Polish University Confronted with Economic Transformation: Two Strategies of Survival

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Abstract: *The process of economic transformation in Poland is briefly characterized, as well as the situation of Polish academic institutions after 1989. Two basic strategies of their adaptation to this situation are outline d.. the strategy of status quo preservation and the strategy of accelerated development. An example is given to demonstrate the efficiency of the latter strategy, viz. the program of reforms carried out at the Faculty of Electronics and Information Technology, Warsaw University of Technology. Finally, conclusions are drawn from the presented analysis of the situation of the Polish academia and recommendations are formulated concerning both individual universities and the whole system of higher education in Poland.*

Keywords: higher education, Polish universities, system of study.

1. Introduction

In 1989 Poland underwent a radical political change that finished its dependence on the Soviet Union and communist ideology. As a consequence, the process of economic reforms was started and has been continued up to now. The main elements of the program of economic reforms are the following:

- abandoning the system of central planning,
- step-by-step development of the private sector of economy,
- step-by-step development of the banking system,
- setting free markets of goods and services,
- opening to international economic cooperation.

The first two years of reforms brought important improvement to the economic situation of Poland: the inflation rate which reached 100% per month by the end of 1989 was reduced to ca. 30%. per year, Polish currency became almost convertible into foreign money, consumer goods that had been absent for years on the Polish market appeared in shops, many private enterprises started to operate. At the same time, within next years (1992-1995) some negative side-effects emerged and overshadowed the first success. The most important of those side-effects are:

- 15% unemployment rate,
- disastrous economic condition of State-owned industrial enterprises of large scale (mines, shipyards, steelworks) and of middle scale (electronic and precision industry);
- year-by-year growing difficulties in planning the State budget that imply troubles in State financed sectors of economy, esp. in health care and education;
- cultural degradation of the society caused by the inflow of pop-culture, by the bankruptcy of many high-level cultural institutions (theaters, orchestras), and by the attractive force of financial opportunities created by the new economic system.

The latter phenomenon is mentioned here since it has significantly modified attitudes of the society towards education goals and institutions.

And what about Polish universities and other academic institutions ? How did they react to such dramatic change in the environment in which they function ? This paper is intended to answer this question. First, in Section 2, the situation of Polish academic institutions in 1989-95 is characterized in more details. Next, in Sections 3 and 4, two basic strategies of their adaptation to this situation are outlined, viz. the strategy of *status quo* preservation and the strategy of accelerated development. In Section 5, an example is given to demonstrate the efficiency of the latter strategy. Finally, conclusions are drawn from the presented

considerations, as well as some suggestions are formulated concerning individual universities and the whole system of higher education in Poland-

2. Polish universities after 1989

The process of deep restructuring of the economy radically changed external conditions of the functioning of Polish universities. The essential elements of the new situation are the following:

- growing demand for the graduates in business-related and management-related disciplines,
- growing demand for service-oriented professions,
- market-driven professional re-orientation of the society,
- accelerated development of international economic co-operation,
- strong pressure on economically efficient education.

The last-mentioned element appeared not only due to the introduction of the mechanisms of market economy, but also because of the substantial budget cuts that reduced the real value of the allowance provided by the Ministry of National Education for each student by about 70°/0 in the period 1990-1995. Although all Polish universities suffer from financial constraints, the situation of engineering schools is particularly difficult for two essential reasons: higher costs of running engineering courses, compared to arts and science courses, and bad shape of the Polish industry.

The whole time interval 1989-1995 may be subdivided into three periods: legal initialization (1989-1991), adaptive restructurization (1991-1993) and creeping frustration (1 993-95). During the first period, new academic laws were passed by the Parliament, a new institution responsible for financing research projects (State Committee for Scientific Research) was established, and new rules for financing the teaching activity of the universities were introduced by the Ministry of National Education. As a consequence, the process of restructuring universities, aimed at adaptation to new circumstances, was undertaken. The following state of affairs was attained in 1993:

- the total yearly enrollment increased from 77000 students (10.97. of the age-group) in 1990 to 170000 students (15. 9% of the age-group) in 1993;
- the total number of academic staff was reduced significantly; consequently, the students-to-professors ratio grew from 9.35 in 1990 to 15.67 in 1993.

