Decline of Academic Standards in Engineering Education ?
– Polish Experience –

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I. Introduction

The process of declining academic standards, observed at American institutions of higher education, has been reported in the 90s by many authors; an extensive review of the relevant sources may be found in a paper submitted to this conference by Brian Manhire from Ohio University[1]. In our paper, we discuss some aspects of this, in fact, world-wide process that can be observed at Warsaw University of Technology, the largest institution of engineering education in Poland.

We focus on:
- university-level academic regulations;
- course grading patterns at a selected faculty – the Faculty of Electronics and Information Technology.

Talking about the university-level academic regulations, we report the changes that occurred in the procedure that is used to determine the final grade for the program (in Poland, this final grade appears on the diploma). As a result of these changes – even if we assume no grade inflation for individual courses that the curriculum is composed of – the percentage of students who graduate with the final grade *outstanding* or *very good* would be now significantly higher than it used to be just few years ago. It may seem to be a paradox that, at the same time, the quality of preparation of the candidates for engineering studies has been systematically decreasing in Poland since 1989.

We make an attempt to explain our observations in terms of both world-wide phenomena afflicting the civilized societies and local phenomena related to the political and economic transformation in Poland after 1989.

II. Preliminary explanations on the Polish system of higher education

In this section, we explain some specific features of the Polish system of higher education that are different from the corresponding regulations in other countries (in particular, in the United States).

The traditional grading scale at Polish institutions of higher education – for courses, theses, and sometimes also course components (examinations, homework assignments, *etc.*) – contains the following marks: 5.0 (the highest grade), 4.5, 4.0, 3.5, 3.0 (the lowest passing grade), and 2.0 (the failing grade).

The weighted grade average, WGA, for N courses taken by a student during a considered period of study (in particular, during the entire period of study) is calculated as:

$$\mathrm{WGA} = \sum_{n=1}^{N} w_n g_n \Big/ \sum_{n=1}^{N} w_n$$

where g_n is the grade received in the nth course, w_n is the weight of the nth course (w_n is usually equal to the number of credit points assigned to the nth course). If a course is retaken by a student (usually because of the failing grade), either the new grade only or both the failing grade and the new grade are taken into account when calculating the WGA, depending on the academic regulations at a particular institution.

A diploma received by a student upon completion of a program of study at an institution of higher education contains the following information:
– the name of the institution (university) and of its department (faculty),
– the name of the degree, *e.g.* Master of Science (M.S.),
– the field of study and, optionally, the area of concentration,
– the final grade.

The scale for the final grade differs from the scale used for grading courses – it has no numerical values. Most institutions use the following scale: *excellent*, *very good*, *good*, *quite good*, and *sufficient*. The regulations for determining the final grade are set by the institution. Since the curriculum requirements for an engineering program (both at the B.S. level and M.S. level) require a thesis and its defense (diploma examination), the final grade is usually determined so that its numerical value (numerical final grade – NFG) is first calculated according to the formula:

$$\mathrm{NFG} = c_1 \cdot \mathrm{WGA} + c_2 \cdot \mathrm{TG} + c_3 \cdot \mathrm{EG}$$

where WGA is the earlier defined weighted grade average, TG is the grade for thesis, EG is the grade for diploma examination (thesis defense), and c_i $(i = 1, 2, 3)$ are weighting coefficients, such that $c_1 + c_2 + c_3 = 1$. Then, the values of NFG are "mapped" into non-numerical grades using a procedure set up at the institution level.

III. Overview of the university-level academic regulations

For the last 10 years, several changes in the academic regulations that affected the procedure for calculation of the final grade for the programs have been approved by the Senate of the Warsaw University of Technology.

According to the regulations being in force in the 80's, the NFG was calculated using the formula:

$$\mathrm{NFG} = 0.5 \cdot \mathrm{WGA} + 0.25 \cdot \mathrm{TG} + 0.25 \cdot \mathrm{EG}$$

where WGA was an arithmetic average (equal weights for all courses) and so that in the case of a retaken course (or even a retaken exam), the final passing grade and all the failing grades were counted. The final grade was determined as shown in Table 1.

