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Technology and technical innovation transfer in engineering education

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ABSTRACT: Technology and the transfer of engineering innovation are among the primary concerns for many countries across the globe. There are at least three basic methods of technology transfer: between generations, between science and industry, and between different countries. Universities have an important role to play with regards to technology transfer. Teaching innovation is an important aspect of technical education, including the preparation for independent creative activity. The article describes a market oriented system in four parts that students have embraced as part of their education; some students even began their own business or developed existing ones. The article also discusses mechatronics design and student training in innovation. Practical reflections are offered on the process. The establishment, objectives and achievements of the UNESCO-approved programme UNISPAR (UNiversity-Industry-Science-PARtnership) are also presented, as well as those of the Baltic Sea Innovation Network (BASIN). It is concluded in the article that the early involvement of students in technical economic activity is highly recommended.

INTRODUCTION

Technology and engineering innovation transfer are some of the main concerns of most countries. It was recently stated that:

> *Innovation has become the industrial religion of the late 20th Century. Business sees it as the key to increasing profits and market share. Governments automatically reach for it when trying to fix the economy* [1].

It is also now recognised that:

> *… technology transfer needs to be done at an international not local level, so that the best partners anywhere in the world come together to turn knowledge into products* [2].

Engineering education cannot separate itself from this problem. There exist at least three basic methods of technology transfer, namely:

1. Between generations.
2. Between science and industry.
3. Between different countries.

One of the most important is technology transfer between generations and it is here that technical universities have a crucial role to play.

Universities are among the main actors in this area; they can and should fulfil at least the first and second means of technology transfer. Furthermore, universities have great potential, so far under utilised, to contribute in the third manner.

TEACHING INNOVATION

Preparation for Independent Creative Activity

The European Commission has identified something called the *European paradox* [2][3]. This refers to

> *… the European seeming inability to turn excellent research results into globally competitive products ... It does seem that Europe's advanced science is too often taken elsewhere to be exploited commercially - usually to the United States.*

Reasons for this may be related to the European risk-and-reward equation and Europe's cultural attitudes to entrepreneurship, risk-taking and success.

This paradox appears not only in the continental scale, but also at universities. It is not easy to persuade many members of academic staff to turn their excellent research achievements into industry applicable offers. Furthermore, this indifference from staff is disturbingly projected into a passive attitude in their students. The consequences of this are manifested in the students' later problems with their creative initiative and unemployment after graduation.

Market Oriented System in Four Parts

In considering these issues, the author of this paper sought to prepare students for independent technically economical lives after university. In the undergraduate diploma seminars a specific market-oriented system has been introduced. Each of the 11 students of the seminar group had to prepare his/her diploma work in four parts. These four elements are detailed further below.

Part 1 is a comprehensive case study including technical and legal aspects of a particular market oriented problems. Examples include:

- Commercialisation of one (from almost 400) scientific innovative offers from Polish universities published in the bilingual Polish UNISPAR journal, *Polish Innovation Market*, in 2001.
- Comparison of the national system of innovation in Poland with other countries and the associated problems of practical implementation.
- The marketing, promotion and telemarketing of products using the Internet.
- The Internet as an alternative form of advertising.
- Scientific-technological parks on an international scale and recommendations for the country.
- Scientific-technological parks in Poland against an international background.
- The Baltic Sea Innovation Network (BASIN).
- Unemployment and human resource problems and their relation to science and education.
- ISO 9000 and its technical consequences.
- Patent laws and intellectual property transfer, etc.

Part 2 covers the WWW home pages of selected product or service.

Part 3 gives a DEMO short announcement of selected product or service.

Part 4 incorporates a business plan of selected product manufacturing or a service workshop.

A further step is the application for a grant from one of the potential sponsors, like the Polish Committee for Scientific Research (KBN), the 5th or 6th Framework Project of the European Union, UNIDO, the UNESCO Venice Office – Regional Office for Science and Technology for Europe (UVO-ROSTE), PHARE, NATO Science Sector, Industry Innovation System (IIS) - Japan, etc.

