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Building Bridges between Academia, Industry and Society:
Reflections on Experience from Three Continents

Fortuna populi pendet juvenum eruditione
The fate of nations depends on the education of youth
Politica, libro VII, **Aristotle** (384-322 BC)

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Today is a very proud day in my life as a scientist, engineer and professor to see the fruits of 48 years of research and teaching recognized by this distinguished University, to whom I have expressed my grateful thanks earlier on for awarding me the prestigious degree of *Doctor Honoris Causa*. Now, I would like to offer some reflections on the interactions of Academia, Industry and Society as perceived from my engineering experience from many countries, on three continents, witnessing in the process many successes and, yes, some failures. I have chosen this general topic for this distinguished audience because I am amazed at the wide range of colleges (15), departments (32) and specializations (170) which are represented at Akademia Górniczo-Hutnicza, going well beyond traditional mining. I am speaking to the members of the High Senate who may be professors, engineers, geologists, mathematicians, physicists, biomedics, business and management leaders, specialists in humanities, and those from fast growing disciplines of technology: automation, information, telecommunications and medical engineering; also some students are present, representing *Uczelnianą Radę Studentów*.

Yet, we all have one thing in common: we are concerned with the development for the good of the country of the mineral resources, hidden in the earth formations of rock and coal. We are united in the uniqueness of the materials we are working with - no matter what our specialty may be. In my case, specializing in rock engineering in mining and tunneling, I would like to elaborate on the special features of my field of scientific endeavor and how it serves academia, industry and society, in the spirit of the AGH motto: *Labore creata, labori et scientiae servio* (by work created, practice and science I serve).

First of all, I must compliment this university as a whole on its expansion into so many areas and its success in becoming one of the two best technical schools in Poland and in the top four of all universities. In fact, I remember that when I visited you for the first time in 1981, I made a note in my report that there were 12,000 students at AGH; today there are over 35,000 with about 1,500 studying mining (and a similar number in metallurgy). I found the explanation for this remarkable achievement when reading the preface of JM Rector Professor Antoni Tajduś in the beautiful volume of "Skarby AGH" where he said: "*We have to walk on the road of progress which means growing specializations; new disciplines are born, other disappear*". This far-reaching vision has clearly paid excellent results.

THE NATURE OF ROCK ENGINEERING

Being involved in engineering and dealing with the oldest engineering material - geologic media such as rock masses - we are provided with a challenging opportunity to study a material which cannot be designed or manufactured, like steel or concrete, but which is provided to us only as found in nature - with all its wonders and uncertainties.

Although mankind has been concerned with the use of rock from time immemorial and the history of human civilization points to the magnificence of structures built in rock and from rock, these early achievements were based on knowledge acquired through practical experience, not uncommonly from imagination and intuition. In fact, a tunnel is even mentioned in the Bible *(2 Chronicles 32:30),* namely the Hezekiah Tunnel built in ~700 BC to supply water during the siege of Jerusalem by the invading Assyrians. [It is still in use (!) and my wife and I visited this remarkable structure in 2000]. Centuries later, a time came when demands for large structures such as dams and tunnels, and mining of mineral deposits under more difficult conditions, such as at great depths, dictated a more rational approach based on scientific knowledge augmented by research. This approach was necessary not only to prevent disasters from taking place due to failure of the rock and the resultant loss of life, but better knowledge could also lead to considerable economic advantages and improvements in the quality of our lives.