Table 1. Final grade calculation in the 80's

NFG	final grade
≥ 4.51	very good
3.51 – 4.50	good
≤ 3.50	sufficient

The regulations adopted in 1991 introduced a new mark for the final grade – *quite good*. Also, the procedure for the calculation of WGA was modified: the decision on assigning different weights to different courses was left to individual faculties and, in the case of a retaken course, the final passing grade and exactly one failing grade was counted (even if the course was retaken more than once). The final grade was determined as shown in Table 2.

Table 2. Final grade calculation in 1991-1994

NFG	final grade
≥ 4.40	very good
3.90 – 4.39	good
3.50 – 3.89	quite good
≤ 3.49	sufficient

In 1994 another mark for the final grade was introduced – *excellent*. The final grade was determined as shown in Table 3.

Table 3. Final grade calculation in 1994-1995

NFG	final grade
≥ 4.50	excellent
4.11 – 4.49	very good
3.76 – 4.10	good
3.40 – 3.75	quite good
≤ 3.39	sufficient

The regulations adopted in 1995 changed the formula for the calculation of NFG:

$$NFG = 0.6 \cdot WGA + 0.3 \cdot TG + 0.1 \cdot EG \, .$$

Since then the final grade has been determined as shown in Table 4.

Table 4. Final grade calculation from 1995

NFG	final grade
≥ 4.70	excellent
4.30 – 4.69	very good
3.90 – 4.29	good
3.50 – 3.89	quite good

≤ 3.49	sufficient

The regulations adopted in 1998 changed the procedure for the calculation of WGA: since then, when calculating the contribution of a retaken course to WGA, only the final passing grade has been counted (failing grades are not considered regardless of how many times the course is retaken).

IV. Preliminary explanations on the statistical data

In Section V, we show some statistics which demonstrate the changes in the weighted grade average and final grades at the Faculty Electronics and Information Technology over the period of the last 12 years. The following remarks must be taken into account when analyzing the presented data:

- The regular full-time students who received their degrees in 1988, 1992, 1996 and 2000 are considered.
- The data refer to the 5-year program leading up to the M.S. degree – the traditional model of engineering education in Poland and the predominant model of studies at the Faculty for students who graduated in 1998 or before. Only for 2000, the students who completed the 4-year program leading up to the B.S. degree are also considered. It must be noted that since the introduction of the two-stage system of studies (B.S. – M.S.) in 1994, only good students (with good scores after the third year of studying) have been allowed to pursue the 5-year program leading up to the M.S. degree; the other students have been required to obtain their B.S. degree first. Therefore, the weighted grade average and the final grades of the B.S. graduates are generally lower than those of the M.S. graduates.
- The data characterize the students admitted in the period 1983-1995. In that period some differences in the average quality of admitted students could be observed. These differences resulted from the year-to-year changes in the number of candidates per place. This indicator was significantly higher in the first part of this period than in its second part. Thus, the candidates admitted in the 80's who graduated in 1988 and 1992 were on average better than those admitted in the 90's who graduated in 1996 and 2000.
- The last phase of the study program is mostly organized by institutes (the Faculty of Electronics and Information Technology is composed of 6 institutes); upon completion of the third year of study, each student selects an institute and an individual advisor who also supervises student's thesis (students with higher grades have a priority in the case of a competition for an institute or advisor).

V. Distribution of final grades – statistical data

In Table 5, we show the number of graduates and the distribution of final grades for the students who completed the program of study at the Faculty in the period 1988-2000. For year 2000, we show the numbers for all the graduates and, in the last column, for the students who graduate with the M.S. degree (the remaining students graduate with the B.S. degree). The symbol "-" in Table 5 means that a particular grade was not allowed by the regulations, as discussed in Section II.

