Some Distinctive Features of the Engineering Education in Russia Compared to Other Countries

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Abstract

This paper considers some distinctive characteristics of the Russian system of higher education in engineering. Examples of such outstanding contributions include aircraft engineering, space technology and high performance computing. These achievements are the result of the Russian efficiency in training engineers. One salient aspect of the Russian system is its strong emphasis on fundamental subjects – e.g. mathematics and physics – and the compulsory apprenticeship in the best companies beginning in the third year of studies. The Russian system is unique compared to other universities. All exams are oral, there are no mid-term exams, only final ones. The curriculum is fixed and must be followed in strict sequence. At present, Russia is in the process of reforming its higher education system. This reform involves the transition from one-level certifying system involving a diploma, to a two-level certifying system involving a Bachelor’s and Master’s degrees. This is to allow its programs to be recognized globally. It also involves the establishment of a “federal system” which would include the most prestigious universities. These “federal universities” are entitled to larger funding from the state budget and greater autonomy than other universities. This paper conducts a comparative analysis for the Electrical Engineering (EE) and Computer Engineering (CE) offered at various institutes in different countries (including Assumption University of Thailand and Asian University). It has been found that, compared to other university, what is distinctive about Assumption University is its relatively low number of fundamental courses and a high number of professional courses. This study employs the k-parameter method recommended by UNESCO.

Keywords: Engineering education, Russian system, effectiveness, fundamental courses, professional courses, k-parameter method.

Introduction

The history of engineering education in Russia dates back to 1701 when the School of Mathematical and Navigational Sciences was established in Moscow by the decree of the emperor, Peter the Great. Mathematics, geodesy, sea sailing, cartography, astronomy and other engineering subjects were taught at the School. At that time, the School was the first and the biggest education institution of its type in Europe. Soon after the establishment of the Navigational School, a number of education institutions in engineering were founded in St. Petersburg and Moscow. From the very beginning, the curriculum developed for those institutions included practical and theoretical subjects as well. That system of engineering education became well-known in the world as the Russian system. The number of engineering education institutions in Russia was increasing intensively during the 19th century and so in 1895 there were 11 higher technical education institutions with 5,497 students (Zhurakovksy et al. 2001). The Moscow Higher Technical College (Moscow Bauman State Technical University, nowadays) was among the most prestigious education institutions. That College was awarded many times, including a golden

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medal in a worldwide workshop in Philadelphia, USA, as well as golden medals in Paris, France, and Vienna, Austria. The high quality of the Russian engineering education resulted in great inventions and outstanding designs. The names of A. S. Popov (radio), V. K. Zworykin (TV), I. Sikorsky (helicopter) and S. P. Timoshenko (engineering mechanics) are widely recognized. This list can be continued. Among other causes, the best traditions of Russian engineering education based on combining high-level theoretical teaching and considerable practical training provided in the 20th century well known achievements in aviation and space technologies, in high-performance computing, etc. Some features of the Russian education system are disputable but anyway it deserves a very serious consideration and its positive experience should be taken into account reasonably in the global world of education. Some statistical details concerning the fraction of engineering education in the whole system of higher education in Russia as of 2003 are given in Table 1 below (Anon. 2003).

Table 1. The share of engineering education in the Russian education system.

<table>
<thead>
<tr>
<th>The indices for comparison</th>
<th>All higher-education institutions</th>
<th>Engineering education institutions</th>
<th>Percentage for engineering fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of institutions</td>
<td>State – 621 Private – 387 Total – 1 008</td>
<td>State – 346 Private – 112 Total – 458</td>
<td>55.7 28.9 45.4</td>
</tr>
<tr>
<td>The number of students</td>
<td>State – 4 794 500 Private – 695 500 Total – 5 427 000</td>
<td>State – 1 351 100 Private – 10 000 Total – 1 361 100</td>
<td>28.2 1.6 25</td>
</tr>
<tr>
<td>The number of teaching staff</td>
<td>248 300</td>
<td>81 600</td>
<td>32.8</td>
</tr>
</tbody>
</table>

From the above table it is clear that in the Russian higher education system the fraction of engineering education plays rather significant role. It is noteworthy that the participation of most gifted students in research activities at the Technical Universities (a modern name for many engineering institutions in Russia) also helps in getting better skills by the future graduates.

