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Effects of Interdisciplinary Education to the Competitiveness of Engineers

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Interdisciplinarity is discussed as one of the effective tools increasing young generation's enthusiasm for engineering; increasing motivation of engineering students; increasing collaboration efficiency between professionals of different fields. Paper includes history and new systems of interdisciplinarity in engineering education, dual education system preparing new graduates for real industrial environment of inter- and multidisciplinary activities.

Key words: interdisciplinarity, engineering education, soft skills, gender, dual education, practice oriented education.

Introduction

Two among the most acute problems of today's industries definitely are the lack of well-educated and experienced engineers and low professional and soft skills of new engineering graduates.

Traditional engineering is not the most fascinating profession nowadays, from year to year less young people choose electrical or mechanical technical fields at universities. What can be the reason of it? While people use more and more electronic devices in everyday life the youth feels less and less interest and challenge in knowing the fast developing technics. Engineering education (EE) and industries have to reflect together to these problems by finding new methods to attract young generation to engineering studies.

Besides of popularity decrease the other problem is the motivation of engineering students. Since the credit system is introduced, dropout rate in Hungary became very high, while industries interviewing new graduates very often unsatisfied.

This paper will not set up interdisciplinarity as the only solution to all our problems described above, but it aims to summarise possibilities and effects of interdisciplinary education to competitiveness of new engineering graduates.

Starting with a short statistics from the last years showing number of applications to EE in Hungary we can state that there were no significant changes in the total numbers of applications to engineering courses in the last 15 years, which means that about 15 thousands young people start engineering courses in Hungary every year. (Fig. 1.)

Fig. 2 shows contrasting of the three biggest HE fields in Hungary. Diagrams show that engineering fields are the second most wanted courses lagging behind economics and exceeding courses of law. From other statistics we know that nowadays Hungarian industries have ~ 6 thousands unfilled engineering jobs and all new graduates can select from 2-3 offers or even more if they speak foreign languages.

And finally Fig. 3. shows changes in number of engineering students of different fields in the last 10 years. In the figure we clearly see that only interdisciplinary mechatronic engineering is the course which could increase number of students. Traditional engineering fields, electrical and mechanical are losing their position. The question is why less and less young people choose traditional engineering? The answer of course is very complex including

Fig. 1. Number of applicants and first year students in EE in Hungary [1]

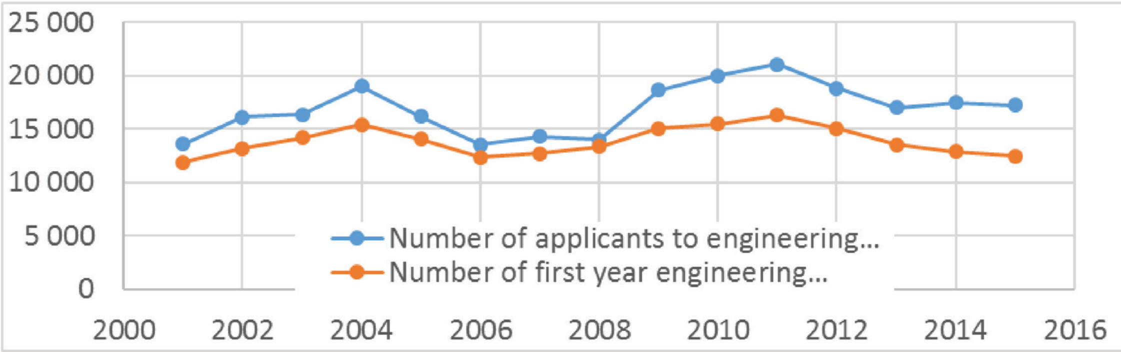
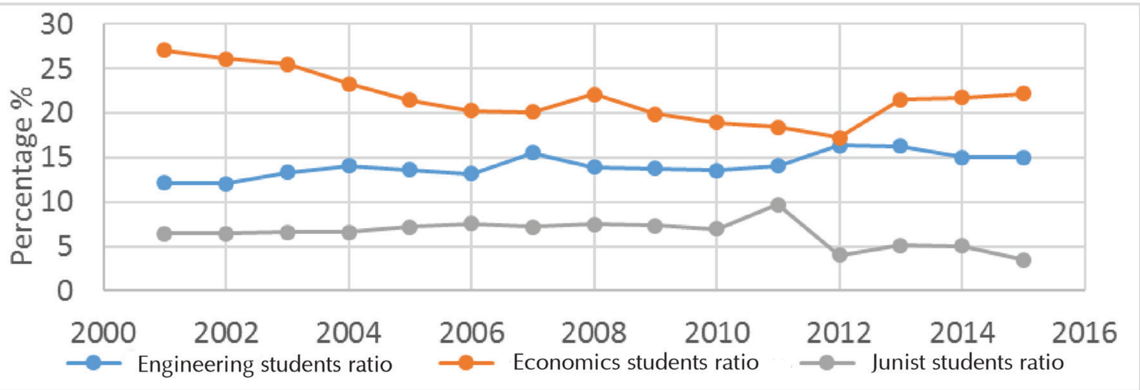