Table 5. Final grades for the Faculty graduates

final grade	1988	1992	1996	2000-total	2000-M.S.
	number of graduates				
	216	318	196	462	246
excellent	-	-	18.9 %	11.3 %	21.1 %
very good	32.0 %	38.4 %	40.8 %	44.6 %	61.4 %
good	62.0 %	54.7 %	34.2 %	39.8 %	16.7 %
quite good	-	5.0 %	5.6 %	3.2 %	0.8 %
sufficient	6.0 %	1.9 %	0.5 %	1.1 %	0.0 %

In Tables 6-8, we show the number of graduates (for 2000, the total number and – in parentheses – the number of graduates with the M.S. degree) and the changes in the distribution of the weighted grade average (WGA) for the students who graduated from three different institutes. In each case, the values of WGA were calculated according to the regulations being in force at the time of graduation (these regulations have changed over the considered period of time, as described in Section III). The selection of the institutes is done so that it illustrates different patterns of student preferences and capabilities:

- The Institute of Computer Science has traditionally recruited very good students.
- The Institute of Radioelectronics has recruited students whose grades have been – in statistical sense – average or just below the average for the entire Faculty.
- For the Institute of Telecommunications the preferences of students have been changed dramatically: in the 80's, it was an institute least demanded by the students (and therefore recruited mostly students with relatively low grades), whereas in the late 90's – because of the changes on the labor market – it has become the most demanded institute.

The three institutes considered here account for most students who receive their diploma from the Faculty. In 2000, 285 out of 462 graduates prepared their theses in one of these three institutes.

Table 6. Weighted grade average for the students who graduated from the Institute of Computer Science

WGA	1988	1992	1996	2000
	number of graduates			
	43	38	18	72(42)
≥ 4.40	2.3 %	10.5 %	27.8 %	23.6 %
4.20 – 4.39	4.6 %	13.2 %	16.7 %	23.6 %
4.00 – 4.19	23.3 %	15.8 %	22.2 %	25.0 %
3.80 – 3.99	16.3 %	18.4 %	11.1 %	19.5 %
3.60 – 3.79	18.6 %	28.9 %	11.1 %	8.3 %
≤ 3.59	34.9 %	13.2 %	11.1 %	0.0 %

Table 7. Weighted grade average for the students who graduated from the Institute of Radioelectronics

WGA	1988	1992	1996	2000
	number of graduates			
	65	57	35	93(41)
≥ 4.40	1.5 %	8.8 %	8.5 %	4.3 %
4.20 – 4.39	9.2 %	17.5 %	17.1 %	14.0 %
4.00 – 4.19	20.0 %	21.1 %	31.4 %	12.9 %
3.80 – 3.99	23.1 %	22.8 %	25.7 %	32.3 %
3.60 – 3.79	27.7 %	26.3 %	14.3 %	25.8 %
≤ 3.59	18.5 %	3.5 %	2.9 %	10.7 %

Table 8. Weighted grade average for the students who graduated from the Institute of Telecommunications

WGA	1988	1992	1996	2000
	number of graduates			
	33	71	39	120(82)
≥ 4.40	6.1 %	1.4 %	10.2 %	20.0 %
4.20 – 4.39	6.1 %	9.9 %	19.4 %	22.5 %
4.00 – 4.19	6.1 %	21.1 %	29.0 %	26.7 %
3.80 – 3.99	18.2 %	23.9 %	29.0 %	24.1 %
3.60 – 3.79	24.2 %	29.6 %	19.4 %	6.7 %
≤ 3.59	39.3 %	14.1 %	16.1 %	0.0 %

VI. Distribution of course grades – statistical data

After each semester is completed, statistics on the course grading across the Faculty are produced. For each course, these statistics show:
– number of students,
– average grade given in the course (GA),
– grade standard deviation (GSD),
– an average value of the weighted grade average for the students who registered for the course (AWGA).

It should be observed that AWGA is a measure of how good the students who registered for the course are. Therefore, the difference GA – AWGA is an indicator of how demanding the instructor is on grading. If for some course GA – AWGA > 0, then the grades for that course are generally higher than the grades received earlier by the students on the course roster. If GA – AWGA < 0, then the instructor is tougher on grading than instructors of other courses taken by his/her students.

The grading statistics for the courses taught in the spring semester of the academic year 1999/2000 show that among 246 engineering-oriented regular courses (individual design projects and seminars are not included):

– for 42 courses, GA – AWGA > 0.5 (very lenient grading),
– for 8 courses, GA – AWGA < - 0.5 (very harsh grading).

