Quality Assessment in Engineering Education – Indicators of Progress

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1. INTRODUCTION

Fast political, social and economic changes have significantly affected the functioning of academic institutions in Central and Eastern Europe. The most essential factors that determine a new environment in which academic institutions operate are substantial budget cuts and unattractive career prospects for university employees.

For example, in Poland as a result of severe economic recession financial support (per candidate admitted to university studies), received by higher education institutions from the Ministry of National Education, decreased in the period of 1990-1997 on average by more than 60%. On the other hand, academic staff, especially talented young people, are attracted by significantly higher salaries offered by private or even state-owned industrial or business enterprises.

Although most academic institutions suffer from fiscal crisis, the situation of many engineering schools is particularly difficult. The main reasons are:

- higher costs of running engineering courses, compared to arts and science courses, which is mainly because of high costs of modern equipment used in laboratories, especially for high-technology areas, like microelectronics, bioengineering, computer networks, where 10- or even 5-year old equipment may be of little use not only for research work, but even for education purposes;
- poor financial status of industrial companies, resulting not only in a diminishing number of research projects supported by industry and little demand for staff training programs offered by the universities, but also affecting decisions of candidates to university studies who tend to prefer studies in arts or business over engineering programs.

Only institutions that could quickly adjust to the new environment by restructuring their educational programs and management schemes have a chance to successfully face the budget cuts and still offer high-quality education. In other words, making adaptive changes in engineering education is a key to ensure quality.

This is in accordance with the first objective with regard to quality that should be sought by an institution, stated by the ISO 9000 standard in the following way[7]: "The organization should achieve and sustain the quality of the product or service produced, so as to meet continually the purchaser's (customer's) stated or implied needs". This means that an ability to meet the quality requirements in the future (under perhaps more difficult external conditions) is of equal importance as the current level of quality.

When assessing the quality of an academic institution, it is therefore essential to examine:

- the changes that have been made over the last few years in the programs of study and in the management of the institution; these changes affect – to a large extent – the current situation of the institution, but are also good indicators of the "make it better" attitude, as opposed to the "preserve status quo as long as possible" attitude of the academic authorities;
- provisions which make future changes easier to perform.

Over the last several years, systems of external quality assessment or accreditation have been developed in many countries[1,2,5,6,10,17,18,19,21,22]. Most existing systems take into account such aspects as curriculum objectives and requirements, teaching methods and techniques, training of student's skills through laboratory and design experiences, use of computers, oral and written communication, qualifications and teaching load of academic staff, facilities and their availability, administration procedures, information system and counseling, admission procedures, student performance, competence of graduates, and internal quality assurance procedures. It appears, however, that appropriate measures which characterize the dynamics of changes made in the past and the preparation of an institution for future changes, being in our opinion essential indicators of education quality, are rather rarely encountered in the existing and proposed external quality assessment systems. One possible explanation of this fact is that in the countries where these systems were developed, the political and economic systems are quite stable, i.e., the external conditions of functioning of academic institutions do not change so rapidly.

In this paper we propose a set of criteria that characterize the effectiveness of past activities aimed at adjusting to the changing environment and the preparation of an institution for continuous changes in the future. As this proposition is based on our experiences with the restructuring of the system of study at the Faculty of Electronics and Information Technology, Warsaw University of Technology, we start with a brief review of the latest changes in this system.

Some of the proposed criteria can and probably should be included into procedures of quality assessment in higher education - existing ones and those under development. We show how this can be done by describing a proposed modification of the system of external quality assessment used – so far experimentally – to examine the quality of education in Polish academic institutions.

2. SYSTEM OF STUDY AT THE FACULTY OF ELECTRONICS AND INFORMATION TECHNOLOGY

The Faculty of Electronics and Information Technology is the largest teaching and research center at the Warsaw University of Technology. The Faculty has ca. 2700 full-time students. They are served by 320 members of academic staff (230 of them hold the Ph.D. degree) and 220 members of technical and administrative staff.

