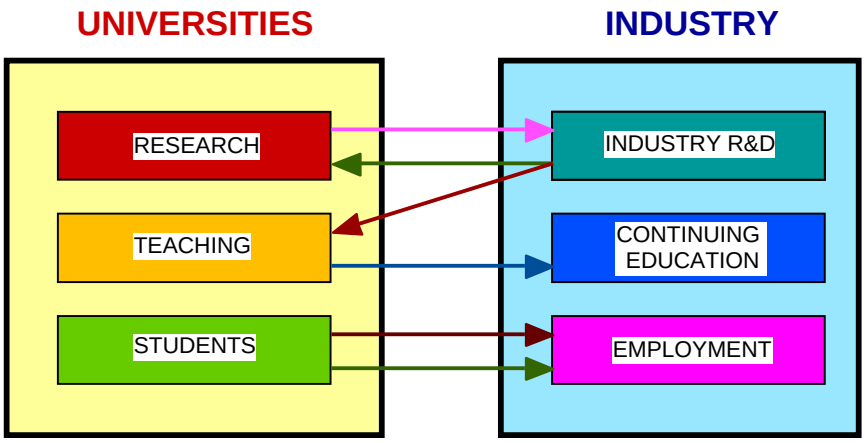

Figure 2: Improved cooperation between research universities and industry will yield national economic benefits

Apart from the benefit of summer jobs, industrial needs generally fall into two categories: short-term and long-term. Often, industry requires the rapid infusion of technological and engineering knowledge in some product development or service. The short-term nature of these needs is best served by hiring an engineering faculty member as a consultant. By allowing, as suggested before, faculty to consult one day per week, many industrial needs will be served. The faculty member can, and should, sign a nondisclosure agreement with the company to safeguard potential trade secrets. The faculty member must advise his/her department of such consulting arrangements (so as to avoid conflict of interest) but the university must not interfere with, or share in, the financial arrangements.

Long-term R&D contracts can also benefit certain industries. Obviously, not every industrial need is suitable for academic research, especially a doctoral thesis. A great degree of care must be exercised in defining and executing such R&D contracts from industry to the university. Companies must be sensitive to the long-term requirements, especially if they form part of doctoral theses. Also, proper administrative procedures must be established that reach the proper balance between open publication of thesis research and safeguard of company proprietary information. In spite of such potential difficulties, industrial contracts with universities can yield mutually beneficial results. *If R&D tax incentives are provided to the company, almost surely such collaborative R&D efforts will become more popular and effective.*

Universities should also encourage industrial experts to teach, on a part-time basis, a course or extended seminar at the university. Engineering faculty often do not have the pragmatic expertise in teaching design-oriented topics, including economic considerations and cost-benefit analyses, and often such subjects are simply not taught. Part-time " Adjunct Professors" from industry can fulfil such academic needs contributing to a balanced theory-practice engineering education.

Rapid technological change requires that practicing engineers and scientists must adopt a lifelong learning process, so as to remain productive and competitive. *It is the responsibility of the university to provide mechanisms to address these continuing-education needs of practicing engineers and technologists.* This can be accomplished by organizing intensive courses, ranging from 1-2 day seminars to 1-2 week subjects, offered during the summer to industrial participants. Tuition should be charged for such offerings, and any profits should be divided between the participating faculty and the university.

To recapitulate: the suggested changes in the academic calendar, freeing the summer for possible industrial jobs for students and faculty, the liberalization of faculty consulting privileges, and the encouragement of appropriate advanced technology industrial contracts to universities will greatly improve the much-needed university-industry collaboration in Portugal. These, in turn, will result in greater economic benefits at the national level.

8. RECAPITULATION

I summarize below the main suggestions discussed in this paper. I believe that these changes would contribute to a significant improvement in the quality of undergraduate education and of research, will improve the well-deserved international visibility and recognition of Portuguese researchers and result in university-industry collaborations that contribute to the national economic welfare.

(1). Change the academic calendar: September 15 to June 15
  (a). eliminate multiple examinations at the end of each semester
  (b). encourage undergraduate research projects, as early as possible

(2). Increase significantly the numbers of full and associate professors, using fair but tough standards for tenure and promotion.
(3). Provide well-deserved financial rewards to distinguished faculty researchers and educators; better people should make more money.
(4). Stop "inbreeding"; it has reached dangerous levels.
(5). Institutionalize international peer-review using visiting committees; at present full professors have too much power and no accountability.
(6). Increase power of department chairs, deans etc, by eliminating political elections
(7). Formalize "research-university" status.
(8). Encourage university-industry collaborations.

9. CONCLUDING REMARKS

There have been very significant improvements in Portuguese university education and research in the past 25 years. However, decision-makers must realize that, during that period of time, dangerous practices have evolved (often under the guise of academic freedom) which, unless addressed and changed, will seriously degrade the future Portuguese quality of technological education and inhibit the best efforts of productive researchers.

