Interdisciplinary Relationships in the "Politehnica" University of Bucharest

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Abstract:
A modern and dynamic society cannot be built on a classical, unidirectional educational system. A modern engineer should have the ability to work with other specialists, in a common language in order to develop complex projects. This is why interdisciplinary relationships are so important in the educational process. The brief description of the engineers' training programs in the "Politehnica" University, presented in this paper, reveals the progress we made to a modern educational system and the things to be done in order to get a healthy study program based on interdisciplinary relationships, discipline and exigency.

The interdisciplinary issue in the educational process is the consequence of the exponential development of teaching matters leading to a different vision of reality and to hyper-specialization. This is the reason why we need a strong connection between different knowledge levels: interdisciplinarity.

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1. Introduction

Interdisciplinarity, as the result of modern society's demands, is continuously evolving by knowledge addition in different researching domains turning into a co-operation between scientific matters. Interdisciplinary relationships can be realized by approaching the same point of view in different matters adapted to pedagogical principles and helping the subject (the student) to gather an overall image of reality by developing an integrated way of thinking. Nowadays it means a way to organize the matter contents, to review curricula and to ensure method transfer from science to science. This transfer can be made on different degrees. It also offers an overall image of processes and phenomena studied in different matters allowing for context interpretation and knowledge application in concrete cases.

A modern, evolving educational system must be based, most of all, on interdisciplinary teaching methods. Only this can assure knowledge correlation from different disciplines in order to form and develop the students' ability to apply their knowledge in practice. It also helps the student to organize and fix gathered information.

In present times, interdisciplinarity represents one of the most important and complete theoretical and practical problems in science development for a new pedagogical view. In fact, it is a matter of complete change in the educational process for teachers and researchers.

By the end of the 18th century, technical schools are founded in some European cities: Vienna, Berlin, Charlottenburg etc. During the 19th century, the higher technical education system gets upgraded to the level of Polytechnic Schools or Superior Technical Schools. Engineering education in this stage is specialized without giving up fundamental education however.

During the second industrial revolution, fundamental changes are made in engineers' training. Thus there appears the problem of a diverse engineering educational system with a definite difference between projecting engineers (project managers and technology specialists) and production engineers (the ones involved in factory production).

This second industrial revolution changes social conditions, the way of life, transport development, automobile development, electrification in all the cities, towns and villages…) and commercial policies.

The third industrial revolution (also called the post-industrial revolution) starts with microprocessor development (from 1971), genetic engineering (from 1973), electro-physical technologies replacing the mechanical-chemical ones (from 1972), researching in thermonuclear fusion and a fast telecommunications evolution. All these changes lead to activity globalization and curricula reformation in superior educational institutes and especially the technical ones.

Thus, the engineering educational system must take care of the following **demands**:

1. Science and technology development leads to an exponential growth of discoveries and inventions demanding vast scientific knowledge for engineers.

2. Scientific discoveries are so advanced that project engineers need to be very well-trained and their intuition must be doubled by a deep knowledge of nature sciences (physics, chemistry, biology) and mind sciences (mathematics, statistics, informatics). Engineers need to be permanently in touch with the scientific world (the technical one, especially) because the newest inventions are part of scientific research projects.

3. Modern engineering is especially based on projects realized by engineers from different domains, so all of them need to have vast common knowledge in order to give them the possibility to rapidly understand other issues besides their specialty.

4. Superior studies of a future engineer must not be expensive so training time is limited and completed with postgraduate studies.

These demands made the second part of the revolution, up to present times, be a continuous evolution period for the higher education system and rendered it more precise.

In other words, at this education level we handle a diverse but united educational system. One must also consider the fact that the number of engineers must grow together with science and technology progress. But this growth must not be unbearable from the economical point of view. Thus higher engineering education was separated in two different levels: projecting engineers (technological and scientific project managers) and production engineers (working in factories, being effectively involved in the production process). Project engineers benefit higher level studies and are more severely recruited so only the best students with special training reach this stage. It also needs a more careful selection and study groups have a low number of members such that every day activities are under a severe control. Workshops and laboratories are properly equipped, too, while the courses and tutorials have the highest level.

2. Essential Disciplines for Building Scientific and Technical Culture

All these conditions ensure a special fundamental training by teaching 12 different disciplines considered to be essential for the scientific and technical culture of a project engineer in only two and a half years. We will now shortly present these disciplines as follows:

Mathematics and statistics represent 12% of the total study period (2.5-3 years from country to country, one year lasting for 23-30 study weeks of six working days and six hours daily). The matter consists of mathematical knowledge necessary to engineering sciences. Special attention must be paid to a well structured presentation of the issues and a special attention goes to non linear field elements presentation. It is also important to increase the receptivity for numerical problems and the statistical approach of engineering problems.