Current Reform of Higher Engineering Education in Russia

Quite recently in Russia existed one-level education system in engineering with duration of study as of 5½ years (11 semesters) plus two more months for completing and defending a thesis. After that, the degree of a Diplomaed Engineer was awarded which was roughly equivalent to a Master of Engineering degree, but there was no such degree as a Bachelor degree. However, in the end of 2007 in Russia was adopted a law introducing a two-level higher education for most education areas including engineering. The new system is similar to that commonly adopted in the world. The first degree is a degree of Bacalavre (Bachelor), for this degree at least 4 years of full-time university study are required. The Bacalavre degree is awarded after defending an individual Diploma project carried out under the guidance of a supervisor and passing final exams. The Bacalavre degree holders may enter Magister (Master) degree program. The Magister degree is awarded on a successful completion of two-year full-time studies. In this case, besides the deepened study of subjects concerning a selected specialization, the students must carry out a year of research and then write and defend a thesis which should provide an original contribution to the field (Anon. 2008). With such two-level system, Bacalavre programs are supposed to satisfy the mass demand for higher education, while the Magister programs should promote professional elites which in their turn will form the basis for further development of engineers and researchers of the highest skills (Doctors). It is supposed that such two-level system is
more flexible and to greater extent meets the needs of the market economy than the former one. Moreover, with transition to the Bachelor/Master certifying system, which is common in the rest of the world, the Russian degrees become more transferable, thus eliminating additional difficulties which Russian citizens faced with the former system when looking for a job or trying to continue their education abroad. These changes should also encourage more foreign students to join the Russian universities and so make the Russian education system more competitive at the present-day international market of educational services.

The Russian education system originated from the Soviet system in which the education of all levels was free of charge for anybody who could pass competitive entrance exams, moreover, the students received small scholarships and were provided with free housing. However, after the collapse of the Soviet Union state funding of the education system was reduced drastically and the universities could not afford anymore paying adequate teachers’ salaries, students’ scholarships, and provide maintenance for their facilities. Because of this, many state universities initiated the opening of commercial positions, and the number of such positions has been growing steadily since then. A number of private universities were also established (see Table 1).

Recently, the process of forming so called “federal universities” on the basis of the most famous and prestigious universities, including those in the engineering area, began in Russia (Anon. 2007). In some cases, it is done by merging a number of highly reputed education institutions in the same region of the country. Such high status universities are supposed to receive increased funding and benefits, including the funding of new constructions of dormitories and lecture halls. Some privileges concerning taxation on property and profits are also given to federal universities. At the same time, the status of a federal university means greater autonomy, e.g., such universities are given the right to create own undertakings for realizing innovation projects and to practice some business activities. Usually, the curricula in the Russian education institutions are designed in accordance with the State Educational Standards which regulate up to 80% of their contents and the remaining 20% are designed independently by the universities. As to the federal universities, they receive a greater autonomy also in concern with the design of curricula as well. Revoking licenses of universities which cannot respond to the high standards in the education area is also expected.

Comparative Analysis of Programs in the Field of Electrical and Computer Engineering at Different Countries of the World

This section contains a comparative analysis for the Electrical Engineering (EE) and Computer Engineering (CE) curricula offered at education institutions at different countries of the world including Assumption University of Thailand (ABAC). The analysis is based on the $k$-parameters method recommended by UNESCO (Bogomolov 1974). The details concerning the method are taken from Ahmed and Sharif (1996). In such approach, up to nine $k$-parameters are used to measure shares and/or quality of the different components and elements of a given program. In this contribution, the analysis is limited to the first three parameters which are being considered as the most important ones. Moreover, those parameters are the best suited for objective evaluations. In this particular case, the parameters $k_1$, $k_2$ and $k_3$ are used to measure the share of the different components of a given curriculum. The program courses are grouped into three disciplines for this purpose; i.e. (Bogomolov 1974):

(i) basic science and basic engineering courses and their share is measured by $k_1$,
(ii) professional courses, and their share is measured by the parameter $k_2$, and
(iii) humanities courses, their share is measured by $k_3$.