Over the last few years, as a result of political and economic transformations initiated in 1989, the conditions of functioning of higher education institutions in Poland have changed significantly[3,14,15]. In response to these changes, a significant effort has been taken to restructure the system of study at the Faculty. Students admitted before 1994 have followed the traditional

pattern of university-level engineering education in Poland, i.e., they have pursued a five-year program leading to an MS-equivalent degree in the selected field of engineering[3,4,14]. With the beginning of the academic year 1994/95, a new system of study was introduced. In what follows, we briefly describe basic features of this system; its more detailed description can be found in other publications[8,11,12,16,20].

Structure of studies:

In the restructured system of study, instead of the traditional five-year MS program, the student has the following options:

- first-stage studies (undergraduate studies) available in two versions:
  - a 4-year program leading to the BS degree,
  - a 3-year program leading to the certificate of basic education in engineering; for a good student, such a certificate is sufficient to apply for admission to second-stage studies;
- second-stage studies: a 2-year program leading to the MS degree; the candidates must hold the Bachelor's degree in engineering or related discipline or the certificate of basic education in engineering;

In addition, a program leading to the PhD degree for candidates who hold the Master's degree in engineering or related discipline is available.

A student admitted to the first-stage studies, after two years of learning mathematics, science, basic electronics and computer engineering, selects his/her specialization (area of concentration). The third year is intended as an introduction to the selected area of concentration. During the last, fourth year of the first-stage studies, specialization-oriented courses are taken, followed by a comprehensive final design project. The second-stage studies are also specialization-oriented, but include in addition advanced applied mathematics and science courses, as well as individual reading and research courses. The last semester is devoted solely to the preparation of the Master's thesis.

The system offers the student a lot of flexibility in designing his/her education path. After three years of study, the student can leave the Faculty with a certificate of basic engineering education and take an employment (at that time he/she has enough knowledge and skills to get a reasonable job offer) or stay at the Faculty and either continue with the first-stage studies (BS program) or apply for admission to the second-stage studies (MS program). Another possibility is to continue education at other academic institution (students holding the certificate of basic engineering education in electronics and information technology are generally recognized as good candidates for pursuing advanced programs in many disciplines, for example, at business schools). After graduating with the BS degree, the student can leave the Faculty and take an employment or apply for admission to the second-stage studies.

Areas of concentration:

The studies are offered in the broad field of Electronics and Information Technology. For the first-stage studies, 12 specializations (areas of concentration) are available. Some of them, e.g. "Software Engineering and Information Systems" and "Management of Telecommunication Networks and Services", have been introduced in response to the trends on the labor market.

As mentioned before, after two years of study, each student is required to select his/her area of specialization. This decision determines, in particular, the general topic of the student's final design project or Master's thesis. Besides, each student is provided with an opportunity to receive a certificate of minor specialization in some other area. This is important because, due to limited capacity of advanced-level laboratories used for individual design or research projects, there are some restrictions on the number of students who can pursue their programs in each area of concentration. Thus, the student who is compelled to work on his/her final project or thesis in an area different from his favorite one, can always include in his/her individual program of study a specified number of courses from the preferred area and be awarded a certificate of minor specialization in that area.

Course offer:

There are almost 400 courses (including courses taught by instructors from outside the Faculty) offered at the Faculty each academic year, and a majority of these courses are actually taught. To facilitate systematic examination of the course offer by the students and their advisors, all courses have been grouped into so-called subject classes. Each subject class contains courses that cover a specific topical area, such as mathematics, digital signal processing, computer graphics, etc.

Each course offered at the Faculty is assigned several attributes, including the number of credit points (credit hours), a list of subject classes the course belongs to, and a list of prerequisite and corequisite courses. Basic courses, intended for all or most of the students, are frequently offered in two or more versions that may differ with regard to the range of topics covered and, possibly, also with regard to the student load (number of credit points).