Fig. 2. Percentage of engineering, economic and jurist students in ratio of total number of first year students in Hungary [1]



effects of media, effects of decreased natural science orientation of schools, but also surveys prove that fear of highly specialised studies also causes popularity drop.

I. History of interdisciplinarity in engineering education

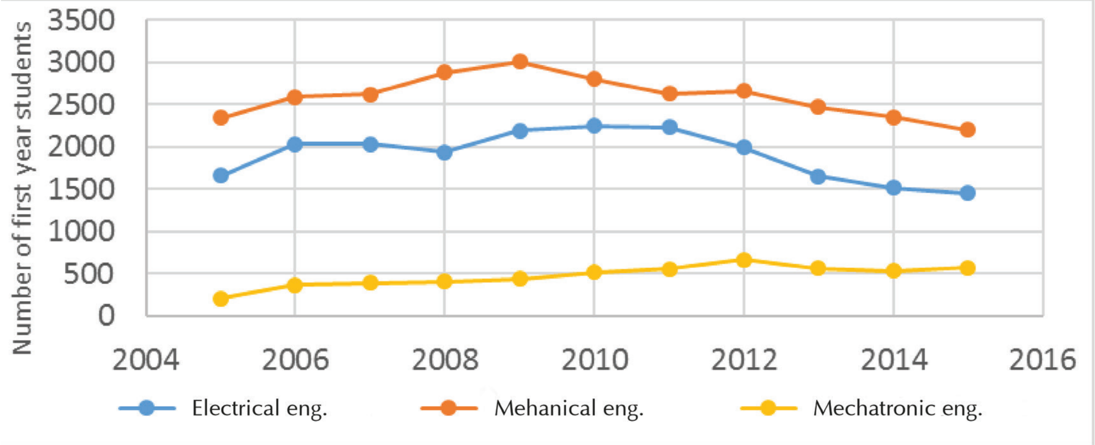
Interdisciplinarity in education has been a traditional method of developing intellectual professionals for centuries. Interdisciplinary knowledge and thinking provide interfacing among representatives of engineering, humanities, the natural sciences and/or the social sciences.

Looking back in history of EE we find that very first engineering educational academies were already deeply based on liberal arts, economy and law.

1.1. Interdisciplinarity of ancient institutes of technology

The world's first institution of technology, the Berg-Schola [2] was founded by the Court Chamber of Vienna in Schemnitz in 1735 in order to train specialists of precious metal and copper mining according to the requirements of the industrial revolution in Habsburg Empire. Maria Theresa nominated it to Bergacademie in 1762. Disciplines of the Bergacademie by today's understanding and definitions were highly interdisciplinary. The 2 years studies included 1 year Mathematics which is

Fig. 3. Number of first year students in different engineering fields in the last 10 years [1]



not the mathematics of today's definitions because it included also mechanics, hydraulics, cartography and other technical sciences and calculuses. In the second year 5 disciplines were thought: Regulations and law in mining; Mining measurements; Ore dressing-flotation; Metallurgy and chemistry; Coinage and gold processing.