Physics has 18% of the total study time (2.5-3 years, with every course consisting of three hours, accompanied by one practice session and one tutorial session both lasting for two hours. A main demand is that the practice lessons (conducted in laboratories) should be individual.

Chemistry has 6 % of the study time. Practice lessons mean 30% of the time allocated to chemistry.

Material sciences have 6% of total study time. This discipline treats characteristics, properties and potential destructive processes, protection procedures, controlling and selection methods for technical use materials. Practice sessions for this field are very important and have been allocated a great amount of study time.

Technical mechanics has 14% of study time. This discipline presents in a compact mathematics language, with certain applications, solid mechanics (kinetics, dynamics, etc.), vibrations, materials' strength, elasticity and plasticity theory and fluid mechanics.

Technical thermodynamics has 3% of study years. The remarkable point in this matter is the fact that due to the multitude and variety of state parameters considered as variable in heat theory it can be applied not only in energy techniques but in processes too.

Electronics and Electrical Engineering have together 12% of study time. This discipline is divided in five sections. "Electric circuits", "Electromagnetic field", "Electro-energetics", "Telecommunications" and "Electronic circuits and devices"

Measurement techniques have 6% of total study time. This discipline is based on measure system principles, sensors and measurement sensors up to microelectronics and micro-techniques.

Automatic adjusting command also has 6% of study time and it presents the technical automation basis.

Technical information has 8% of total study time, and is strongly connected to the computer, the most important tool in this domain.

Projection and Development takes up 5% of study time. This discipline outlines general relationships, procedure strategies and essential principles of projecting methods, principles and procedures, technical processes projecting methods.

Since an engineer must be knowledgeable in economic or legal matters, they are also introduced in his fundamental training and they represent 4% of study time.

Standardization describes the functioning and structure of standard organizations, of the rules' importance and their action as technical stadium documents and technical products commerce instruments.

Law and legislation in the studying country contains: material law, procedural law, contracts and guarantees, work legislation, administrative law, social insurance and taxes, data protection, energy law and environment protection.

The patent system is presented in the studying country. It presents the following: the system's significance, European patent legislation, international co-operation in patenting, utilization methods and rights upon employees' inventions.

Economics of the firm contains: the object of study, basic patterns in the **economics of the firm**, constitutive and functional decisions.

These disciplines constitute the basic preparation of all the engineers working in industry and research units. The information has been presented following the "Hutte Engineering tutorial. Fundamentals" (1989 Germany, translated in 1995 into Romanian) as well as educational plans of different technical universities in the world.

Generally, every university chooses its own distribution of study time for every discipline. But the difference cannot exceed 20%. The abovementioned disciplines are taught in all technical faculties in the world.

In fact, one can affirm that these disciplines assure fundamental training for any industrial specialization engineers, constituting B.Sc. studies. The three years of fundamental studies (consisting of an interdisciplinary training) are followed by specialty studies (master courses).

Three major problems impose interdisciplinarity, i.e. interdisciplinary relations around a project needing specialists from different domains, a concept that can be correctly enlightened considering the interaction between operating domains, and a political practice considering the incoming every day existence problems. The first two are exclusive engineering-specific issues.

In the educational system, the inter-disciplinary demarche can be applied by disciplinary connection, course themes and project evolution. It must also be considered that discipline content determination must take into account the projects to be realized. The argument pleading for interdisciplinarity in a project does not consist of the fact that the disciplines represent a wrong knowledge theory, but they never give a complete image of the isolated things. They fulfill their role efficiently when integrated.

3. Analysis of the Higher Education System at "Politehnica" University of Bucharest

Analyzing the higher educational system in the "Politehnica" University of Bucharest from its foundation to present times, we can assume the following considerations:

The "Politehnica" University of Bucharest" has its origins in 1818 when Gheorghe Lazar succeeded to obtain Wallachia's Prince Ion Gheorghe Caragea's approval to hold engineering classes at "Sfantul Sava" School.

From 1919 the Professors' Council of the "National Road and Bridges" School decided that women could also be admitted with the same rights as men.

In 1920, the "National Road and Bridges School" turns into the "Polytechnic School of Bucharest".

In 1948 the "Polytechnic School of Bucharest" (consisting of 7 faculties) becomes the "Polytechnic Institute of Bucharest", which has four faculties (Electrical Engineering, Mechanics, Industrial Chemistry and Textiles), while the other faculties were turned into stand-alone higher education institutions: the "Construction Institute of Bucharest", the

“Architecture Institute of Bucharest”, the “Mine, Oil, Gas and Geology Institute”, the “Forestry and Agronomy Institute in Brasov”.