Curriculum requirements:

To receive a degree, the student must satisfy the curriculum requirements (degree requirements). The curriculum requirements are formulated using the names of topical areas (subject classes) rather than the names of specific courses; for each required topical area, the minimum number of credit points that must be earned by taking courses from the corresponding subject class is specified. Compulsory courses in each class can be specified, but in general, the mechanism of prerequisite and corequisite requirements is employed to ensure an appropriate sequence of courses taken by each student. In addition to being allowed to select courses within each relevant subject class (restricted elective courses), the student can (and should) include in his/her program a certain number of courses selected from the entire course offer (free elective courses).

To obtain a degree, the student must satisfy the curriculum requirements for at least one area of concentration. The requirements are, however, formulated in such a way that the student can take quite a large number of free elective courses. Thus, by carefully planning his/her individual program, the student can obtain the degree in one area and a certificate of minor specialization in another. This way, a large number of interesting patterns of education in the broad field of electronics and information technology can be created. Besides, by taking a large number of free elective courses at other, possibly nonengineering institutions, the students can pursue interdisciplinary programs.

To help the students design their individual programs of study, a model program of study, which contains a list of recommended courses for each semester, has been developed for each area of

concentration. The students are, however, free to deviate from this model, as long as their individual programs satisfy the curriculum requirements. Good students are even encouraged to look for unconventional education paths.

Academic regulations:

The key regulation is "the rule of flexible studying" which states that a full-time student is allowed to decide on the distribution of workload during the period of study (the number of courses taken each semester). Student's freedom in deciding on the workload in each semester is only limited by the necessity to satisfy each semester the minimum performance requirements which are formulated in terms of the grade point average and the number of credit points earned from the beginning of the study. The minimum requirements imply in particular that the first-stage studies that nominally take 4 years must be completed in no more than 5 years. Such regulations leave the student a lot of freedom in adjusting the pace of studying to his/her capabilities and other relevant factors. In particular:

- a good student can earn his/her degree earlier than scheduled and immediately start his/her job career,
- a less capable student can take fewer courses per semester than his/her colleagues and thereby avoid a dismissal due to inferior performance in the courses taken,
- a student can register for fewer courses than recommended and take a part-time employment,
- a good or even average student can submit an "empty" registration form and take a one-semester or even one-year "leave of absence" to take a full-time job without withdrawing from the program and loosing student rights and privileges.

The freedom students have in designing their individual programs of study inevitably leads to potential conflicts due to insufficient supply of some resources or services. A conflict occurs, for example, when too many students attempt to register for an attractive course with a rigid enrollment limit. Such conflicts are usually resolved by taking into account the performance of the competing students (their position in the ranking, determined by the grades received in all the courses taken). This procedure obviously motivates students to good learning. It should, however, be mentioned that, although the system generally favors good students, special measures have been adopted to minimize the frustration of the students who have lost in a competition for critical resources. For example, as mentioned earlier a student who is not admitted to pursue the program in his/her favorite area of concentration, can still take courses he/she is primarily interested in and earn a certificate of minor specialization in that area.

Organization and administration:

A flexible system of study requires quite a sophisticated organizational structure. Its effectiveness is critically dependent on usage of information technology. In particular, a computer network of appropriate size is necessary for effective functioning of an information, administration, and management system. Currently, a network of more than 900 computers supports both educational and organizational activities.

The computer network forms a basis for the development of a comprehensive information system that provides the students and academic staff with 24-hours-a-day access to all necessary information (course offer, course syllabi, course and examination schedule, detailed description of regulations and procedures, etc.).

The information system is closely related to the integrated computer-aided administration system ERES2, developed at the Faculty, which supports administrative tasks related to education. This ORACLE-based system supports student registration, monitoring of the student progress, course and examination scheduling, classroom assignment, publishing (printing of course catalogue, course schedule, course rosters, student progress records, certificates), administration of student housing and financial aid, and several other tasks.

