Evolution of Electrical and Computer Engineering Education in Poland

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Abstract

Over the last decade, there have been many changes in engineering programs offered by institutions of higher education in Poland. Many institutions have departed from the traditional model of five-year integrated BS-MS studies and moved to two-stage studies. The changes have also affected the organization of the educational process and the curricula. We illustrate the evolution of engineering education in Poland by characterizing the electrical and computer engineering curricula of the 80’s and 90’s and giving their quantitative comparison.

1. Introduction

The process of deep restructuring of the economy, following the political upheaval of 1989, has radically changed external conditions influencing Polish universities. The essential elements of the new situation are:

- growing demand for the graduates in business-related and management-related disciplines,
- growing demand for service-oriented professions,
- market-driven professional re-orientation of Polish 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 a substantial increase in the number of students (by about 180% over the period 1989-1998) and a very limited increase of the budget that reduced the real value of the allowance provided by the Ministry of National Education for each student by about 60% over the period 1990-1998. 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 the poor condition of Polish industry.

2. Engineering education in Poland

In Poland, a university is an art-and-science-oriented institution and has no engineering college or engineering departments. Programs of study in engineering are offered by other academic institutions: technical universities (also referred to as universities of technology or polytechnic institutes), technical academies, engineering colleges, and some other specialized schools. A vast
majority of students admitted to technical universities pursue a five-year (10-semester) program leading to the MS degree in the selected field of engineering. Shorter, 4- or 3.5-year programs leading to the BS-equivalent or BEng-equivalent degree are offered mainly by engineering colleges. PhD degrees are obtained either through doctoral programs lasting 4 years that are organized by some universities, or are pursued without course work, typically by teaching and research associates of academic institutions.

Besides mainstream programs of higher education, there are correspondence and evening studies. These studies account for about 20% of all students at technical universities. Classes are organized over the weekend for correspondence students and during the evenings over the week for evening students. There are also some forms of continuing education in Poland, mainly various post-graduate studies which last 2 or 3 semesters and terminate with a certificate of completion; courses offered at these kinds of studies vary depending on current market needs.

Engineering curricula have traditionally been based on a rigid core of compulsory courses, with a certain number of slots to be filled with restricted or free elective courses. Student’s work load has been quite heavy - a full-time student frequently has had to take 10 or more courses per semester, with about 30 hours of regularly scheduled lectures, recitations, and laboratory sessions per week. Each graduating MS student has had to submit and defend a thesis.

A typical technical university in Poland is divided into faculties (similar to departments at American universities) which are subdivided into institutes, that are further subdivided into divisions, although, many institutions have changed this structure. Faculties correspond to various fields of study in engineering, such as chemical, civil, electrical, etc. Besides these main engineering faculties, technical universities also have specialized centers, such as biotechnology, applied physics and mathematics, computing services, foreign languages, enterprise development, social sciences, continuing education, physical education, etc. Centers provide service courses and other academic services for universities but, typically, they do not offer their own degree programs. More information on engineering education in Poland can be found in other publications 6,7,9,12.

Within engineering education, 27 fields of study (out of a total of 93) are available to students at Poland’s academic institutions. Four of them roughly correspond to the area of electrical and computer engineering (ECE) in the US, viz.: Computer Science and Engineering (CS), Control Engineering and Robotics (CR), Electrical (Power) Engineering (EE), Electronics and Telecommunications (ET).