Historically, this field of rock engineering, which is my chosen profession and scientific research arena, is a very young science having been organized formally less than 50 years ago. In fact, it was in Europe that the first International Congress on Rock Mechanics was held in Lisbon in 1966. Why did it take so long to compile reliable engineering data and arouse concentrated and widespread research and teaching in this field? The reason is that unlike other engineering materials, a geologic material such as rock presents the designer with unique problems; rock formations are most complex in nature, varying widely in their properties, and the choice of material is limited to what is found at a given mining or tunneling site. Most of all, however, the designer is confronted with rock as an assembly of irregular blocks of rock material, separated by various types of geologic discontinuities, such as fractures or faults. This assemblage constitutes a rock mass, including both the rock material and also the geologic features, and is characterized by many parameters of influence. This rock mass, because of its complexity and size, cannot be tested in the laboratory, like steel or concrete. Understanding the overall behavior of such a complex formation is a major challenge - a difficult but important task which is best appreciated by the fact that try as we may to this day we do not have the ability to predict the earthquakes which occur in many parts of the world.

Yet, we have achieved the capability of constructing extensive engineering works such as tunnels, underground power houses, metro stations, in a wide range of rock formations, we can build mines to extract minerals and coal, construct foundations, excavate rock slopes, dams, shafts, oil reservoir wells, build underground storage facilities for oil, gas, water and nuclear waste. Rock engineering allows us to improve our environment, mitigate natural hazards, and improve our quality of life.

We should be justly proud of the many good things in rock engineering achieved during the past 50 years, but also saddened by bad planning and mistaken decisions, resulting in accidents and disasters involving loss of life and resources. Learning from failure has always been the way in engineering, so what is important is to ensure that mistakes are not repeated and that the new generation of professionals understands past actions and can build meaningfully on the accomplishments of its predecessors. Today, mistakes can be significantly reduced, even in new types of rock engineering applications.

I also firmly believe that to achieve this, engineering must include considerations of social, economic, global and even personal factors. This is crucial for educating and training the world-class engineers of 21st century.

My involvement in rock engineering during the past four decades was most satisfying because of three main reasons:

(1) the interdisciplinary nature: being able to feel equally at home working with civil engineers on tunneling projects or with mining engineers concerned with coal mine strata control or with engineering geologists analyzing ground conditions for petroleum storage. It is fascinating to use our knowledge from one discipline for the solution of problems in another!

(2) the interdependence of site exploration, design, construction and operation - each with its own objectives - all striving to fulfill the overall objectives of the project. This requires an understanding of the issues involved, the state-of-the-art methods to be used, as well as close co-operation between the owners, design engineers and contractors, and even other parties, such as the general public.

(3) the opportunities for unique research topics, enriching teaching and guiding young researchers. My "laboratory" was the actual sites of engineering projects where my students and I have studied the behavior of rock masses rather than testing samples of rock in a conventional laboratory. This research has taken me to the Channel Tunnel between Britain and France, the deepest gold mines in Africa, earthquake sites in Kobe, Japan, and underground power stations in Ethiopia, South Africa, India and New Zealand, not to mention civil, mining, petroleum and natural gas projects in the USA. Seeing young people grow and succeed and seeing the fruits of one's research applied in engineering practice is most rewarding.

I have learned in the process that to guarantee its capacity for renewal and development as a modern discipline, our field must consist of three elements, ***research, practice*** *and* ***education.*** Understanding the theory, developing good practice and engaging in education, go hand-in-hand in earning a discipline prominent recognition.

ENGINEERING RESEARCH

"*If you can measure what you are speaking about,*
and express it in numbers, you know something about it"
Lord Kelvin (1824-1907)

For a scientific investigation to be effective in rock engineering, it should involve theoretical and experimental aspects, laboratory and field testing, applications in design alternatives, and monitoring of the structural behavior during construction. Only then, can such research be considered a scientific discovery. But even then, in the case of research by professors, Boyer (1990) in "Scholarship Reconsidered" observed that the professoriate has <u>four</u> vital functions or activities in the process of scholarship: ***discovery*** (research to generate new knowledge, as per above example), ***integration*** (interpreting and fitting of the new knowledge into existing multidisciplinary problems), ***application*** (applying specialized knowledge to socially consequential problems), and ***teaching.*** The present academic incentive and reward system for professors values mainly the scholarship of discovery. Hence, students are in effect given secondary consideration in the American university system where research is the top priority.