Advising the students:

With so many options available, even with an effective and easily accessible information system, the students might get lost if some form of advising by the members of academic staff are not provided. A special non-credit tutorial-type course, called "Orientation", taught by experienced instructors, has therefore been included in the curriculum for the first-, second-, and third-year students. Advising on how to design an individual program of study to take advantage of the available opportunities is part of this course. During the fourth year of the first-stage studies, each student is assigned an individual advisor who later also supervises the student's final design project. Individual advising also takes place throughout the entire period of the second-stage studies.

Development and updating of curriculum:

The flexible way in which curriculum requirements are formulated makes it easy to continuously update and refine the curriculum. To stimulate this process, the work on the development of curriculum has been distributed. Each area of concentration has its coordinator - a professor individually responsible for the formulation of curriculum requirements and model program of study. Also, for each subject class, there is a person responsible for coordination of all courses in that class. The area coordinators and subject class coordinators are responsible for reacting promptly to advances in science and technology and to trends on the labor market. The Curriculum Committee coordinates actions taken by area and subject class coordinators and makes decisions that involve several areas of concentration; only the most important, strategic decisions regarding the curriculum are made by the Faculty Council.

Promoting cost-efficiency:

The freedom students have in selecting courses makes it possible to promote efficiency and quality through appropriate organizational and financial decisions. The elective courses that do not attract enough students are not run. The recently adopted rules make the distribution of funds among the six institutes comprising the Faculty less dependent on the number of courses taught by their employees and more dependent on the number of students enrolled in these courses. Also, the teaching load of an individual instructor is calculated as a function of the number of students attending his/her courses, and the instructor receives extra payment when his/her teaching load exceeds a certain limit. Clearly, for such mechanisms to work, appropriate measures must be taken to assure that the competition among the institutes and individual members of the academic staff is fair (e.g. it must be ensured that students are not attracted by setting less demanding requirements on examinations).

3. INDICATORS OF PROGRESS

The deep restructuring of the system of study at the Faculty of Electronics and Information Technology has had a very positive impact on the quality of education; this topic is discussed in detail in[11,13]. Here, we only mention that - despite diminishing interest in engineering studies among secondary school graduates in Poland - since the introduction of the new programs, the number of candidates who applied for studies at the Faculty has increased by almost 80%. As a consequence, with an unchanged enrollment limit, capabilities and performance of the students have significantly increased. The grade point average for the group of students who entered the first-stage studies at the Faculty on October 1, 1994 (the first group admitted to the restructured program), was - at the end of their third year of study - significantly higher than for the students who entered the Faculty earlier.

Based on experiences with the restructuring of the system of study at our Faculty, encouraged by an observed improvement in education quality, we propose a number of criteria that are - in our opinion - good indicators of some essential aspects of education quality at a given academic institution. Most of the proposed criteria characterize the dynamics of changes made in the past and the preparation of the institution for future changes. They are, therefore, referred to as indicators of progress.

Although most of the proposed criteria refer to an institution as a whole rather than to a particular program of study, they have an essential impact on the quality of any program offered by the institution. Therefore, they can and perhaps should be considered also when an individual program of study is evaluated, e.g. for the purpose of accreditation. The proposed progress-indicating criteria are classified into three groups:

- criteria that characterize systematic, long-term effort of the institution aimed at adjusting to the changing environment and improving the quality of education,
- criteria that characterize an effort made by the institution to attract a large number of good candidates for study and thereby respond to the pressure made by other institutions competing for candidates,
- criteria that characterize the preparation of an institution for continuous changes in the future.

Some of the proposed criteria are specific to Poland, with its traditional - not particularly well suited to the new economic situation - system of engineering education, and to other countries facing fast political and economic transformations. Most of the criteria are, however, universal and refer to any country.