According to official statistics, by the end of 1997, 54 529, i.e. about 20% of all students of engineering studied in the above-listed fields at 18 State institutions controlled by the Ministry of National Education (Table 1), 4 State institutions controlled by other ministries (the Ministry of National Defense, the Ministry of Transport and Maritime Economy), and several private institutions. The private institutions accounted for approximately 4% of CS, CR, EE and ET students. The breakdown of students and graduates of CS, CR, EE and ET by the form of studies is shown in Table 2.
<table>
<thead>
<tr>
<th>academic institution</th>
<th>fields of study</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Mining and Metallurgy in Cracow</td>
<td>CS, CR, EE, ET</td>
</tr>
<tr>
<td>Bialystok Technical University</td>
<td>CS, CR, EE, ET</td>
</tr>
<tr>
<td>Cracow University of Technology</td>
<td>CR, EE</td>
</tr>
<tr>
<td>Czestochowa Technical University</td>
<td>CS, EE</td>
</tr>
<tr>
<td>Technical University of Gdansk</td>
<td>CS, CR, EE, ET</td>
</tr>
<tr>
<td>Koszalin Technical University</td>
<td>CS, CR, ET</td>
</tr>
<tr>
<td>Lublin Technical University</td>
<td>EE</td>
</tr>
<tr>
<td>Lodz Technical University</td>
<td>CS, CR, EE, ET</td>
</tr>
<tr>
<td>Opole Technical University</td>
<td>CS, CR, EE</td>
</tr>
<tr>
<td>Poznan Technical University</td>
<td>CS, CR, EE, ET</td>
</tr>
<tr>
<td>Radom Technical University</td>
<td>EE</td>
</tr>
<tr>
<td>Rzeszow Technical University</td>
<td>EE</td>
</tr>
<tr>
<td>Silesian Technical University in Gliwice</td>
<td>CS, CR, EE, ET</td>
</tr>
<tr>
<td>Szczecin Technical University</td>
<td>CS, CR, EE, ET</td>
</tr>
<tr>
<td>Swietokrzyska Technical University in Kielce</td>
<td>EE</td>
</tr>
<tr>
<td>Technical and Agricultural Academy in Bydgoszcz</td>
<td>EE, ET</td>
</tr>
<tr>
<td>Warsaw University of Technology</td>
<td>CS, CR, EE, ET</td>
</tr>
<tr>
<td>Wroclaw University of Technology</td>
<td>CS, CR, EE, ET</td>
</tr>
<tr>
<td>Technical University of Zielona Gora</td>
<td>CS, EE</td>
</tr>
</tbody>
</table>

Table 2. Breakdown of students and graduates of CS, CR, EE and ET by the form of studies

<table>
<thead>
<tr>
<th>FORM OF STUDIES</th>
<th>STUDENTS (December 31, 1997)</th>
<th>GRADUATES (January 1 - December 31, 1997)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CS</td>
<td>CR</td>
</tr>
<tr>
<td>on-campus, regular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>integrated (BS+MS)</td>
<td>7 151</td>
<td>5 009</td>
</tr>
<tr>
<td>undergraduate (BS)</td>
<td>2 131</td>
<td>494</td>
</tr>
<tr>
<td>graduate (MS)</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>on-campus, evening</td>
<td></td>
<td></td>
</tr>
<tr>
<td>integrated (BS+MS)</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>undergraduate (BS)</td>
<td>852</td>
<td>0</td>
</tr>
<tr>
<td>graduate (MS)</td>
<td>64</td>
<td>0</td>
</tr>
<tr>
<td>correspondence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>integrated (BS+MS)</td>
<td>138</td>
<td>0</td>
</tr>
<tr>
<td>undergraduate (BS)</td>
<td>4 521</td>
<td>0</td>
</tr>
<tr>
<td>graduate (MS)</td>
<td>155</td>
<td>301</td>
</tr>
<tr>
<td>total</td>
<td>15 447</td>
<td>5 814</td>
</tr>
</tbody>
</table>
3. Evolution of the structure of studies

For the last several years, many engineering education institutions have departed from the traditional model of five-year integrated BS-MS studies and moved to two-stage studies in which the first stage leads to the degree of "inzynier" equivalent to the bachelor's degree, and the second stage leads to the degree of "magister inzynier" equivalent to the master's degree. This process has been quite spontaneous, i.e., it has not been co-ordinated by any body of central administration. As a result, different institutions have developed several versions of the system which differ with regard to the length of the first stage or second stage and the regulations regarding the transfer of students from the first stage to the second stage. Two basic versions are illustrated in Fig. 1.

The first version, shown in Fig. 1(a), can be referred to as a (purely) serial system. In this system, the length of the first stage is typically 7 semesters, and the length of the second stage is typically 3 semesters. To be admitted to the second stage, a candidate is required to hold a bachelor's degree, i.e. to complete the first stage. It is assumed that a majority of candidates for the second stage receive their first degree from the same institution in which case a smooth transition is possible. For a student who completed the first stage at a different institution, the completion of an extra one-semester adaptation program may be required.