The values of these parameters are obtained as the ratio of the total hours, $S_i$, allotted to each discipline to the total number of hours, $S_T$, allotted to compulsory classes.
with a teacher, i.e., $k_i = \frac{S_i}{S_T}$, $i = 1, 2, 3$ (Bogomolov 1974).

The values of the abovementioned three $k$-parameters for the curricula of some institutions around the world are given in Table 2, including data concerning the Computer Engineering curriculum at Assumption University of Thailand (ABAC), calculated using the method of Bogomolov (1974). All evaluations in the Table 1 are given for undergraduate programs. The other data in that table is taken from Ahmed and Sharif (1996). The contents of Table 2 give some evidence of an emphasis on the fundamentals in the Russian engineering education: the parameter $k_1$ for MPEI is higher than that for curricula of some other universities under consideration. On the other hand, there can be seen some specific features in concern with Assumption University of Thailand: the parameter $k_1$ in its engineering curricula is rather low, while the presence of a higher number of professional courses is indicated by the parameter $k_2$. A specifically high value of the parameter $k_3$ (share of humanities) for ABAC can be at least partially explained by the necessity of intense English teaching in accordance with the international status of the university, there are four English courses (English I, English II, etc.). Also, Assumption University of Thailand emphasizes on the concept of ethics before knowledge in the pursuit of truth and knowledge, which explains to a certain extent the higher number of humanities courses.

Table 2. The share of the different components of the curricula for some institutions around the world ($k_1$, $k_2$, $k_3$ – parameters).

<table>
<thead>
<tr>
<th>Institute</th>
<th>Country</th>
<th>$k_1$ (fundamentals)</th>
<th>$k_2$ (professional courses)</th>
<th>$k_3$ (humanities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indian Institute of Technology</td>
<td>India</td>
<td>0.542</td>
<td>0.384</td>
<td>0.045</td>
</tr>
<tr>
<td>Moscow Power Engineering Institute, MPEI</td>
<td>Russia</td>
<td>0.512</td>
<td>0.340</td>
<td>0.148</td>
</tr>
<tr>
<td>University of Salford</td>
<td>UK</td>
<td>0.490</td>
<td>0.420</td>
<td>0.086</td>
</tr>
<tr>
<td>Asian University</td>
<td>Thailand</td>
<td>0.477</td>
<td>0.386</td>
<td>0.136</td>
</tr>
<tr>
<td>Massachusetts Institute of Technology, MIT</td>
<td>USA</td>
<td>0.394</td>
<td>0.485</td>
<td>0.120</td>
</tr>
<tr>
<td>Assumption University of Thailand (ABAC)</td>
<td>Thailand</td>
<td>0.295</td>
<td>0.477</td>
<td>0.227</td>
</tr>
</tbody>
</table>

Traditionally, a high share of the fundamentals in Russian engineering curricula becomes especially warranted nowadays in conditions of a very fast technological progress. At the same time, the emphasis on instrumentation and tools in teaching engineering students is not reasonable in general because latter can become outdated even before a student graduates a university. Moreover, the pace of development in the areas concerning high technologies continues to increase steadily. Computer engineering (including software engineering), information technology, etc., are based on algebra, mathematical logic, operations research, discrete mathematics and on other classical sections of mathematics. The existing tendency to substitute teaching of fundamental subjects with training in usage of one or another software product is rather dangerous. As a result, instead of understanding the reasons for the implementation of some technical solutions and accumulating ability to find reasonable solutions independently, the students gain mainly the knowledge in users’ interfaces with respect to the most common software products.