The grading statistics for courses having the most "interesting" grading patterns are shown in Table 9.

Table 9. Course grading statistics – selected cases

course	students	GA	GSD	AWGA	GA – AWGA
Integrated optoelectronics	14	4.86	0.23	3.86	1.00
Programmable controllers	44	4.69	0.50	3.70	0.99
Satellite telecommunication systems	85	4.84	0.39	3.89	0.94
Electronics 3	114	4.49	0.62	3.69	0.80
Fundamentals of digital transmission	163	4.36	0.30	3.96	0.40
median value of GA		3.86			
Photonic systems and networks	73	3.45	0.64	4.23	-0.78
Evolutionary methods and machine learning	62	3.19	0.65	3.96	-0.78
Switching systems	31	3.11	0.73	4.16	-1.05

VII. Observations derived from the statistical data

Based on the data shown in Sections VI and VII, the following observations can be made regarding the grading standards at the Faculty of Electronics and Information Technology, Warsaw University of Technology.

The currently applied course grading standards across the Faculty appear highly inconsistent. There exist numerous courses in which the instructors are much tougher on grading than an "average instructor" at the Faculty. On the other hand, there are many courses in which the instructors are very "student-friendly" with regard to grades. Among these courses, the ones in which the value of the GSD is low.0 are of special concern.

The process of the inflation of course grades over the considered period of the last 12 years can easily be observed. As shown in Table 6, in 1988 only 30 % of students completing their programs at the Institute of Computer Sciences had the weighted grade average above 4.0 (maximum = 5.0), whereas in 2000 this number increased to 72 %. The same trend can be observed at the other institutes, although some differences between the institutes exist. In particular, the very high rate of grade inflation at the Institute of Telecommunications can – to some extent – be explained by the increasing popularity of this field of study among the students (increasing quality of admitted students).

It must be noted that the data shown in Tables 6-8 are biased by two factors:

– differences in capabilities of the students admitted to the Faculty as a whole and to individual institutes being a consequence of the varying number of candidates for study (the admission

requirements for the students who graduated in 1988 and 1992 were higher than for the students who graduated in 1996 and 2000);
– the changes in the university-level regulations concerning the calculation of the weighted grade average (the average course grades for 1992-2000 are generally lower than those shown in Tables 6-8 because some – for 1992 and 1996 – or all – for 2000 – failing grades were not considered when calculating the value of WGA.

The process of grade inflation is particularly well seen when the final grades for the program are concerned. This process is a superposition of two trends: inflation of course grades and changes in the university-level regulations concerning the calculation of the final grade. As a result, a significant degradation of the value of final grades has occurred. In the 80's, the final grade *very good* was quite difficult to obtain. As shown in Table 5, in 1988, only 32 % of the graduates received the *very good* grade. In the 90's, the value of being *very good* has diminished; first, because of an introduction of the grade *excellent*, and second, because higher course grades and the final grade calculation procedure made it easier to obtain. In 2000, 56 % of the graduates were *very good* or *excellent*, and for the students who completed the M.S. program this percentage was even higher – 82 %. Getting a *very good* grade on a M.S. diploma is not a reason to be proud any more; in fact, *very good* has become a below-average grade (more students receive *excellent* than *good* or lower grades).

VIII. Tentative interpretation

The observed phenomena are, undoubtedly, related to the evolution of the attitudes and skills of the consecutive generations of students. There have been many causes contributing to the acceleration of this process by the end of the XXth century:
– rapid development of information technology and its implications in every-day life;
– increasing number of candidates approaching the institutions of higher education;
– rapid expansion of image-based pop-culture.