In 1782 Emperor Joseph II established the Institutum Geometricum as part of the Faculty of Liberal Arts at the University of Buda. The Institutum, the direct predecessor of the Budapest University of Technology and Economics, is the first in Europe to award engineering degrees to students of land surveying, river control, and road construction. In this institution students could apply for 3 years course only after finishing liberal arts studies. EE included 1 major and 2 minor subjects. The major was applied mathematics, and the minors were mechanics and agriculture [3].

1.2. Interdisciplinarity in engineering education in the middle of 1900s

In 1900s years EE dramatically developed and strengthened all over the world. Slow specialization and field separation characterised the education until the 1970s. Electrical engineering course in 1950s at the Technical University of Budapest was merged with mechanical engineering. Tab. 1 shows structure of electrical EE plan from 1953-1958. Ratio of different fields in the education would entitle this education as a highly interdisciplinary education including humanities and economics 36%, mechanical engineering 19% just a little less than the major studies which is electronic engineering 23%. All over the electrical and electronic fields do not exceed 50%.

I.3. Interdisciplinarity in engineering education in the late 1900s

At the last third of XX. Century EE became highly specialised in several countries. It happened mainly in biggest countries where number of students made possible this type of specialization. Thus major studies included machine tool engineering, train engineering, bridge engineering, ship engineering, etc. with even more specialised minors. Tab. 2 shows an educational plan of an electromechanical engineering major course in Moscow's STANKIN University called "Automation and complex mechanization of machine tools" between 1980-1985.

From the Tab. 2 we can realize that in spite of high specialisation in machine tools the course of STANKIN is very close to today's mechatronic engineering courses and it can be easily called interdisciplinary.

Table 1. Educational plan in electronic engineering in 1950s [4]

Main fields of studies	Subjects	Number of subject semesters	Proportion %
Humanities and economics	Politics, Economics, Industrial management, Military studies and service, Foreign language	28	36
Mathematics	(10 hours per week!)	4	5
Natural sciences	Chemistry, Physics, Electron physics	5	6
Mechanical engineering	Descriptive geometry, Technical drawing, Machines theory, -drawing, -elements, -operation, Mechanics, Precision mechanics	15	19
Electrical engineering	Electrical materials, Alternating current, Electricity, High voltage technics, -transmission and -laboratory	8	10
Electronic engineering	Electron valves, Radiotechnics, Telephone technics, Low power transfer, Electroacoustic, Measurement and instrumentation, Impulse technics and remote vision, microwave technics, Automation	18	23
Thesis project		1	1

Moreover it was a project oriented course as 7 half year projects in the certain disciplines were included (they are signed by P). So the question is when we have lost interdisciplinary and project based character of our EE.

I.4. Changes in electrical and electronic engineering education in the first decade of 2000s

Comparing Hungarian bachelor level educational plans to above described two in electrical engineering, we realise that mechanical engineering disciplines are fully disappeared from the plans just as the chemistry. Humanities and economy subjects ratio is dropped to 16% while new fields like IT occupied only 9% of educational plan. The only possibility for including some interdisciplinarity into education is that 8% optional subject which can be selected by students from any scientific fields. Number of subject semesters are also dramatically decreased from ~80 to ~50.

Data of Tab. 3 underline that this is the education which cannot be called

Table 2. Educational plan of course in "Automation and complex mechanization of machine tools" in 1980 [4]

Main fields of studies	Subjects	Number of subject semesters	Proportion %
Humanities and economics	Politics and philosophy, Economics, Industrial management, Work safety, Foreign language	20	25
Mathematics		4	5
Natural sciences	Chemistry, Physics	4	5
Mechanical engineering	Descriptive geometry, Technical drawing, Basics of machine theory P, Machine drawing, - elements P, Mechanics, Hydraulics, Pneumatics, Material science, Material handling and transportation P, Machine tools theory, - technology, - design P, Cutting tools	24	30
Electrical engineering	Electrical materials, Electricity, Electronics, Industrial electronics P, Digital technics, Electrical machines and drives, Measurement and instrumentation, Automation P, Process control of machine tools P	18	23
Computer science	Computer technics, engineering and economical calculations, programming	7	9
Thesis project		2	3

interdisciplinary, and that is the reason why also industry and students miss interdisciplinarity from our education. The problem is realised in the last years and several action plans were worked out and new methods are being introduced into our education.