Such a spectacular improvement of efficiency had been achieved despite the severe cuts of allowances provided by the Ministry. Clearly, this yields a measure of the reserves that had existed in the universities before 1993, but - on the other hand - it characterizes the efforts undertaken by academic institutions to meet the challenge of "hard times" of transformation. The expectations engendered by those efforts were frustrated in 1994 when further cuts of financial support for education sector turned out to be inevitable. All the negative side-effects of the underfinanced transformation appeared with more force and evidence:

- having exhausted simple reserves, the universities started to look for other (than restructuring) means of survival: paid forms o education, letting out for hire lecture halls and parts of university buildings, running non-academic business;
- disappointed academic staff came to a conclusion that higher education is out of the priorities of the new authorities who seem to ignore the significance of high intellectual qualifications as their communist predecessors used to do;
- requiring more of the academic staff, the authorities reduced the subsidies and - what is incongruous - refused to allow the universities to rationalize the system of salaries.

The last-mentioned problem became crucial during recent years because of the progressing differentiation of the involvement of the academic staff into academic work. According to the current regulations, professors who spend 60 hours per week at the university and those who limit their presence to 8 hours spent in the classes should be paid at the same level, i.e. at the level of a scrub-woman in a bank.

In the next two Sections, two typical reactions of the universities to the difficult and ambiguous situation are described. They seem to well represent essential components of the universities behavior since they have been adopted in various proportions by all of them.

3. Strategy of *status quo* preservation

The traditional model of a Polish university is characterized by:

- overvaluation of autonomy and other academic qualities historically attributed to the European universities;
- the priority of collective over individual authorities (i.e. the Senate over the Rector, the Faculty Council over the Dean);
- an inflexible and fragmented management structure;

♦ the priority of long-term over short-term effects.

Thereare several practical consequences of this model which determine behavior of a Polish university in a crisis situation. The first of them is a preference for cost-based rather than effect-based management - for thinking in terms of preserving the substance (infrastructure) rather than in terms of attaining goals; this preference often implies a kind of aversion to managerial style of 'running an academic institution. The second important consequence of sticking to the traditional model of the university is the domination of the claim-driven attitudes among the academic staff. To demand preservation, restitution or expansion of academic rights or dues in a formal way seems to be more natural than getting those rights or dues in practice by an appropriate change of structures, managerial moves, etc.

The above-described attitudes constitute a natural basis for a strategy called here "strategy of *status quo* preservation" whose main elements are the following:

♦ submitting petitions to the authorities - internal (Rector and Senate) or external (Ministry of National Education, Scientific Research Council, Parliament) - for additional financial support;
♦ increasing yearly enrollment over the limits of available resources at the cost of the quality of education (reduced laboratory courses, lectures in overcrowded auditoria);
♦ renting university rooms for non-academic purposes (shops, offices, bars, etc.);
♦ using laboratory resources for running small private companies or services;
♦ letting academic staff take external, frequently non-academic jobs;
♦ minimizing teaching-related activities to save time for profit-yielding activities, in particular - avoiding program changes;
♦ Postponing necessary changes in management structures, organization of the university and its units to preserve balanced relationships among the academic staff and aviod costs of resulting restructuring process.

It should be clearly stated that the strategy of *stares quo* preservation is quite a rational reaction to the changing political and economic environment. Although very dangerous in a long term, it may be a quite effective way of pulling through a difficult time of transition. To some degree, this strategy has been applied by all the Polish universities.

4. Strategy of accelerated development

An alternative to the strategy of *status quo* preservation is an active approach leading to significant transformations of an academic institution. The primary goal is to adjust the system of study to the current and future needs of the customers (students, employers, government, society at large). The motivation behind this strategy comes from the belief that an academic institution will eventually benefit (in terms of extra money, and not only prestige) from high quality of services offered, i.e., that this quality will attract candidates for university studies, and the number of candidates will determine - at least to some extent - the budget of academic institutions, and therefore the position on the market of academic services.