1. Criteria that characterize systematic long-term effort of the institution aimed at adjusting to the changing environment and improving the quality of education:

(a) availability of documents (analytical reports etc.) issued over the period of the last several years, containing predictions of changes in areas relevant to the functioning of the institution (economic situation, advances in science and engineering, revolution in information technology, trends on the labor market, evolution of international standards of engineering education etc.); such documents can be produced by compiling data from external sources;
(b) availability of official documents issued over the period of the last several years, explicitly stating the mission of an institution and a long-term and short-term strategy of development of the institution (its education system, organization and management); the long-term strategy

should account for the predicted changes and include - as its essential part - a plan of activities aimed at improvement of education quality; such documents should be accepted by institution ruling bodies and made known to the academic community;

(c) recent history of development of curricula, including
   - introduction of new programs of study,
   - introduction of new areas of concentration,
   - significant revisions of the course offer within the existing degree programs and areas of concentration;

(d) recent history of investments in resources and facilities,

(e) recent trends in availability of human and material resources and facilities in relation to the number of students (annual budget per student, student-to-academic staff ratio, availability of individual advisors - time per student, size of lecture and recitation group, computer and library resources, etc.).

2. Criteria that characterize an effort made by the institution to attract a large number of good candidates for study and thereby respond to the pressure made by other institutions competing for candidates:

(a) existence of multiple education paths, i.e. several programs of study of different duration, leading to different diplomas or certificates, and suitable for full-time students and part-time students;

(b) "openness" of the system of study to students with different educational background, coming from different institutions after graduation or after completing a part of a program of study;

(c) availability of a wide spectrum of specializations (areas of concentration) and support for interdisciplinary programs (existence of a credit transfer system);

(d) existence of a large, diversified, and well-structured course offer, with two or more versions of basic courses taught by different instructors; courses should be grouped into subject classes which would facilitate their review by students and their advisors;

(e) provision for each student to design an individual program of study which best matches his/her interests, professional career objectives, financial status, and other relevant conditions; this is greatly facilitated by the formulation of curriculum requirements (degree requirements) using credit points and subject classes, rather than the names of specific courses;

(f) possibility to design the individual education path incrementally, so that decisions regarding the length of study (highest certificate or degree sought), the choice of specialization etc., could be made as late as possible in the course of study (not at the beginning of the study);

(g) possibility to individualize the intensity of study, i.e. to adjust the student workload (the number of courses taken) in each term to individual capabilities and preferences; in particular, it is important to ensure that temporary difficulties, e.g. a failing grade in one course, do not imply either larger-than-nominal workload in the following term or an "idle" period of study in which only the failed course is to be retaken;

(h) availability of various forms of counseling, including individual advising by members of academic staff; availability of a distributed information system that provides the students and academic staff with 24-hours-a-day access to all necessary information in an electronic form (course offer, course syllabi, course and examination schedule, detailed description of regulations and procedures, etc.).

3. Criteria that characterize the preparation of an institution for continuous changes and improvements in the future:

(a) appropriate decision structure; the decision-making process should be distributed, so that constant improvements could be made quickly without a direct involvement of the highest-level academic officers or academic bodies;
(b) effective procedure for continuous updating of the curriculum; such a procedure should allow for fast recognition of the need for improvement and relatively effortless implementation of necessary changes and adjustments, so that weak points in the curriculum could be quickly eliminated and the curriculum could be kept up-to-date and well suited to the needs of the customers;
(c) existence of mechanism that stimulate "academic competition":
   - among organizational units and individual members of academic staff; examples of such mechanisms include: cancellation of courses that do not attract enough students, fund allocation policy which takes into account course enrollment figures, etc.; for such mechanisms to work, appropriate measures must be taken to assure that the competition is fair (e.g. to ensure that students are not attracted by setting less demanding requirements on examinations);
   - among students; examples of such mechanisms include regulations that give good students higher priority when accessing highly-demanded resources (attractive courses with enrollment limits, individual advisors of the highest prestige, etc.); such mechanisms must be augmented with special measures that minimize the frustration of the students who have lost in a competition for scarce resources;
(d) effective administration procedures supported by an integrated computer-aided administration system which should handle student registration, monitoring of the student progress, course and examination scheduling, classroom assignment, publishing (printing of course catalogue, course schedule, course rosters, student progress records, certificates), and many other administrative tasks related to education.