The second version, shown in Fig. 1(b), can be referred to as a serial-parallel system. In this system, the length of the first stage is 7 or 8 semesters, and the length of the second stage is

![Diagram of two-stage study system at Polish technical universities](length of studies in semesters)
typically 4 semesters. Two paths are available for those who enter the first stage and decide to continue with the second stage:

- a student completes the first stage and then, if admitted, enters the second stage; some credit transfer is normally performed which frequently allows him/her to complete the second stage in 10 or 11 semesters after being admitted to the first stage;
- a student skips the last part of the first stage (the last semester or the last two semesters) and, if admitted, enters the second stage; this path normally takes 10 semesters and is equivalent to the traditional integrated BS-MS program.

As alluded to before, the process of transformation from the traditional study system to the two-stage system has not been controlled at the national level – the decisions have been left to initiatives of universities or even their individual organizational units (faculties). However, increasingly more official bodies have declared their support for the new structure. In particular, on September 12, 1997, the concept of the two-stage system was officially endorsed by the Conference of Rectors (Presidents) of Polish Technical Universities - the intention to enhance the flexibility and openness of engineering studies through the introduction of a three-stage study system (with PhD studies considered as the third stage of the system) was declared.

4. Evolution of curricula

Changes in engineering education have not been limited to the general structure of studies. Significant changes have been made at many institutions of higher education in Poland in the organization of the education process and in the curriculum. The most significant changes include:
- the number of courses to be taken each term has been reduced by integrating lectures, recitations, lab sessions and projects, formerly frequently existing as separately graded items;
- the number of contact hours per week has been reduced, with the education becoming more dependent on self-study;
- the percentage of elective courses in the curriculum has increased;
- the percentage of humanities, social science, business and management, and language classes in the curriculum has increased.

Moreover, in many institutions the design components of engineering courses related to hands-on experience have also increased at the expense of lectures and recitations.

Such changes have been observed regardless of whether or not the new, two-stage structure of studies has already been adopted by an institution. In fact, they usually were initiated a few years before the introduction of the two-stage system of studies.

The above trends are illustrated in Table 3 where the evolution of the curricula at the Faculty of Electronics and Information Technology, Warsaw University of Technology, is shown. Two fields of study, *Computer Science and Engineering* and *Control Engineering and Robotics* are considered. Three different 5-year programs leading to the master’s degree are compared 4:

- the integrated BS-MS program, offered to all students admitted before 1990,
- the integrated BS-MS program, offered to all students admitted in the period 1990-1993,
the program implemented in the framework of the two-stage system of studies as a combination of the first 6 semesters of the first stage with the 4-semester second stage, offered to students who were admitted after 1993.

Table 3. Evolution of curricula at the Faculty of Electronics and Information Technology, Warsaw University of Technology

<table>
<thead>
<tr>
<th></th>
<th>Computer Science and Engineering</th>
<th>Control Engineering and Robotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>total number of contact hours</td>
<td>3870 b</td>
<td>3420</td>
</tr>
<tr>
<td>number of contact hours per week</td>
<td>28.7</td>
<td>25.3</td>
</tr>
<tr>
<td>non-technical courses</td>
<td>19.4%</td>
<td>17.6%</td>
</tr>
<tr>
<td>mathematics and physics</td>
<td>13.2%</td>
<td>10.9%</td>
</tr>
<tr>
<td>engineering</td>
<td>55.8%</td>
<td>59.2%</td>
</tr>
<tr>
<td>thesis-related activities</td>
<td>11.6%</td>
<td>12.3%</td>
</tr>
<tr>
<td>restricted technical electives</td>
<td>-</td>
<td>1.3%</td>
</tr>
<tr>
<td>free technical electives</td>
<td>9.3%</td>
<td>15.8%</td>
</tr>
<tr>
<td>technical courses - tutorials</td>
<td>19.5%</td>
<td>11.1%</td>
</tr>
<tr>
<td>technical courses - labs and projects</td>
<td>25.3%</td>
<td>34.3%</td>
</tr>
<tr>
<td>number of courses</td>
<td>103</td>
<td>81</td>
</tr>
<tr>
<td>number of courses/semester</td>
<td>11.4</td>
<td>9.0</td>
</tr>
</tbody>
</table>