To survive in the new, competitive environment, an institution has to offer an attractive and high-quality system of study. Some of the essential features of such a system are:

♦ flexibility, which means that each student has a lot of freedom in designing his/her education path and can make choices regarding the level of education (degree), specialization, course selection, work load in each term, etc.;
♦ support for interdisciplinary studies;
● adequate presence of skill training activities in the curriculum (this is of critical importance for some disciplines, such as engineering);
♦ adaptability, which means that adjustments in curricula, reflecting advances in science and technology, and trends on the labor market, can easily be performed;
♦ existence of mechanisms that promote good teaching and good learning;
♦ compatibility of the degrees and curricula with international standards.

It should be observed that, to reach some of these characteristics, a significant investment is needed. Advances in some disciplines, such as information technology, are so rapid that just adapting the student laboratories to these changes requires tremendous amount of work and huge expenses. Other kinds of problems are associated with an extension of flexibility of the system. For example, with a large course offer, a significant relaxation of restrictions on the design of individual programs of study makes an optimal course scheduling and classroom assignment a very difficult task - the schedule must change, at least in part, from one term to another, depending on the students' choices, and some adjustments might also be necessary after the new term starts. This requires very efficient computer-aided administrative procedures.

Since restructuring of the system of study, aimed at the above stated objectives, has to be performed with no extra financial support, it must be accompanied by appropriate changes in the area of management and administration that would allow running the education process in a more cost-efficient way, e.g.:

- ♦ establishing appropriate rules for allocation of funds among the organizational units responsible for carrying out teaching duties, which promote efficiency;
- ♦ optimization of utilization of resources (lecture rooms, laboratories, etc.), allowing for extension of education services (new programs, more students);
- ♦ extended usage of information technology in education and administration.

The major risk associated with any significant change in the system of study lies in a possibility of a total financial collapse. The following scenario can be easily envisioned. The Ministry of National Education keeps allocating funds to academic institutions proportionally - in some part -to the number of students. Trying to adjust to such a policy, the institutions, disregarding quality of instruction, continue to admit more and more students to obtain a larger share of the available funds or, at least, not to lose in this race for money. Thus, the quality of education is directly affected, especially, those programs where access to modem facilities or contact of students with instructors on individual basis is of primary importance. Other, probably even more important, problems result from the underpayment of university employees. Traditionally, most successful changes at academia have been driven by highly motivated academic community and their devotion to the goals of their institutions. With low salaries, most members of academic staff are forced to leave or take part-time employment outside the university. This practice is especially conspicuous in disciplines where there is a growing demand for highly qualified work force (economics, management, information technology). With limited time, that the members of academic staff working also at other places can devote to their academic duties, and with growing frustration of those who do not have extra source of income, any reform of an academic institution that requires initiative, commitment, and significant amount of work is at serious danger.

In the following Section, we show how the above-discussed problems have been dealt with at the Faculty of Electronics and Information Technology, Warsaw University of Technology.

5. Case study

The Faculty of Electronics and Information Technology is the largest teaching and research center at Warsaw University of Technology. The Faculty has more than 2500 students who are served by 350 members of academic staff (220 of them hold Ph.D. degrees) and 200 members of technical and administrative staff. The size, organizational complexity, and autonomy of the Faculty makes it similar to a small university.

Over the last few years, following the recent trends in engineering education - cf. the report [1], papers by Christiansen [2], by Denning [3], by Duggan [4] and by Manley [5], a special issue of *ZEEE Communications Magazine [6],* as well as papers by Vemuri [7] and by Barnes [8] - an unprecedented effort has been taken to restructure the Faculty and make the system of study more suitable to the needs of our customers, as described by Toczyłowski and Woźnicki [9], by Morawski et al. [10], by Kraśniewski and Woźnicki [12], [13]. As a result, each student entering the Faculty is now provided with an opportunity to select an education path that best suits his/her capabilities and professional career objectives.