It was completely new experience for students and they were very satisfied. After the connection of all these works, they obtained a kind of comprehensive manual of effective activities in the market. Some of them even started their own business or developed existing ones.

The next, more extended exerxise could be the example of the so-called *Cambridge phenomenon* of the growth of New Technology-Based Firms (NTBFs) [4]. There exist now in the Cambridge area some 600 NTBFs and this illustrates a very dynamic application of scientific knowledge to commercial objectives.

Mechatronics Design

Mechatronics has many definitions. One of these definitions comes from Millbank, who stated that:

> *Mechatronics is not a subject science or technology per se - it is instead to be regarded as a philosophy- a fundamental way of looking at and doing things, and by its very nature requires a unified approach to its delivery* [5].

Mechatronics comprises many disciplines including the economy, technology and manufacturing. It is important to train students be prepared for collective work in the design of more complicated systems on the principles of mechatronics. To be effective they should be able to use tools based on deep science that are as simple and as fast as possible. This is because so-called *time-to-market*, ie production cycle of new variants (rapid design), is a very important factor for success.

For this case, the author asked each of about 20 students to prepare joint work in a computer laboratory, including practical principles of machine building (strength and quality of materials, bearings, friction, etc), electromagnetics (magnetic and electric circuits of components, power loss, eddy currents, electrodynamic forces), heating, cooling, hydraulics, etc. As a result they prepared jointly a kind of comprehensive manual of dynamic design.

The next step was to design independently, with the help of this manual and consultation with specialised colleagues, a mechanism that was not very complicated (eg part of an ABS braking system or wagon retarder). The basis of it, as prepared by the author, was a simple, formalised table of generalised degrees of freedom, generalised quantities and various energies involved in the process. Then, on the basis of Hamilton's principle and the *Euler-Lagrange* equation, they formulated specific equations of motion. The analysis of system motion and finding the extremities of the variation problem appeared as a simple and easy practical tool, even for the undergraduate student.

Such an approach could be a good substitute for the expensive and difficult package SABER.

Another effective tool for the rapid design of electromagnetic equipment is presented in another work [6]. Here one interactive design variant is calculated on the PC in less than one second, instead of a few months with popular commercial packages. The computer package was basically prepared by students of electronics and computer science under the instruction of a professor.

It is not easy to select a teaching programme that satisfies all the needs of a future engineer. However, one good indication is the scientifically based principle *time-to-market* in a broad meaning. After all, market success is a main criterion and proof of the effectiveness of engineering education. Market success is also the basis for the standards of living of both the nation and individuals. It gives a chance for the development of science, culture, basic and applied research, the proper solution of problems of employment and human resources, etc. The USA is a good example of this.

The preparation of future engineers for their independent professional life should consist of three basic stages. These are as follows:

- Teaching of theoretical tools (mathematics, physics, economy, foreign languages).
- Teaching of practical engineering tools (computer technology, modelling of physical fields, system dynamics and processing).
- Self-checking of the ability to find science-based solutions of complex technical and manufacturing problems (diploma thesis).

The procedure mentioned above serves this idea.

Some practical reflections can be formulated for the beginner of engineering activity as follows:

- A university does not teach; it only delivers the possibility of the effective self-responsible study of individuals.
- *Those who are interested in application cannot avoid complexity* [7].
- *Mathematics is too important to be left to mathematicians* [7].
- *... mathematicians resolve what is resolvable, whereas engineers... have to resolve everything.* This statement has a similar meaning. Engineering solutions should be fast, simple, at low cost and confirmed experimentally - both at the 1st phase of preparing and checking reliability of methods, at the 2nd phase of the final test, and at the 3rd phase of manufacturing [8].
- Beware of applying without sufficient thought a sophisticated theory and *universal* expensive commercial packages and method unless attempts have been made to resolve the same with a more simple approach.