To illustrate the aforesaid assertion about the domination of the fundamentals in the Russian education system, as an example one can consider an approach to teaching higher mathematics for such majors as Electrical/Electronic/Computer Engineering. Typically, it is done during five or six semesters and takes around 400 academic hours (in the Russian education system an “academic hour” equals forty-five minutes), of them one half of the said hours is devoted to lecturing and another half to tutorials with
solving problems, respectively. It includes usually the following:
- higher algebra and analytical geometry;
- differential calculus and integral calculus;
- \( n \)-dimensional functions, functions of many variables, multiple integrals;
- differential equations and operational calculus;
- functions of complex variable, probability theory;
- discrete mathematics.

In some American universities, the total number of hours for mathematical courses is comparable with that in the Russian system, but usually there is only lecturing and no official tutorials for solving problems in a program. As a result, the number of courses which are taught in an American university is greater. It can be conjectured that the mathematical background of graduates of an American university is broader but Russian graduates have better skills in solving problems. The advantages and disadvantages of both approaches are disputable.

A typical example is related to the teaching of the theory of electric circuits for the abovementioned specializations. It continues for two semesters and consists of two parts: direct current (DC) circuits and alternating current (AC) circuits with traditionally very strict requirements during the examinations.

As it can be seen from Table 2, the share of the professional subjects (parameter \( k_2 \)) in Russian engineering education system is also rather significant. Industrial training at the best companies in the field starts in the third year. Individual design projects in various professional subjects are done since the fifth semester. The studies at the Bachelor level are completed by carrying out an individual Senior design project.

The Russian engineering education system exploits some advantages which make its future promising. Among them are mathematical traditions existing in the most prestigious universities. Besides, the Russian secondary/high schools give a fundamental basic education of a very good quality. During the 20th century, a unique system, which functions up to now, was created for seeking and selecting gifted children via specialized mathematical schools, circles, contests, etc. However, the Russian education system faces nowadays a set of problems and may be the most serious one is in concern with its "elitist" nature: there is a great difference in the quality of education and research provided by a small number of prestigious universities on one side and by a very large number of ordinary ones on the other side (Anon 2003b).

### Distinctive Features of Teaching Process Organization

Since the 19th century, the Russian higher education system preserves some organizational forms which are disputable but anyway may seem sometimes rather attractive. In a very vivid and nostalgic manner, those features are described from the viewpoint of a foreign student who graduated from the Moscow Power Engineering Institute, MPEI (Chowdhury 2006).

First of all, the curriculum is fixed for each specialization and all subjects in it are compulsory and should be taken in a strict sequence. It sounds inflexible, but such regulation relieves a lecturer from fighting against some students’ attempts to violate the order in concern with prerequisites, which is not quite uncommon among senior students in an American-like system.

There are no mid-term examinations but only final examinations, which are conducted in the end of the semester. There are four grades: 2 (unsatisfactory), 3 (satisfactory), 4 (good), 5 (excellent). All examinations are carried out in a spoken form. In the beginning of an examination, a student gets an individual questionnaire which in a way resembles a lottery. A grade is announced to a student immediately after his/her talk with an examiner and the grade is written down in student’s individual booklet which serves as a real-time transcript. If a student wants to get a better grade, he/she may ask the examiner for additional questions but there is a risk that the grade may become even lower. Students with low grades are expelled automatically.

Traditionally, the requirements for examinations in fundamental courses are very strict.
Conclusion

The Russian higher education system, and in particular its engineering branch, is being intensively reformed. Integrating the Russian system into the international market of educational services is one of the main goals of the reform (Pokholkov and Agranovich 1998). The solution to that problem requires expanding academic mobility, adopting international standards in engineering curricula and increasing university autonomy. At the same time, the Russian education has its unique features and some advantages which should be preserved. Moreover, the positive experience of the Russian education system deserves not only acquaintance with it, but its spreading as well. It is hoped that this short contribution will serve that noble goal.

References