The growing process is more accentuated after 1968 and during 1989-1990 the Polytechnic Institute had 10 faculties (Electrical Engineering and Energy, Automatics, Electronics and Telecommunications, Mechanics, Machine Construction Technology, Agriculture Mechanics, Chemistry Technology and Metallurgy…). Step by step, superior technical education system changes from unity in diversity (considering the subject’s possibilities) to a unity in uniformity (mass education). From the sixth and the seventh decade of the 20th century we can only talk about mass education as the number of faculties was getting larger and the exigency became very low. However we can affirm that there was an attempt to retain exigency by high level admission tests and allocating the best jobs to the best graduates (graduates with first-class honor’s degrees had the possibility to choose their jobs).

It is also remarkable that due to an explosive development of the superior technical education system between 1848 and 1990 the endowment did not match with student numbers, and fundamental training was deeply damaged, as these disciplines were a little more difficult.

In 1993 the Polytechnic Institute of Bucharest became the “Politehnica” University of Bucharest having 12 faculties and two colleges from 2002, and 13 faculties from 2003. The total number of students is now around 20000.

The “Politehnica” University of Bucharest has been visited in 1990-1992 by several series of European Union experts who noticed that the superior educational system in this unit has two major deficiencies due to laboratory endowment and low connections with industry production, further, students’ fundamental training is two low because of the courses’ reduction.

It was clear now that the slogan sustaining the connection of the educational system and research was only demagogic. The only result of this action was bringing into technical universities disused machine tools and apparatus from factories. This operation started after 1990.

The question is now: What did the Polytechnic University do after the analysis of EU experts? It continued the same policies, similar to the ones before 1989, of a unity in uniformity mass system. Besides, the Education and Research Ministry decided in 1997 that educational institutions’ finance should be based on the number of students. Thus the training of future engineers became weaker and weaker. The study period was reduced by giving up practice lessons in laboratories which were only a few anyway and now they are going to zero. Furthermore, the exigency is much lower because, due to funds necessity in order to pay didactic personnel, they had to give up exigency in order to have an appropriate number of students; many faculties renounced admission contests and recruitments are made considering high-school results. Where the contest was not removed, it was only a formality as many questions were middle-school level and only a few reached the lower high school level. Private education institutions, even weaker than the public one, organizing admissions exclusively on high school results, concurred even more to exigency decrease of the public education system which needed students to be financed. In fact, Romania is one of the few countries (if not quite the only one in the world!) where private educational system is a profitable business only for their owner, not for graduates too. They are not at all interested in the value of the graduates they declare specialists in different domains. Their diplomas are not covered in knowledge. The specialists they declare are over-evaluated.

All over the world, and especially in the most technologically advanced countries, the educational level in private institutions is higher than in the public ones. Generally, private education units are sustained by businessmen and private companies in order to obtain high level specialists to act in industry, research and business.

There is an explanation: During the communist age from 1948-1989 educational levels suffered a continuous degradation, first a slower one but later (after the 7^{th} decade of the 20^{th} century) this degradation was more striking. After the 1989 revolution leaders did not straighten the educational system, on the contrary they damaged it even more without any excuse. Why?

In “Politehnica” University of Bucharest as in other Romanian technical universities engineers’ certificate is uncertain: are they diploma or certificated engineers, as long as the training time and curricula are both the same? It is also known that diploma engineers’ educational level should be higher than the level of the certificated ones, and should be recruited from the best high-school students. Generally, from one series of students there are not too many students specialized in a certain domain. Didactic and research laboratories’ endowment level is very high just as courses and tutorial level. On the other hand, although certificated engineers have the same fundamental training, the level is lower but the technical and economic training are better, special attention being paid to public relations.

The common training of the two types of graduates is the worst possible choice in this development stage of science and technology because the costs are very high and both educational categories are damaged.

A cautious analysis of the educational program for the “Politehnica” University of Bucharest engineers leads to following conclusions:

- there are too many disciplines, over 40 instead of 12-16 like in other countries’ superior education institutions
- some of these 40 disciplines are only chapters of the ones in Euro-Atlantic countries
- there is no correlation between disciplines, a great blow to interdisciplinarity
- mathematics, statistics and natural sciences (physics, chemistry) are precarious
- practical training is also very low (laboratory endowment is practically inexistent and so is the connection with the corresponding industry), besides, educational programs are inconsequent in order to manage the budget from the ministry

The causes which led to this deplorable state of the technical education system are as follows:

1. Small salaries of the education personnel. In Romania, (unlike in any other country in the world) there are many specialized teachers and few teachers for fundamental training, so the first ones have the monopoly over educational plans, ensuring themselves vacant jobs and cumulative norms for supplementary payment.
2. CNEA (The National Council for Quality Assessment and Insurance) precepts for university management are realized by the national peculiarities of the 1948-1989 period, not the ones before 1948, when the educational system was in concordance to Euro-Atlantic countries. These precepts are far away from any applicable norms of educational systems in EU countries.