These are only the most important ones – common to the countries historically related to the sources of Latin civilization. The long-term success of this civilization has been explained by historians and philosophers in many ways, but all they have seemed to agree that abstract thinking was an important cornerstone of this civilization that supported its success. The idea of *classification* that underlies abstract thinking enables us to grasp infinite reality using a finite set of concepts and rules. It makes us also capable of getting control over exponentially growing quantity of information. It enables us to communicate verbally – to speak and understand speech, to write and to read with understanding. A particular feature of this type of communication is its selectiveness – both communicating persons are able to intellectually control the majority of transmitted information. This is not a case in image-based communication, established – for example – by means of television, where only small part of information stream is subject to such a control, while its majority is "absorbed" unconsciously by the receiving person. The image-based communication is a distinctive feature of the information age, with all its positive and negative consequences. The latter ones have recently reflected on the decreasing students' ability to really understand and correctly use abstract notions; to fully understand traditional handbooks of mathematics or physics; to draw logical conclusions from the results of computation or results of a physical experiment.

The evolution of the attitudes and skills of the consecutive generations of students is confronted with the growing requirements towards the engineering profession in the modern societies, and – consequently – towards engineering education:

- New technologies become out of date after *ca.* 3 years while the cycle of reaching full professional efficiency by a graduate is 6–8 years (4–6 years of study and 2 years of initial professional experience). Consequently, it seems to be useless to base the education of the future engineers on the ideas that will become obsolete at the beginning of their professional careers. The rapid advancement of technologies is accompanied by an exponential growth of the volume of engineering knowledge that cannot be unlimitedly added to the engineering curricula. This should be the reason for more synthetic and methodical teaching of the fundamentals.
- The main competence of an engineer is to solve technical problems, or – more precisely – to design solutions to those problems, to supervise the implementation of those solutions and to use them in practice. Therefore, the *skill* of creative thinking seems to be of primary importance for an engineer's professional success, and – consequently should be taught at the university.
- The professional success of an engineer is determined not only by his/her knowledge and skills, but also in the same degree by his/her personality and *attitudes*. They should be also formed at the university.
- The extension of the engineers' responsibility for human life and happiness implies increased requirements concerning their moral standards. It is a moral duty of engineers to take into account ecological, cultural and ergonomic aspects in designing technical objects and actions. Consequently, providing the graduates with opportunities for developing ethical views and attitudes becomes an obligation for the university. This is an objective of humanities and social sciences introduced in the curriculum, but it is also a role of the system of study to increase the students' responsibility for the effects of their professional activity and develop the culture of quality.

How the above-outlined expectations towards engineering education are in every-day academic life confronted with hard reality of declining students preparation for meeting them ?. The intellectual distance to physical reality has been growing enormously in the experience of the new generations of students due to the omnipresence of virtual-reality technology. Their experimental capabilities and skills have been severely handicapped by the withdrawal of the majority of secondary schools from offering laboratory exercises supporting lectures in physics, chemistry or biology. On the other hand, their potential for abstract thinking has been considerably reduced by the lack of appropriate training, implied by several factors:

- predominant role of image culture in their early formation;
- predominant orientation of secondary schools on the preparation of candidates for the most fashionable (after 1989) studies, *viz.*: business, management, law and public relations;
- predominant orientation of young people on quick financial success requiring concentration on a narrow specialization rather than on broad fundamentals;
- post-modernist way of thinking, promoted by media and some post-Marxist academic milieus, undermining traditional systems of values – including such values as wisdom, logic and systematic philosophy.

The limited ability of abstract thinking disables the students to understand fundamental ideas and concepts that inevitably appear in academic lectures.

Example: Two groups of students, each composed of *ca.* 100 students of the fifth semester, have been tested at the Faculty of Electronics and Information Technology (Warsaw University of Technology) in such a way that they were asked to give a one-sentence definition or description of four concepts: *theory*, *model*, *measurement* and *logical induction*. Only a few of them were able to correctly interpret all the concepts; the concept of *logical induction* turned out to be the most difficult.