Instead of the traditional five-year program leading to the Master of Science (Master of Engineering) degree in the selected field of engineering - cf. the paper by Filipiak and Path [14] - we now offer each student the following options:

- ♦ first-level studies (undergraduate studies) available in two versions:
  - (a) a 4-year program leading to the Bachelor of Science degree,
  - (b) a 3-year program leading to a certificate of basic education in engineering, sufficient to apply for admission to second-level studies;
- ♦ second-level studies: a 2-year program leading to the Master of Science degree, open for holders of the Bachelor's degree or certificate of basic education in engineering.

Both first- and second-level studies are currently offered in 12 areas of concentration, representing the full spectrum of electronics and information technology.

There are about 400 courses offered by the Faculty each academic year. All courses are grouped into so-called subject classes, each of which covers a specific subject area, such as Mathematics, Digital Signal Processing, Computer Graphics, etc. Courses are designed to integrate theory and practice, and to provide students with both knowledge and skills: a typical course involves, besides traditional lectures and tutorials (recitations), some form of design projector hands-on experience in a laboratory.

The curriculum requirements (degree requirements) are formulated so that the student could take advantage of the richness of the course offer, as shown by Kraśniewski and Toczyłowski [11], and by Kraśniewski and Woźnicki [13]. The curriculum requirements are formulated using the names of subject classes rather than the names of specific courses; for each required class, the minimum number of credit points that must be earned by taking courses from this class is specified. In addition, the student is required to earn some number of credit points by taking free elective courses. By taking such courses at other, possibly nonengineering institutions, the students can pursue interdisciplinary programs.

The key academic regulation is "the rule of flexible studying" which states that the student is allowed to set his/her work load (number of courses taken) in each semester according to his/her capabilities and preferences, as long as he/she satisfies the minimum performance requirements. This means, in particular, that the student is allowed to register for fewer courses than recommended and take a part-time employment or submit an "empty" registration form and take a one-semester or even one-year "leave of absence" to take a full-time job. Clearly, under the rule of flexible studying, a good student can earn his/her degree earlier than scheduled and immediately start his/her job career.

To enhance adaptability of the system, the process of curriculum development has been decentralized and individual responsibility for maintaining quality of components of the curriculum has been assigned. For each area of concentration, there is a person responsible for the formulation of the degree requirements and the recommended plan of study. Also, for each subject class, there is a person responsible for that class. The collegiate body - the Curriculum Committee - takes only major decisions that involve several areas of concentration and approves the recommendations made by the area and subject class coordinators.

With regard to the general characteristics (degrees available, number of credit hours required to obtain a particular degree) our system of study closely resembles that of American universities. When formulating degree requirements, we frequently referred to the standards established by American and West European engineering program accreditation institutions, in particular by ABET [15].

Studies at our Faculty are still free of charge. Unlike many other Polish universities, which have significantly (by a factor of two or more) increased the number of admitted students, we have only slightly increased an annual enrollment limit in order not to compromise the quality of education. Because of that we have suffered from decreasing financial support from the Ministry of National Education. The situation is additionally complicated by the fact that, in the new programs of study, the fraction of most expensive education activities involving hands-on experience and carried out in small groups (labs, design projects) is significantly higher than in the earlier offered programs. The transformations in the system of study have therefore been accompanied by several changes in the administration and management of the Faculty, necessary to make the system cost-efficient, as described by Toczyłowski and Woźnicki [9], and by Woźnicki and Kraśniewski [16].

To diminish the costs, since 1990, the number of Faculty employees has been reduced by more than 30%. New regulations for financing teaching activities have also been adopted. These new regulations make the financing of teaching less dependent on the number of courses taught and more dependent on the number of students enrolled in these courses. This promotes efficiency by eliminating elective courses earned out for 5-6 students and encourages instructors to offer high-quality courses that could attract a large number students. The costs of teaching have also been reduced by employing students as graders and teaching assistants - so far, this practice, well known and proven worldwide, has been very rare at Polish universities.