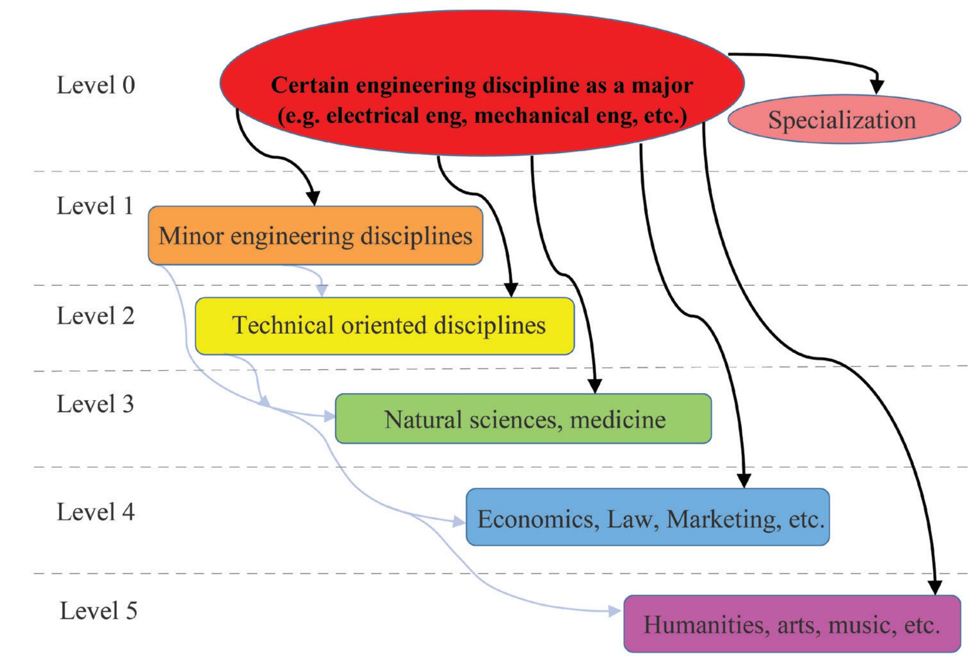
II. Boundaries and system of interdisciplinarity in engineering education

We can accept that education is interdisciplinary if two or more disciplines are included and combined with necessary interactions between each other. It means that putting simply together disciplines from different sciences will not result a real interdisciplinary knowledge. Disciplines should be built up on each other, they should incorporate, theories and practices of one disciplines should be elemental part of other disciplines composing a fully comprehensive system of knowledge. From the view of scientific fields 5 different levels of interdisciplinarity can be defined. The lowest level of interdisciplinarity includes disciplines of engineering fields close to each other and the highest level of interdisciplinarity includes engineering disciplines combined with arts and humanities. Fig. 4 shows

Table 3. Educational plan of 2000s in electrical engineering

Main fields of studies	Total number of semesters	Proportion %
Humanities and economics	7	16
Mathematics	3	6
Natural sciences	2	4
Mechanical engineering	0	0
Electrical engineering	25	52
Computer science	5	10
Optional subjects	4	
Thesis project	2	4

Fig. 4. Levels and interactions of interdisciplinarity in engineering



different levels of interdisciplinarity and the Nowadays uncountable different interdisciplinary engineering courses are offered by universities of the world. The level of interactions are very different and depends highly of the selected disciplines, also freedom of selection is varying in wide range. In some universities (mostly in USA) students have a full freedom to compose their studies from all the university's