- this number does not include the activities associated with the preparation of the master’s thesis
- the curriculum requirements include, in addition, 3 periods of 4-week industrial training for each program
- this is an average number given under assumption that the preparation of the master’s thesis takes one semester of studying, i.e. the total number of contact hours is distributed over 9 semesters
- for each program, 180 hours are devoted to physical exercise
- this is an average number given under assumption that the preparation of the master’s thesis takes one semester of studying, i.e. the total number of courses is distributed over 9 semesters

These programs are compared with regard to the following characteristics:
- the total number of scheduled contact hours during the period of study;
- the percentage of scheduled contact hours associated with the following four groups of courses that comprise the curriculum (the total number of contact hours is given in parentheses):
  - non-technical courses (foreign language, humanities & social sciences, business & management, physical exercises);
  - mathematics and physics courses;
  - engineering courses (basic engineering courses, courses related to the field of study and to the area of concentration);
- courses which involve individual work that leads to the preparation of the thesis: large design projects, individual reading and research courses, diploma seminars, etc. (the preparation of the thesis itself is not included);

• the percentage of technical elective courses (restricted and free electives) in the curriculum;
• the percentage of tutorials and group laboratory and supervised project sessions in required technical courses (mathematics, physics, and engineering courses);
• the total number of courses (units for which a grade that occurs in students’ records is given) and the average number of courses per semester (assuming that the preparation of the master’s thesis takes one semester of study, i.e. the number of courses is divided by 9); if the curriculum requirements include elective courses and their number is not directly specified (the number of scheduled contact hours is only given), this number is estimated using an average "size" of an elective course.

The evolution of the curricula have not been driven by any regulations at the State level. Most Polish technical universities are autonomous institutions which means that they are solely responsible for their curricula. In fact, in most universities, this responsibility has been moved down to the level of faculty. The only constraint in design of engineering curricula are – according to the Act on Higher Education - the minimum requirements set for each field of study by the National Council of Higher Education (NCHE), an independent body composed of representatives of institutions of higher education.

So far, the minimum requirements have been formulated by the NCHE only for a limited subset of fields of study and only for the traditional 5-year integrated BS-MS program. These requirements specify some general characteristics of the curriculum and, for a specific field of study, define a list of subject areas that must be covered by the curriculum and the corresponding number of scheduled contact hours.

The general curriculum requirements formulated in 1996 for electrical and computer engineering (ECE) related fields of study - Control Engineering and Robotics and Electrical (Power) Engineering – can be summarized as follows:

• approximately 3350 (approximately 3300 for Electrical Engineering and approximately 3400 for Control Engineering and Robotics) hours of scheduled classes (contact hours) – lectures, tutorials, group laboratory and supervised project sessions; in addition, an equivalent of about 400 contact hours should lead to the master’s thesis; (for a 10-semester program with a 15-week semester, this requirement translates into about 25 contact hours per week);
• not less than 40% of all scheduled classes should be practice-oriented activities (tutorials, laboratory and project sessions);
• the curriculum should include a 12-week period of industrial training;
• the general distribution of courses should be close to the following proportions:
  - non-technical subjects - 10%,
  - basic subjects (maths and science, fundamentals of engineering) – 35%,
  - technical subjects related to the field of study – 55%.
Detailed curriculum requirements for the field *Electrical (Power) Engineering* are as follows (the required minimum number of contact hours is given in parentheses):

A. Non-technical subjects (360, equivalent to about one semester of study):
   - foreign language (180)
   - humanities & social sciences, business & management (90)
   - physical exercises (90)

B. Basic subjects (990, equivalent to about 2.5 semesters of study):
   - mathematics (300)
   - physics (180)
   - materials (45)
   - circuits and fields (300)
   - computers in engineering (120)
   - engineering graphics (45)

C. Basic subjects related to the field of study (645, equivalent to about 1.75 semesters of study):
   - fundamentals of electronics and power electronics (105)
   - electric machines (135)
   - control (75)
   - high voltage engineering (60)
   - fundamentals of power engineering (60)
   - safety in electrical engineering (30)
   - microprocessors (60)
   - measurement and instrumentation (120)

These requirements sum up to 1995 hours, i.e. they cover 54% of the entire curriculum. For each of the above-listed subjects, the NCHE requirements specify a detailed list of topics to be covered.