Based upon discussions with my Portuguese colleagues, I am convinced that the vast majority of responsible educators and researchers support the "spirit", if not the "letter," of my suggestions and agree with the need for urgent reform. Students will benefit from a more balanced, orderly, and less frantic technical education. Opponents will consist of "academic dictators" and senior faculty and administrators that are afraid that they will lose their power, and expose their mediocrity as teachers and researchers, by changing the "status-quo." Probably, unions will be opposed since I do not advocate "equality for everyone." Some will argue that the suggested changes do not agree with "tradition." They should be reminded that "mediocre traditions" are certainly not the hallmark of a progressive society!

I hope that the Portuguese government, and especially the ministers of Education and Science and Technology, will take the initiative in forming a "blue-ribbon" panel, with very wide and broad representation, to discuss the needed reforms and to make specific recommendations for changes in the applicable laws. It is imperative that this panel should not be dominated by present high-level university administrators; rather, it should include several young faculty members and postgraduate students with recognized research and education credentials. The panel should also include well-known Portuguese faculty that currently are employed abroad. Finally, the panel should solicit opinions and advice from other distinguished European and American educators, researchers and academic administrators.

There is nothing worse than a wasted fertile mind.

APPENDIX A: BIOGRAPHICAL SUMMARY

Michael Athans (formerly Michail Athanasiadis) is Professor Emeritus, Dept. of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, Cambridge, Mass. USA and Visiting Research Professor, Instituto de Sistemas e Robótica, Instituto Superior Técnico, Lisbon, Portugal.

Michael Athans was born in Drama, Greece on May 3, 1937. After high school he emigrated to the USA where he attended the University of California at Berkeley from 1955 to 1961 where he received his BSEE in 1958 (with highest honors), MSEE in 1959 and Ph.D. in control in 1961.

From 1961 to 1964 he was employed as a member of the technical staff at the MIT Lincoln Laboratory, Lexington, Mass. USA where he conducted research in optimal control and estimation theory. From 1964, till his early retirement in 1998, he was a faculty member in the MIT Electrical Engineering and Computer Sciences department, where he held the rank of Professor. He also was the director of the MIT Laboratory for Information and Decision Systems (LIDS) from 1974 to 1981. He acted as the thesis supervisor for 41 MIT doctoral students and over 80 Masters students. In 1978 he co-founded ALPHATECH Inc., Burlington, Mass., where he serves as Vice-Chairman of the Board of Directors. He has also consulted for numerous other industrial organizations and US government panels. In 1995 he was Visiting Professor in the Department of Electrical and Computer Engineering at the National Technical University of Athens, Greece. In 1997 and since 1998 he is a Visiting Research Scientist in the Institute for Systems and Robotics, Instituto Superior Técnico, Lisbon, Portugal.

Dr. Athans is the co-author of *Optimal Control* (McGraw Hill, 1966), *Systems, Networks and Computation: Basic Concepts* (McGraw Hill, 1972) and *Systems, Networks and Computation: Multivariable Methods* (McGraw Hill, 1974). In 1974 he developed 65 color TV lectures and study guides on *Modern Control Theory*. In addition, he has authored or co-authored over 325 technical papers and reports. His research interests and contributions span the areas of optimum system and estimation theory, multivariable control systems, and the application of these methodologies to defense, large space structures, IVHS transportation systems, aerospace, marine, automotive, power, manufacturing, economic, and military C3 systems. His latest research interest revolves on the use of system-theoretic methods for human immunological systems.

In 1964 he was the first recipient of the American Automatic Control Council's *Donald P. Eckman Award* "for outstanding contributions to the field of automatic control by a young researcher". In 1969 he was the first recipient of the *Frederick E. Terman Award* of the American Society for Engineering Education as "the outstanding young electrical engineering educator." In 1980 he received the *Education Award* of the American Control Council for his "outstanding contributions and distinguished leadership in automatic control education." In 1973 he was elected Fellow of the IEEE and in 1977 Fellow of the AAAS. In 1983 he was elected Distinguished Member of the IEEE Control Systems Society. He received the *1993 H.W. Bode Prize* from the IEEE Control Systems Society, which also included the delivery of the prestigious *Bode Plenary Lecture* at the 1993 IEEE Conference on Decision and Control. His latest award is the *Richard E. Bellman Control Heritage Award* of the American Automatic Control Council "In Recognition of a Distinguished Career in Automatic Control; As a Leader and Champion of Innovative Research; As a Contributor to Fundamental Knowledge in Optimal, Adaptive, Robust, Decentralized and Distributed Control; and as a Mentor to his Students" presented in June 1995 at the American Control Conference. In 1996 he was awarded honorary doctorates from the National Technical University of Athens, Greece, and from the Technical University of Crete, Chania, Crete, Greece.

Professor Athans has served in numerous committees of IEEE, IFAC, AACC and AAAS; he was president of the IEEE Control Systems Society from 1972 to 1974. In addition he is a member of AIAA, Phi Beta Kappa, Eta Kappa Nu, and Sigma Xi. He has served as Associate Editor of the IEEE Trans. on Automatic Control, Journal of Dynamic Systems and Control, and the IFAC journal “Automatica.”