Another critical problem associated with a growing number of students is the shortage of space (classrooms and laboratory rooms) in the Faculty building. By designing the course schedule using appropriate rules and techniques, that have been developed at the Faculty, we have increased the utilization of the available resources, and have thereby eliminated the need for renting classrooms outside the Faculty.

As studies at the Faculty are free of charge, specific regulations are necessary not to allow for unlimited usage of university resources by the students. According to these regulations, a student can register free-of-charge for a specified number of courses, sufficient to satisfy the curriculum requirements. Students must pay for extra courses and for each course in which they have received a failing grade (such a course must be retaken or some other course from the same subject class can be taken instead).

Since 1990, a significant effort has been made to expand the computer network and to develop a new integrated information system that supports a large variety of administrative and managerial tasks, as shown by Toczyłowski and Traczyk [17]. The complete database of the system is available in a small local network that serves the Dean's Office and the Registrar's Office. Most data are

also accessible in the Faculty network that currently contains about 800 computers and serves all the Faculty's employees and students.

To improve the quality of education services offered by the Faculty, some dedicated mechanisms of quality assurance have been implemented, but an improvement in education quality results primarily from the general characteristics of the system of study - its flexibility and adaptability. In particular:

- An opportunity to design an individual program of study that best suits student's capabilities and professional career objectives enhances student's interest in the higher education institution, its academic staff, courses it offers, and studying in general. Furthermore, the responsibility students take for their own education usually motivates them for more efficient learning which, in turn, results in better qualifications of graduates who enter the labor market.
- An opportunity to take fewer courses than recommended in a semester allows less capable students to perform well in all the courses taken, and thus successfully pursue the program. In addition, as several "exit points" are available, the student, after recognizing his/her problems, can appropriately adjust the level of education sought. This way, almost all admitted students have a chance to complete the studies.
- The freedom students have in designing their individual programs of study inevitably leads to potential conflicts in accessing critical resources. A conflict occurs, for example, when too many students attempt to register for an attractive course with a rigid enrollment limit. Regulations that resolve such conflicts by taking into account the performance of the competing students create an incentive for good learning.
- A large course offer and diversity of individual programs designed by the students result in a situation when only some fraction of courses offered by the academic staff are actually taught. This naturally eliminates outdated and poorly taught courses. As the instructors receive extra payment when their teaching load exceeds a certain limit, individual members of the academic staff are also motivated to offer high-quality courses that could attract a large number of students.
- With the new organization of curriculum development, necessary changes are implemented quickly, so that the curriculum can be kept up-to-date and adjusted to the changing needs of the customers. For the programs of study in electronics and information technology, where in 3-4 years ca. 50'%. of knowledge becomes out of date, this is absolutely essential if the quality of education is to be assured.

6. Conclusions and recommendations

The main goal of this paper is to demonstrate the complexity of the conditions under which Polish universities have to adapt to the new economic reality. Two basic strategies are outlined that - combined in various proportions - have been adopted by all the academic institutions: the strategy of *status quo* preservation and the strategy of accelerated development. It has been shown that both of them are based on a rational assessment of the uncertain situation, and both involve some risks of failure - therefore both must be applied with caution. Although the authors have assumed a risk of accelerated development, they have not completely rejected the elements of the strategy of *status quo* preservation since they are aware of the fact that some limits of patience and reserves of human and material resources have been reached, and the strategy of accelerated development cannot be productive in the nearest future without substantial increase of financial support. This strategy will not work effectively if it is not fostered by political decisions and legal regulations (at the government level) that stimulate entrepreneurship at State-financed higher education institutions or, at least, do not penalize activity. The most important issues are:

- providing institutions of higher education with fill autonomy, in particular with regard to financial policy (no administrative salary limits, etc.);
- distribution of funds among public institutions based on quality of education, not only quantitative indicators (number of students);
- introduction of various forms of fully or partially paid studies, at least in some areas, and allowing for diversification of fees according to quality of education services offered and demand for these services.