Detailed curriculum requirements for the field *Control Engineering and Robotics* are as follows (the required minimum number of contact hours is given in parentheses):

A. Non-technical subjects (450, equivalent to about 1.25 semesters of study):
   - foreign language (180)
   - humanities & social sciences (90)
   - economy, accounting, law, management (90)
   - physical exercise (90)

B. Basic subjects (800, equivalent to about 2.1 semesters of study):
   - mathematics (320)
   - physics (180)
   - computers in engineering (180)
   - fundamentals of signals, systems and control (120)

C. Basic subjects related to the field of study (540, equivalent to about 1.5 semesters of study):
   - mechanics (60)
   - circuits and electronics (120)
   - control (240)
fundamentals of robotics (120)

These requirements sum up to 1790 hours, i.e., they cover 47% of the entire curriculum. For each of the above subjects, the NCHE requirements specify a detailed list of topics to be covered.

The general characteristics of curricula in ECE-related fields of study for the selected programs at Polish technical universities are shown in Table 4. We consider only 5-year programs leading to the master’s degree, implemented either in the traditional way (integrated BS-MS program) or within a two-stage system where a student skips the last part of the first stage of studies and enters the second stage of studies. The curricula for the first stage leading to the bachelor’s degree are not considered here because they are difficult to compare (they differ in length) and for such programs there are no commonly accepted requirements (similar to the above described NCHE minimum requirements for 5-year master programs). The following programs are considered:

- **Computer Science and Engineering:**
  - the program implemented at the Faculty of Electronics and Information Technology, Warsaw University of Technology (WUT-FEIT) in the framework of the two-stage system of studies as a combination of the first 6 semesters of the first stage of studies with the 4-semester second stage of studies 4;
  - the program at the Faculty of Electrical Engineering, Automatics, Computer Science and Electronics, University of Mining and Metallurgy, Cracow (UMM) 3;
  - the program at the Faculty of Electronics, Telecommunications and Informatics, Technical University of Gdansk (TUG) 10;
- **Control Engineering and Robotics:**
  - the program implemented at the Faculty of Electronics and Information Technology, Warsaw University of Technology (WUT-FEIT) in the framework of the two-stage system of studies as a combination of the first 6 semesters of the first stage of studies with the 4-semester second stage of studies 4;
  - the program at the Faculty of Electrical Engineering, Warsaw University of Technology (WUT-FEE) 3;
  - the program at the Faculty of Electronics, Telecommunications and Informatics, Technical University of Gdansk (TUG), characterized by the numbers given for the area of concentration Computer-Supported Control Systems, being representative of the whole program 5;
- **Electrical (Power) Engineering:**
  - the program at the Faculty of Electrical Engineering, Warsaw University of Technology (WUT-FEE), characterized by the numbers given for the area of concentration Power Engineering – Electronic Systems, being representative of the whole program 2;
  - the program at the Faculty Electrical Engineering, Technical University of Zielona Gora (TUZG), characterized by the numbers given for the area of concentration Power Engineering – Electronic Systems, being representative of the whole program 11.
These programs are compared in Table 4 with regard to the criteria used earlier when describing the evolution of curricula at the Faculty of Electronics and Information Technology, Warsaw University of Technology (Table 3).

The following observations can be made:
- The ECE-related curricula at different institutions and even within the same university differ significantly with regard to general characteristics, such as student load (number of scheduled contact hours per week) and level of flexibility (percentage of elective courses in the curriculum).
- Although most of the examined curricula were developed before the National Council of Higher Education (NCHE) requirements were published, they comply - at least with regard to their general characteristics - with NCHE requirements.