Table 4. Typical interdisciplinary engineering professions

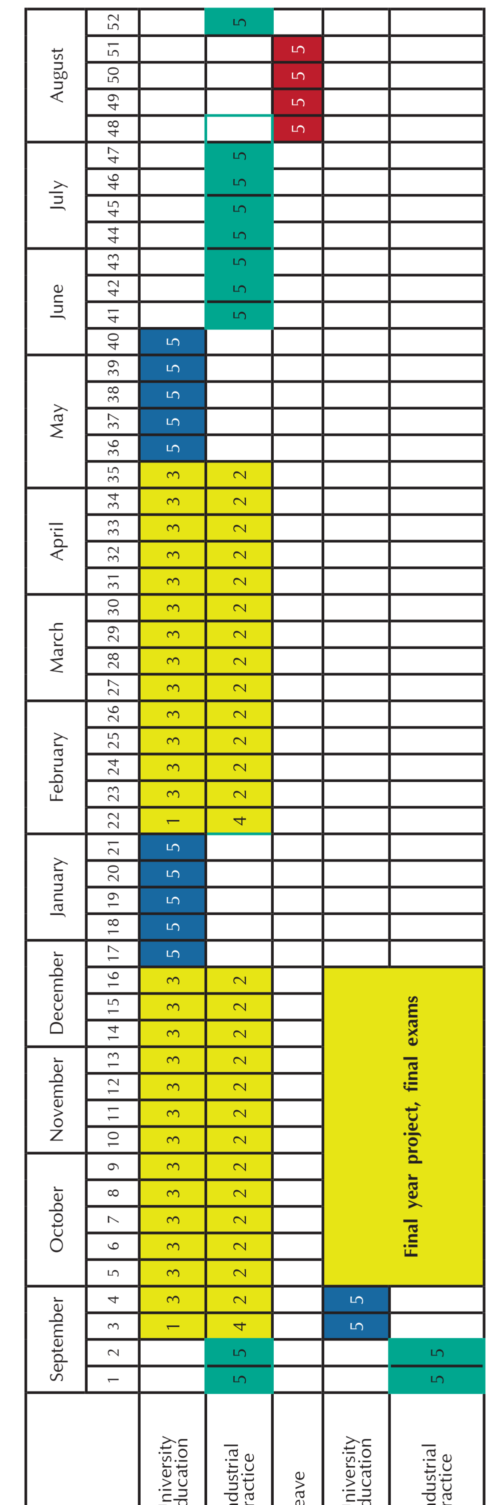
Level 0 +	Electronic engineering +	Resulting profession
1 + 2	Mechanical + IT	Mechatronic engineer
1	Vehicle eng.	Car electronics
2	IT	Computer Science Engineer
2 + 2	Logistics + IT	Process engineer
3	Biology	Bioengineering
3	Chemistry	Chemical process control engineer
3	Medicine	Medical engineer
3	Material science	Nano-engineer
3 + 3	Biology + Medicine	Biomedical engineer
4	Economics	Manager of technological innovation and entrepreneurship
4	Management	Engineering management
4	Law	Intellectual property engineer
4	Law	Safety engineer
5	Music	Acoustical Engineering
5	Performing art	Theatre engineering
5	Fine art	Industrial and Product Designer

discipline offers. In other methods pre-defined composition of fields is set-up in order to get a defined interdisciplinary professional at graduation. Such pre-defined compositions are widely used in Hungary.

III. Practice oriented dual education in engineering as a tool of interdisciplinary studies

Dual education in higher education is a new system in Hungary introduced by Mercedes Benz with cooperation of Kecskemйt College [7]. In the new system companies support certain number of students and provide them strong practical education in their field. Students applying successfully for dual education study together with non-dual students at the university, so they go through the same university courses as their non-dual colleagues, but while non-dual students' academic year includes 2x14 weeks active semester and 2x6 weeks exam session, all over 40 weeks, dual students have 26 weeks at the university plus 22 weeks at companies, all over 48 working weeks per year including study at the university and practicing at the industry. As companies compose their particular educational plan in close cooperation with the university, these plans are characterised by high added value in disciplines which are not included into the normal university education. Students learn standardized processes, working in team, in multicultural and multi-language environment, also they learn industrial planning, economics, production or design process management, communication, etc. Fig. 5 shows time share between university and company. Numbers in squares show number of working days per week to be spent at university / company / leave.

Fig. 5. Time share in duel education



Conclusion

Statistics of Hungarian higher education underline necessity of interdisciplinarity in EE. Traditional courses of EE encourage mostly male students, but the situation is much better at interdisciplinary courses. In this decade when the total number of the 18th year age population is decreasing none of the university courses can allow to acquire students only from the one half of the population. Besides of more female also a small part of males suppose easier interdisciplinary studies and sympathize with such courses. It means that from input side advantages are obvious, but acceptation of interdisciplinary graduates by companies is a question. The first experiences at least in Hungary are not very encouraging. Companies know well traditional engineering but they are not really familiar with abilities and knowledge of Computer science engineers, Engineering managers or Biomedical engineers. They state that developers of special fields (for example car electronics and -sensor developers) should be highly educated in the specialized fields. This view should be accepted, thus industrial needs will make a right selection of specialised or/and interdisciplinary professionals. Future research on experiences should be performed in coming years.