The basic engineering criteria for the selection of one of the numerous methods and packages offered include the following:

- Is easy to use with moderate sized (PC) computers, without special education of the users in field theory and sophisticated numerical methods.
- Provides fast (only a few seconds) interactive analysis and optimisation of three-dimensional (3-D) systems, with graphic demonstration or simple synthetic parametric formulae.
- Yields useful design data, eg reduced power losses in kW, savings in US$, etc.
- Maintains flexibility with minimum costs in terms of time and effort.
- Offers the possibility to consider easily complicated, 3-D, 3-phase, asymmetric structures, hot-spots and heating effects, non-linear permeability, eddy-current effects, etc [3].

UNESCO-UNISPAR AND BALTIC REGION BASIN ACTIVITY

Considering the importance of science and innovation for a country's development, the 27th session of the General Conference of UNESCO approved the programme UNISPAR (UNiversity-Industry-Science-PARtnership) in 1993. This programme aims to promote

> *… international co-operation in terms of networking as well as information dissemination and at assisting UNESCO Member States in the identification and implementation of university-industry joint projects at national, regional and international levels.*

In 1995, upon the suggestion from Dr A. Badran, then Assistant Director-General for Science of UNESCO, and Dr Y. Aoshima, then UNISPAR Chief, the Polish UNESCO-UNISPAR Working Group Society was instituted. Later, in 2000, in cooperation with the UNESCO Venice Office – Regional Office for Science and Technology for Europe (UVO-ROSTE), the regional EuroUNISPAR innovation network was established. This belongs to a global UNESCO-UNISPAR network, together with the Baltic Sea Innovation Network BASIN (see Figure 1). The author of this paper was invited to become the Coordinator of the EuroUNISPAR and a member of trilateral BASIN Steering Committee.

The innovativeness and competitiveness of the economy is based on three main pillars, which are as follows:

- Creators of innovations, without whom does not exist any possibility.
- Information, without which innovation is unavailable and dead.
- The marketing and commercialisation of research results.

To execute these needs, Polish UNESCO-UNISPAR has edited a special bilingual bulletin *Polski Rynek Innowacji ≡ Polish Innovation Market (PRI ≡ PIM).* This publishes short announcements on innovative scientific offers of Polish universities that are, more or less, ready for industrial implementation, for Small and Medium sized Enterprises (SMEs) and the economy in general.

The two first pillars are fulfilled partly by the bilingual *PRI ≡ PIM* bulletin. In 20 issues of *PRI ≡ PIM* almost 400 innovative offers of Polish universities have been published thus far [9]. They are now under a commercialisation process within the EuroUNISPAR and BASIN regions.

However, this is not easy. To be more effective, it is necessary to organise a broader institutionalised, international, European innovation and science-industry market. This should include educators' and students' activities.

On the other hand, the Baltic Sea Innovation Network (BASIN), as shown in Figure 1, is a programme initiated in 1999 by the Innovation Institute of Stockholm, Stockholm, Sweden, on the invitation of the Director-General of UNESCO in order to:

> *… develop a network for exchange of ideas and concepts for the transformation of innovations in the Baltic region into economic and social development.*

The first BASIN meeting was held in Helsinki, Finland, from 6-7 May 1999. The following Steering Committee meeting was held in Koszalin, Poland, in July 2000, and then in Lodz, Poland (BASIN2000). The BASIN2000 meeting was accompanied by a poster session: *Presentation of Innovations* in order to present academic innovative research projects and foster their industry applications.

The objectives of BASIN2000 were to:

- Establish the next step in the development of the BASIN project.
- Determine the best ways to overcome the low degree of university-industry cooperation.
- Present innovative offers for industry.
- Check the feasibility study and business plans of these offers.
- Make contracts with industry and foreign partners.

The above objectives are still valid. There only needs to be greater and more active participation from students and graduates.

CONCLUSION

Students and young graduates of engineering education represent great potential in innovations and, at the same time, can be quickly prepared for independent activity in the contemporary market, especially for Small and Medium sized Enterprises (SMEs). Their involvement in the early stages of technical economic activity is highly recommended.