Table 4. General characteristics of curricula in ECE-related fields of study for selected programs at Polish technical universities

<table>
<thead>
<tr>
<th></th>
<th>Computer Science and Engineering</th>
<th>Control Engineering and Robotics</th>
<th>Electrical Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WUT-FEIT</td>
<td>UMM</td>
<td>TUG</td>
</tr>
<tr>
<td>total number of contact hours</td>
<td>3480</td>
<td>3285</td>
<td>3795</td>
</tr>
<tr>
<td>number of contact hours per week</td>
<td>25.8</td>
<td>24.3</td>
<td>28.1</td>
</tr>
<tr>
<td>non-technical courses a</td>
<td>19.0%</td>
<td>5.0%</td>
<td>15.0%</td>
</tr>
<tr>
<td></td>
<td>(480)</td>
<td>(165)</td>
<td>(390)</td>
</tr>
<tr>
<td></td>
<td>+(180)</td>
<td>+(0)</td>
<td>+(180)</td>
</tr>
<tr>
<td>mathematics and physics</td>
<td>10.8%</td>
<td>16.9%</td>
<td>11.9%</td>
</tr>
<tr>
<td></td>
<td>(375)</td>
<td>(555)</td>
<td>(450)</td>
</tr>
<tr>
<td>engineering</td>
<td>60.8%</td>
<td>75.3%</td>
<td>66.0%</td>
</tr>
<tr>
<td></td>
<td>(2115)</td>
<td>(2475)</td>
<td>(2505)</td>
</tr>
<tr>
<td>thesis-related activities (does not include thesis)</td>
<td>9.5%</td>
<td>2.8%</td>
<td>7.1%</td>
</tr>
<tr>
<td></td>
<td>(330)</td>
<td>(90)</td>
<td>(270)</td>
</tr>
<tr>
<td>restricted technical electives</td>
<td>10.3%</td>
<td>4.6%</td>
<td>0</td>
</tr>
<tr>
<td>free technical electives</td>
<td>10.3%</td>
<td>0</td>
<td>5.5%</td>
</tr>
<tr>
<td>techn. courses - tutorials</td>
<td>6.7%</td>
<td>16.3%</td>
<td>15.0%</td>
</tr>
<tr>
<td>techn. courses - labs and projects</td>
<td>34.8%</td>
<td>24.6%</td>
<td>35.2%</td>
</tr>
<tr>
<td>number of courses</td>
<td>69</td>
<td>77</td>
<td>85</td>
</tr>
<tr>
<td>number of courses/semester</td>
<td>7.7</td>
<td>8.6</td>
<td>9.4</td>
</tr>
</tbody>
</table>

a the first number in parentheses gives the number contact hours associated with foreign languages, humanities & social sciences, business & management; the second number in parentheses gives the number contact hours associated with physical exercise

- In all cases student’s load is quite heavy – there are a lot of regularly scheduled classes and the number of courses taken each semester is high, at least compared to the international standards of engineering education.
- Compared to American standards of engineering education (e.g. ABET criteria ¹), non-technical subjects are underrepresented in the curricula.
For some programs, the level of flexibility (the percentage of elective courses in the curriculum) is quite low. It must be noted, however, that detailed curriculum requirements are typically defined not for a field of study, but for a particular area of concentration or even for a particular profile within an area of concentration. For example, at the Faculty of Electrical Engineering, Warsaw University of Technology, there are four areas of concentration within the field of Electrical Engineering and a curriculum is defined for each of 21 profiles within these four areas (the curriculum described under the heading "Electrical Engineering WUT-FEE" in Table 4 is one of them). Therefore, a student has, in fact, more choices in designing an individual program of study than suggested by Table 4.

It appears that the development of practical skills is very well emphasized in ECE programs – tutorials, group laboratory and supervised project sessions constitute a significant portion of the curriculum and, in addition, each student has to do some practical work as part of the process that leads to the completion of the master's thesis. It should be mentioned, however, that in Polish universities the idea of an open laboratory is still not very popular - student's access to laboratories for individual work outside of scheduled classes is quite limited.