REFERENCES

1. www.felvi.hu – statistics of Hungarian higher education (Hungarian).
2. Dr. Mihalovits János: Az első bányatisztképző iskola alapítása Magyarországon. (The first mining engineerig school in Hungary). Publisher: M. kir. József Nádor Műszaki és Gazdaságtudományi Egyetem, Bánya-, Kohó- és Erdőmérnöki Karának Könyvkiadó Alapja. 1938. (Hungarian) http://www.rfmlib.hu/digitkonyvtar/dok/rudabanya/mikoviny_samuel_az_elso_banyatisztkepzo_iskola_alapitasa.pdf
3. Milleniumi Évkönyv BME, 2000. (Hungarian) http://mek.oszk.hu/08400/08404/08404.pdf
4. Diploma supplement of a student studying at Technical University of Budapest between 1953-1958.
5. Diploma supplement of the author.
6. Anita Thaler: Interdisciplinarities – Student's perception of interdisciplinary Engineering Education in Europe. GIEE2011: Gender and Interdisciplinary Education for Engineers. Proceedings. Paris, 2011. [Section 2, pp.209-221].
7. Tóth, Ákos, István Pap, and István Bársony. "A duális, és a hagyományos képzésben részt vevőhallgatók tanulással kapcsolatos motivációinak összehasonlító elemzése a Kecskeméti Főiskola GAMF Karán". Gradus 1.1 (2014): 14-21. (Hungarian).

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An Interdisciplinary Approach for Acquiring Competence for Social Responsibility

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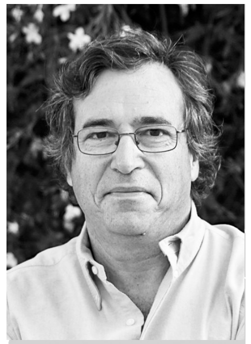

J.J. Perez

Graduate students should exhibit hard competences – specific knowledge- in their field of study and, also soft or transversal competences that provide complementary abilities to use the former in any specific environment. Social responsibility is among the list of transversal competences. This competence provides graduates a guidance to develop their activities as professionals within a framework of sustainable development, in such a way that projects include considerations concerning environmental, social and economic dimensions. In the present work we revise the concept of social responsibility and propose a quality assurance procedure to assess and improve the level of competence achieved by graduates.

Key words: interdisciplinary approach, higher education, sustainable development, social responsibility.

1. Introduction

The effective progress of humankind requires policymakers and leaders to be competent for social responsibility. Social responsibility provides an ethical framework to act with the vision needed to understand the strongly interwoven environmental, economic and social consequences of specific decisions taken, guaranteeing a vision of long-term strategies for the benefit of society at large. Lack for social responsibility competence by leaders in technology, government, business and industry may result in choices that can compromise the development of present and future generations.

Social responsibility is a transversal competence that should be acquired along a study program, requiring further development during the professional life. Accordingly, Institutions of higher education through their study programs and Professional associations through the professional code of ethics have a direct responsibility to build up a solid competence for social responsibility of leaders in technology, government, business and industry.

The process of acquiring competence for social responsibility by graduates is connected to a holistic education for sustainable development delivered from Higher Education Institutions. A holistic education requires not only greening study programs, but involves greening the campus [1]. The present work aims to review different aspects connected to the implementation of a holistic approach on education for sustainable development and describes a quality assurance system to assess its degree of implementation by Institutions of Higher Education.

2. Sustainable development

Different studies suggest that with present population growth rate and use of resources, the Earth will reach its carrying capacity at the end of the XXI century [2, 3]. Fortunately, these studies also suggest that there is a model of sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs [4]. This model takes into account an expected increase of technological efficiency, but the most important requirement is a change in people's lifestyle. More specifically, citizens need to change their consumption