4. INDICATORS OF PROGRESS IN A QUALITY ASSESSMENT SYSTEM

As mentioned earlier, criteria which characterize the dynamics of past activities aimed at adjusting to the changing environment and the preparation of an institution for continuous changes in the future are rather infrequently encountered - at least in their explicit form - in the external quality assessment systems for higher education. One possible explanation of this fact is that in the countries where such systems were developed and are used, the political and economic systems are quite stable, i.e., the external conditions of functioning of academic institutions do not change so rapidly.

We believe however that, for a country whose higher education system is strongly affected by a fast transformation of the political and economic system, the criteria that reflect the dynamics of changes made at the academic institution in the past and the preparation of the institution for future changes, such as those proposed in Section 3, are good indicators of education quality. Although most of the criteria proposed in Section 3 refer to an institution as a whole rather than to a particular program of study, they have an essential impact on any program offered by the institution. Therefore, some of them should be included into procedures of quality assessment -

existing ones and those under development – regardless of whether the entire institution or an individual program of study is assessed.

In what follows, we show how this can be done by describing a proposed modification of the system of external quality assessment which is used – so far experimentally – to examine the quality of education in Polish academic institutions[9].

This system has been developed by the Council for Higher Education (CHE) – a body independent of the Ministry of National Education, composed of representatives of higher education institutions. This system, hereafter referred to as the CHE system, like many other existing systems, is intended for the quality assessment of a specific program of study (degree program in one specific field of study) offered by a given institution. Based on the results of such an assessment, decisions on accreditation and classification of the accredited programs are taken. The system contains a number of general evaluation criteria, which can be detailed, extended or transformed into specific requirements by a committee responsible for the organization of quality assessment in a specific field of study.

The evaluation criteria used in the system are classified into three groups: necessary, basic, and auxiliary. The necessary criteria must be satisfied by a program of study to get an accreditation and category B. An accredited program which satisfies the basic criteria is given category A. If, in addition, the auxiliary criteria are met, the program is given category A+. Below, we list the CHE evaluation criteria in each of these three groups.

I. Necessary criteria:

1. Quantity and qualifications of the academic staff as stated in the CHE requirements.
2. Assignment of teaching duties according to regulations that define formal qualifications required for specific activities (in particular, for giving lectures).
3. Sufficient resources and facilities (lab equipment, libraries, etc.) and their availability.
4. Curriculum that meets minimum requirements set by CHE.

II. Basic criteria:

1. Existence of internal quality assessment system (including assessment of courses by students and direct observation of teaching activities of junior members of academic staff by senior members of academic staff).
2. Content of curriculum, including the breadth of the offer (areas of concentration). Scope and level of basic courses recommended for all students (required and recommended textbooks). Fraction of elective courses in the curriculum and formal qualifications of their instructors.
3. Availability and quality of supplementary courses (second foreign language, courses in humanities and social studies for engineering students, engineering courses for students of arts, etc.).
4. Availability of information on course syllabi, textbooks, etc.
5. Physical space (lecture halls, etc.), size of a lecture group (average number of students registered for a lecture section), recitation group, lab group, etc.
6. Admission procedure.
7. Category C (or higher) - in classification of the State Committee for Scientific Research - of the institution that offers the program (applicable for master-level programs only).