The numbers in Table 4 do not give a complete view of the organization and content of the ECE curricula in Poland. Their other characteristic features are:

- too narrow specialization, i.e. too many highly specialized courses in the required curriculum, leaving little room for the development of individual (possibly interdisciplinary) programs of study;
- too little emphasis on general engineering topics, not related directly to the field of study; for example, mechanics and chemistry courses are quite unusual in the ECE curricula, except for the field Control Engineering and Robotics;
- insufficient integration of passive and active forms of learning; it happens quite frequently that for a particular subject, the lecture and tutorials are run in one semester and the laboratory or the project in the next semester; besides, even if a particular subject area is completely covered in one semester, separate grades are given for the theoretical knowledge part (exam grade) and skills development part (lab or project grade);
- insufficient integration of the content within course sequences – unnecessary redundancy and insufficient coverage of some areas;
- insufficient level of training in personal (transferable, soft) skills, in particular in teamwork, technical communication (both written and oral), self-development, leadership, etc.
- insufficient level of training in understanding society-oriented aspects of engineering – safety, ethics, sustainable development, etc.

5. Future developments

The evolution of ECE education in Poland has been under way since 1989, and many significant changes can be expected to come within the next 10 years. The future changes of the systems of study and of ECE curricula may be critically influenced by legal changes implied by the new Act on Higher Education to be passed by the Polish Parliament in 1999. The fundamental issues to be covered by this Act have been currently discussed by the Polish academic milieu. Some of them seem to be of particular relevance to the evolution of engineering education and to ECE education, viz. 14:
• a proposition to elevate the future Act on Higher Education to the so-called code-of-law status and make it a general framework regulating the entire sphere of higher education while greatly increasing the role of school statutes as sources of law;
• the creation of a legal framework for supervision by the Minister of National Education of all the institutions of higher education; definition of conditions under which the Minister’s supervision of a public institution of higher education may be replaced by the supervision of the school council;
• the definition of public institution of higher education in a way allowing the creation and functioning of all such schools according to the same general principles, regardless of their character or ownership status;
• the replacement of the existing separate institutions of National Council of Higher Education and the State Accreditation Board for Scientific Titles and Degrees (SAB) as well as of the postulated Academic Accreditation Committee (AAC) with a new institution retaining the old name of National Council of Higher Education and consisting of three chambers—the National Council, SAB and AAC—serving as a single central institution for regulation/standardization and accreditation in higher education;
• the obligation of public institutions of higher education and non-public institutions of higher education enjoying the rights of public institutions to obtain accreditation of study programs in the fields of study in which State diplomas are conferred, as part of generally applicable procedures;
• granting the fully autonomous public institutions of higher education the right to decide about their internal structure, as well as about the kinds and competencies of their organs and principles of the appointment thereof (the only exceptions here being the rector and senate);
• granting public institutions of higher education the right to create associations of schools and federations, including also those with legal entity status;
• better safeguarding of the public institution of higher education’s right to preserve the integrity of its assets, and also its right to use these assets, including also the right to invest capital with the view to obtain resources from outside the State budget (including credit) which could be used to boost the institution’s development potential;
• granting public institutions of higher education the right to implement their own systems of assessing the teaching and the right to implement their own remuneration systems;
• strengthening the position of institutions of higher education as “direct employer” by granting school organs a free hand in shaping criteria and legal forms of employment, mutual obligations and defining responsibility for neglect of employee duties; extending the freedom of contract-based employment in higher education;
• presentation of a well-defined proposal for a system of sharing the costs of studies by the State and students.

6. Conclusion

Similar to the situation in America, electrical and computer engineering education in Poland is evolving. While curricula in both countries are undergoing changes, and are to a degree converging, both the extent of change and the change mechanisms are different. While America has a long market-economy tradition, this is not the case for Poland. And while both
Polish and American educational institutions are striving to adjust to the realities of changes in business practices in the emergent global economy, the adjustments in Poland are simultaneously both facilitated and exacerbated by Poland's recent shift from a command to market economy.

In Poland, curricular response is now much more institutionally independent rather than centrally controlled as it was in the past. Also, the institutional interface to the (market) economy is more direct in Poland than in America, where changes are being driven indirectly through the program accreditation process, i.e. ABET's EC 2000 criteria.

The rather extensive changes to Polish electrical and computer engineering education that are described herein are an effort to move the field of study to a more competitive position in the new economic and political arena Poland has entered. It is hoped that these changes will result in improved educational processes that will better serve the needs of Poland and its people.

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