The negative effects of incomplete understanding are amplified by the inability to concentrate on a line of logical reasoning. Consequently, an average student is unable to benefit from an average academic lecture. He/she is rather inclined to browse in the *Internet* or in the books – preferably, in the books providing detailed explanations without room for personal deduction and reflection. On the other hand, the lack of elementary practical skills, concerning the use of simple tools and instruments, is deterring students from courses supported by laboratory exercises – other than software games – and prevents them from learning by hands-on experience. The avoidance attitude towards experimental work is reinforced by the signals coming from the job markets for our graduates: the most desirable profile of professional qualifications seems to be that of a software engineer able to arrange and maintain a computer network in a bank or in a telecommunication company. Taking into account that salaries offered by those institutions are up to 10 times higher than a standard Ph.D. scholarship, one may easily imagine that it is practically impossible for our students to be seduced by the beauty of abstract thinking or experimental work in a measurement laboratory.

A discrete charm of virtual reality, offered by information technologies, supported by the post-modernist way of thinking, is ravaging the mentality of young people:

– they loose the sense of the borderlines between the world of images and reality;
– they loose the interest in managing physical objects – manipulation of images seems to be more attractive for them;
– they loose the reflex of verifying results of operations performed on the models by means of appropriate experiments;
– they loose criticism towards results of computation.

The disintegration of knowledge, reflected in the structure of contemporary universities, is strongly supported by the students demand for specific knowledge and skills preparing them to the best-paid jobs. No room is left in practice for the real academic studies aimed at the development of personalities and at other long-term objectives, such as moral or intellectual leadership.

The above-characterized circumstances exert a constant pressure on the academic teachers of Polish institutions of engineering education. This is the pressure on providing cheaper and quicker engineering education, requiring – at the same time – less involvement of the educated students. Why the academic teachers yield to this pressure ? A tentative answer could be as follows:

– They have less time for teaching than ever; being severely underpaid for many years, they have had to undertake extra jobs outside of the university.
– They are getting older, and – consequently – less apt to understand youth of today; young M.S. degree and Ph.D. degree holders are deterred from the universities by extremely low salaries if compared to those available outside of the academia.
– The State spending *per capita*, for teaching activities, has been decreasing for 10 years; in 2000, it reached ca. 40 % of its real value for 1991. Consequently, important attempts to modernize the teaching infrastructure and methodology have been frustrated.
– There is no external system of program accreditation or teaching quality assessment.

Under such circumstances, it is easier to survive in the market environment (represented mainly by two factors: job markets for graduates and broad electivity of courses for students) when providing lower quality educational services in a fashionable area of technology and following a lenient pattern of course grading: less work for more money !

IX. Conclusion

By examining the grading patterns for the courses taught at the Faculty of Electronics and Information Technology, we observe that:
– there are very significant differences between the grade point average and grade standard deviation values for the courses taught at the Faculty;
– some strange grading patterns occur for a few courses (*e.g.* a high grade point average and grade standard deviation very close to 0.0).

The differences in grade point average values cannot be explained by simply stating that the students enrolled for some courses are better that those who take other courses, as we compare the grades received by the students in a particular course with the grades received by the same students in all the courses taken before (since the beginning of the study at the Faculty).

By examining the statistics of final grades received by the graduates of the Faculty of Electronics and Information Technology within the period 1988-2000, we observe that there is a significant and systematic increase in the share of the best grades. This tendency cannot be explained by the improvement in the quality of the students because – in fact – we face an observable deterioration in this respect.

We have made an attempt to explain our observations concerning grade inflation in terms of both world-wide phenomena afflicting the civilized societies and local phenomena related to the political and economic transformation in Poland after 1989. On one hand, we have looked at the hypothetical causes of pressure the students exert on the academic staff to get better grades, on the other, we have tried to explain why some members of the academic staff have been susceptible to the pressure exerted by the students. But a fundamental practical question remains open: *What can be done under circumstances described in this paper ?* There have been made some attempts at the Faculty of Electronics and Information Technology (Warsaw University of Technology) to remedy the difficulties, as described in our previous papers[2-4]. However, all they seem to only partially solve the existing problems, but not eradicate their causes. The roots of the problems remain untouched, and no clear strategy for fighting them has been put forward up to now. Some basic questions to be answered are the following:

- Who should act in this respect at the primary and secondary level of education ?
- Who should act, if at all, in the world of media to counterbalance the destructive tendencies observed there ?
- What is the role and responsibility of the academic institutions for both fields of action ?

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