3. Analytical programs of the curricular disciplines are not consulted when the educational plans are realized in order to set up every discipline in its own position. Generally courses are distributed according to the most influential persons' free wish. There are disciplines that could be easily taught in 2-3 hours/week in a semester but they are allotted 5 hours/week just as there are disciplines needing 8 hours/week in one semester but only have 3 hours/week.
4. The funds from the Education, Research and Innovation Ministry are based on the number of students, not on educational plans to be respected. Thus the faculties are trying to keep the number of students all the studying period no matter what their training is, so the student rules. Natural sciences (Physics, Chemistry) and Mathematics are harder to assume and, since the students are not motivated and do not wish to work hard, they agree to reduce the amount of fundamental training.
5. Students are most content with technological disciplines because they are mostly descriptive and have no practice lessons. So with no math and no practice there is no effort and everything is easier.
6. Administration staff in Romanian universities is not occupied by contest, favoring this way group interest.

Because of this fact incorruptible persons who really wish to reform the educational system cannot access leading positions. After 40 years of communism and another 30 years of probations (some successful but many disastrous), in order to reach the level of a normal competition-based society, fundamental reform of the educational system is now more than ever a necessity for the proper training of the young generation. Such a reform demands:

a) Proper funds. Well-trained personnel cannot be prepared with only 1000-2000 euro per student while EU countries spend more than 8000 euro for each student
b) Organization. A modern society is based on competition and in our country this can only be achieved by giving up mass education and reforming to subject- based education
c) Promoting criteria for education personnel should be similar to the ones used in EU countries
d) Administration staff selection should be based on professional contest. Only well prepared teachers can ensure a normal exigency in educational system.
e) Study period and curricula should be correlated to similar universities in EU countries
f) Research development in universities so they could become scientific and cultural centers.
g) A normal exigency which can be ensured by a proper control of the graduates. B.Sc. and Master graduate exams should be similar to the ones in Euro-Atlantic universities. Education staff should not be ashamed with their students but proud of them.

We cannot finish this paper without outlining the fact that during the years 2007 and 2008 several attempts were made to improve the Romanian educational and research system. For example in the "Politehnica" University of Bucharest the educational funds were used for laboratory endowment, for new apparatus and complete experiments so that they look like the ones in Euro-Atlantic universities. Besides, due to research funds gained from contracts obtained in different competitions, many departments managed to equip scientific research laboratories or to found new ones being able this way to recruit some of the best students to work there, to do their diploma papers and publish scientific articles in specialized publications just as Western universities are doing. There is also growth in scientific information activity. Step by step quality finds its place.

Unfortunately, in 2009 the economic crisis affecting many countries came to Romania too and the first domains which are most sensitive to this crisis are education and research because their funds are seriously reduced. In the scientific research domain, the funds were drastically reduced (3-4 times) although in other countries it did not happen this way.

4. Conclusions

The conclusion would be that our leaders do not consider education an important value for the country's prosperity. It is pretty hard for Romania, when its economy depends on EU states' economy, to find a good solution to get out of the crisis. However, a list of priorities for the future must contain scientific research and education because only well-trained personnel can face socio-economic changes. Besides, a basic idea should govern funds' repartition from the budget so the money should not be given where nothing happened till now because it never will.

Currently an idea is gaining prominence: the domains heading to bankruptcy must not be interfered with in order to get rid of their leaders. This would help the crisis away because the incompetents could never change. The system should force the incompetents leave and this way help the organizations. The normal way would be to let competent personnel use the resources and develop the domain. Since the Romanian Education and Research have not had proper funding from 1848 till 2006, they deserve to receive considerable funds even in crisis times. This mistake must be repaired because an improperly financed system would keep the level of the graduates under that of the Western countries and increase the exodus of our good personnel to these countries.

One must notice that in the only two years when education benefited from suitable financing many young people who had left the country several years ago returned. We must not give up hope, and we must try to convince the politicians in charge with education and research in Romania that if they continue this trend they would go down in history as incompetent leaders who did not support essential issues for our country.

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