III. Auxiliary criteria:

1. Language skills of students and members of academic staff (courses taught in foreign languages).
2. Provision for design of an individual program of study by selected students; credit point system.
3. Usage of computers, including computer-assisted administration of the education process.
4. International cooperation, including exchange of students and instructors, student symposia, student contests, etc.
5. Compatibility with the European standards of higher education (if such standards are defined for the considered field of study).
6. Category B (or higher) - in classification of the State Committee for Scientific Research - of the institution that offers the program (applicable for master-level programs only).
7. Master's theses related to research projects carried out at the institution that offers the program (applicable for master-level programs only).

Compared to the other existing or proposed systems of quality assessment, the above described CHE system is very simple. This can be explained by the lack of tradition of quality assessment in Polish academic institutions and an intention not to discourage the academic community by proposing a difficult-to-apply procedure. However, as mentioned earlier, for a specific field of study, the system can be extended by adding - in each of the three groups - additional criteria. Also, each criterion can be made more precise by formulating appropriate subcriteria, including quantitative performance indicators.

It can be observed that the CHE system and its reported extensions (intended for the field of electrotechnics, physics, and medical sciences[9]) does not include most of the criteria listed in Section 3. Being more specific, only criteria 2(c), 2(d), 2(e), and 3(d) formulated in Section 3 are to some extend represented in the CHE system by basic criterion 2 and auxiliary criteria 2 and 3.

It can be argued that the criteria listed in Section 3 refer to the institution and the CHE system is intended for assessing a particular program of study, and not an institution as a whole. However, it should be noted that the existing systems for assessing the programs of study, usually contain a large set of criteria which account for the "institutional perspective". Also, the CHE system has been intended as a tool to assess "provisions made by a higher education institution to assure appropriate quality of education"[9]. Therefore, it appears justified to propose an extend the CHE system by some of the progress-indicating criteria listed in Section 3.

We propose to extend the set of basic criteria by adding two items which reflect the "make it better" attitude, i.e., which characterize systematic effort taken to adjust to the changing environment and to improve the quality of education:

- existence of a long-term development strategy based on a clearly defined mission of the institution and analyses of the predicted changes in its environment, and containing a long-term plan of activities aimed at improvement of education quality; the formulation of such a strategy and the progress in its realization should be reflected in official documents issued over the period several years;
- recent history of development of curricula, including an introduction of new areas of concentration and other significant revisions of the course offer within the considered program of study.

We also propose to extend the set of auxiliary criteria by adding the following criteria that reflect the flexibility and adaptability of the system of study:

- existence of multiple education paths, i.e. several programs of study (in a given field) of different duration, leading to different diplomas or certificates; a possibility to take key decisions regarding the education path as late as possible in the course of study;
- possibility to adjust the workload in each term to individual capabilities and preferences of a student;
- effective procedure for continuous updating of the curriculum.

It should be noted that in this paper we do not discuss possible extensions of the CHE system in general; we just focus on inclusion of criteria serving as progress indicators. Under this assumption, the above proposed modification of the CHE system seems to be to sufficient for the current level of complexity of the system. As the system evolves in the future, other criteria can be added. Also, additional criteria can be formulated as part of extra requirements associated with a specific field of study.

5. CONCLUSION

We believe that the quality of engineering education is a very dynamic concept, especially at the times when conditions of the functioning of academic institutions change rapidly. The quality assessment should, therefore, not be limited to evaluation of the current state of a program of study, but should reflect – to a large extent – the "make it better" attitude of the institution authorities and amount of the work done to predict changes and adapt the education process to these changes. Appropriate criteria should be formulated and included in the existing and proposed systems of quality assessment.

Based on experiences with the restructuring of the system of study at the Faculty of Electronics and Information Technology, Warsaw University of Technology, we formulate a set of criteria that characterize the dynamics of the engineering education. We also propose an extension of the experimental system for assessment of education quality in Polish academic institutions by some of the formulated criteria.