Thus, further developments in the Polish universities will be highly influenced by the State policies concerning the system of higher education. The following actions are worth being recommended:

- designing and implementing a general program for the development of higher education in engineering and economics in Poland, based on the potential of technical universities;
- designing and implementing a realistic policy of financing higher education at the level which at least guarantees its modest development;
- introducing new rules of financing universities (preventing them from pathologies described in Section 3), including new remuneration principles enabling the academic staff to integrate income from various sources;

- introducing a system of external evaluation enabling the independent bodies (e.g. accreditation boards) to control the quality of education in the universities and their departments,

It is worth mentioning that the above recommendations, deduced by the authors from practical rather than theoretical experience, converge with those formulated by Wnuk-Lipinska in [18] on the basis of systematic surveys of Polish academic institutions in 1985-1993.

References

1. "Designing a Curriculum for the '90's - Why Change," Special Report, Currents, Winter 1992.
2. D. Christiansen, "New Curricula," IEEE Spectrum, p. 25, July 1992.
3. P. J. Denning, "Educating a New Engineer," Communications of the ACM, vol. 35, no. 12, pp. 83-97, Dec. 1992.
4. T. Duggan, "The Changing Nature of Engineering Education and the Shape of Things to Come," Proc. 3rd World Conference on Engineering Education, vol. 1, pp. 3-19, Portsmouth, Sept. 1992.
5. B. W. Manley, "Engineering Education: Serving the Customer?," Proc. 3rd World Conference on Engineering Education, vol. 1, pp. 21-28, Portsmouth, Sept. 1992.
6. IEEE Communications Magazine, special issue on engineering education, Nov. 1992.
7. V. R. Vemuri, "Computer Science and Engineering Curricula," IEEE Trans. on Education, vol. 36, no. 1, pp. 108-110, Feb. 1993.
8. F. S. Barnes, "Engineering Education Under Attack," IEEE Trans. on Education, vol. 37, no. 1, pp. 1-2, Feb. 1994.
9. E. Toczylowski, J. Woznicki, "Restructuring an Electronic Engineering Faculty," Proc. American Society for Engineering Education Annual Conf., Edmonton, pp. 2495-2499, June 1994.
10. R. Z. Morawski, A. Krainiewski, J. Woznicki, "Reintroduction of a B.S. Program of Study at the Faculty of Electronics and Information Technology, Warsaw University of Technology", Proc. American Society for Engineering Education Annual Conf., pp. 2405-2413, Anaheim, June 1995.
11. A. Krasniewski, E. Toczyłowski, "Methodology for Development of Flexible and Adaptable Engineering Curricula", Proc. American Society for Engineering Education Annual Conf., pp. 929-938, Anaheim, June 1995.
12. A. Kraśniewski, J. Woźnicki, "Flexibility and Adaptability of the System of Study: Underrated Aspects of Quality in Higher Education", in: Quality Review in Higher Education (cd. E. Wnuk-Lipinska, M. Wójcicka), pp. 223-250, TEPIS Publishing House, Warsaw 1995.
13. A. Kraśniewski, J. Woźnicki, "Flexibility and Adaptability of the System of Study as Premises of Quality Assurance", Proc. 4th World Conf. on Engineering Education, vol. 2, pp. 295-300, St. Paul, Oct. 1995.
14. J. Filipiak, A. R. Path, "Engineering Education in Poland," IEEE Communications Magazine, pp. 58-64, Nov. 1992.
15. Program Evaluators Manual, Accreditation Board for Engineering and Technology, IEEE Engineering Accreditation Commission, 1992.
16. J. Woźnicki, A. Kraśniewski, "Systems of Study vs. University Management in a Competitive Environment", Proc. First International Symp. on Higher Education Management: A Polish-American Dialogue, pp. 165-182, Łódź, June 1994.
17. E. Toczyłowski, T. Traczyk, "On Cost-Effective Flexible Enrollment Information System ERES," Proc. American Society for Engineering Education Annual Conf., pp. 1558-1563, Edmonton, June 1994.
18. E. Wnuk-Lipińska, "The University Transformation: Conservatism and Innovations", in: Science in Society (cd. W. Gasparski, T. Airaksinen), IFiS Pub., pp. 91-103, Warsaw 1995.

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