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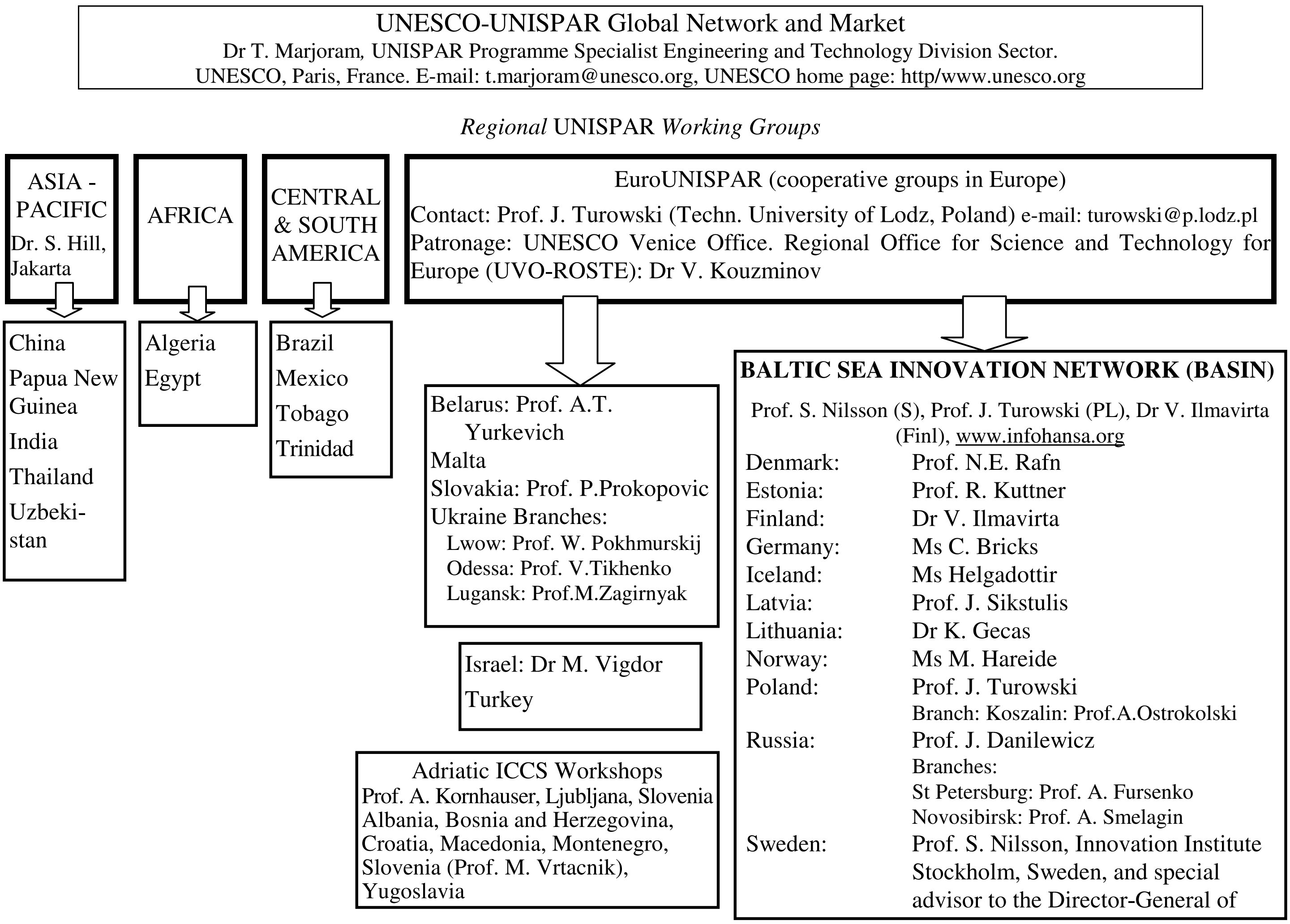

Figure 1: Draft of the present global UNESCO-UNISPAR network [9].