References

1. *Criteria for Accrediting Programs in Engineering in the United States (revised December 1995)*, Accreditation Board for Engineering and Technology, Engineering Accreditation Commission, 1995.
2. J. Donaldson, A. Staropoli, M.-O. Ottenwaelter, Ch. Thune, A. I. Vroeijenstijn, *European Pilot Projects for Evaluating Quality in Higher Education*, 1994.
3. A. Filipkowski, "Engineering Education in Poland: Facing the United Europe", *Proc. 3rd World Conference on Engineering Education*, vol. 1, pp. 41-51, Portsmouth, Sept. 1992.
4. J. Filipiak, A. R. Pach, "Engineering Education in Poland," *IEEE Communications Magazine*, pp. 58-64, Nov. 1992.
5. M. M. H. Frederiks, D. F. Westerheijden, P. J. M. Weusthof, "Effects of Quality Assessment in Dutch Higher Education", European Journal of Education, 29, pp. 181-200, 1994.
6. D. Green, L. Harvey, "Quality Assurance in Western Europe: Trends, Practices and Issues," *Proc. 5th Int. Conf. on Assessing Quality in Higher Education*, pp. 177-198, Bonn, July 1993.
7. *ISO 9000: Quality Management and Quality Assurance Standards - Guidelines for Selection and Use*, International Standard Organization, 1987.

8. A. Jakubiak, R. Z. Morawski, "Towards Meeting the International Standards of Engineering Education", *Proc. 4th World Conf. on Engineering Education*, vol. 2, pp. 252-257, St. Paul, Oct. 1995.
9. J. Kawecki, *System for Quality Assessment in Higher Education Institutions (developed and verified by the Council for Higher Education)*, Council for Higher Education, Warsaw, 1996 (in Polish).
10. H. R. Kells, *Self-Regulation in Higher Education: A Multi-National Perspective on Collaborative Systems of Quality Assurance and Control*, Higher Education Policy Series 15, Jessica Kingsley Publishers, 1992.
11. A. Krasniewski, R. Z. Morawski, J. Woznicki, "Some Underestimated Aspects of Quality Assessment in Engineering Education", *Proc. American Society for Engineering Education Annual Conf.*, (CD-ROM), Milwaukee, June 1997.
12. A. Krasniewski, E. Toczylowski, "A Methodology for Development of Flexible and Adaptable Engineering Curricula", *Proc. American Society for Engineering Education Annual Conf.*, pp. 929-938, Anaheim, June 1995.
13. A. Krasniewski, J. Woznicki, "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. A. Krasniewski, J. Woznicki, "Engineering Education in Poland: Responding to the Challenge", *IEEE Potentials*, pp. 43-46, April/May 1996.
15. R. Z. Morawski, B. Manhire, J. Starzyk, "Engineering Education in Poland", *Proc. American Society for Engineering Education Annual Conf.* (CD-ROM), Seattle, June 1998.
16. R. Z. Morawski, A. Krasniewski, 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.
17. S. C. Palmer, "Quality Audit and Assessment in English Universities," *Proc. American Society for Engineering Education Annual Conf.*, Edmonton, June 1994.
18. *A Report on Methods and Mechanisms, and Policy Recommendations to the European Community*, Liason Committee: Quality Assessment in European Higher Education, Brussels, 1993.
19. A. Staropoli, "L'Evaluation de l'Enseignement Superieur en France", in E. Wnuk-Lipinska, M. Wojcicka (Eds.), *Quality Review in Higher Education*, TEPIS Publishing House, Warsaw 1995.
20. E. Toczylowski, J. Woznicki, "Restructuring an Electronic Engineering Faculty," *Proc. American Society for Engineering Education Annual Conf.*, Edmonton, pp. 2495-2499, June 1994.
21. A. I. Vroeijenstijn, *Improvement and Accountability: Navigating Between Scylla and Charybdis*, Higher Education Policy Series 30, Jessica Kingsley Publishers, 1995.
22. D. F. Westerheijden, J. Brennan, P. A. M. Maassen (eds.), *Changing Contexts of Quality Assessment: Recent Trends in European Higher Education*, 1994.

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