Reflections from AFRICA: Seizing New Research Opportunities

In my introductory section, I referred to the important statement by Pan Rector Professor Antoni Tajduś who emphasized the need for moving into new areas of specialization, as opportunities arise. I can confirm from my own experience the validity and success of such progressive thinking when I worked in the mining industry in South Africa, at that time (1967-72) the leader mining industry in the world because of the importance of gold and coal mining.

The research group of 32 persons which I directed consisted of 23 mining and mechanical engineers as well as geologists, plus a number of technicians and workshop specialists. We had a generous budget, provided by a government subsidy and industrial funding, and excellent laboratories - all because of the need to solve the pressing problems of rockbursts in deep-level (3 km below the surface) gold mining and major stability and safety problems with coal pillars in room and pillar coal mining. At the same time, the industry itself established their own research teams as well as laboratories and, gradually they could put more people and resources in mining research projects. After a few years, we were facing considerable competition, reduced funding and shortage of staff.

At that time, I was also chairman of the National Group on Rock Mechanics, affiliated with the ISRM, and organized a number of symposia for our mining and civil engineering members, including visits to mines and tunnels to show applications of rock mechanics. It soon became obvious that the strong South African mining industry did not have enough qualified people to spare for civil engineering tunneling and, worse, civil engineering students were not trained in rock mechanics, only in soil mechanics. Hence, most tunneling projects in the country had to be directed by engineers recruited from abroad. By chance, I had two tunneling engineers and one geologist on my staff from Austria - <u>the</u> leading tunneling country at the time - and decided to use them to train my people for different specialties involved in all aspects of tunneling. We then organized a conference for the civil engineering industry on *"Tunneling in Rock: Investigation, Design and Construction",* and published its Proceedings (1974) featuring invited experts from Europe. As a result, industrial contracts poured in because our mining engineers could do excellent work in civil engineering tunneling. Within a few years, my research group had a virtual monopoly on assisting the industry with tunnel design projects, and we also initiated research into tunnel engineering which eventually led to the development of the RMR system. By 1977, we published a two-volume compilation of *"Exploration for Rock Engineering in Mining and Tunneling"* which became a handbook for design and construction of excavations in rock masses. Ironically, the other research group, set up by the industry and dedicated solely to mining, was eventually disbanded as most of its personnel moved to the booming tunneling industry.

Ever since, even after I accepted a position in the United States, I looked for opportunities to expand a Mining School's expertise to civil engineering applications, and train mining engineers for tunneling jobs. Such opportunities were embraced in my activities at the Pennsylvania State University, when mining became unpopular, and at the Superior School of Mines of the Universidad Politécnica de Madrid in Spain.

Today, new initiatives are emerging in Europe to train tunnel engineers as an engineering specialization at *Masters* level. For example, at Warwick University in Great Britain, an MSc degree in Tunneling and Underground Space was announced just this year. Similar initiatives include École Politécnique de Lausanne and Politecnica de Torino.

May I express the hope that the continuing expansion of Akademia Górniczo-Hutnicza will include education and training of mining engineers for specialization in tunneling. Responding to a recent appeal in the journal *Tunnels & Tunneling International,* a one-year MS degree in tunnel engineering, offered in English, would be most welcome in Europe and AGH could become an important center providing such a service because of its human resources and high reputation. Moreover, professors and docents could also initiate new research projects in such modern subjects as rock mass excavability for tunnel boring machines, which is in demand and an area largely unexplored. This would be very relevant, for example, for any metro projects when building train stations and tunnels in Poland's large cities. I noted from a recent press release that the tunneling contract for the 2nd Metro line in Warsaw of US $944 million, which includes 47.2 km of tunnels, was recently won by the Italian-Turkish-Polish consortium; does this mean that international competition signifies an increased demand for experienced tunnel engineers in Poland?

ENGINEERING PRACTICE

"*Scientists discover what is, engineers create what has never been*"
Theodor von Karman, 1911

There are three main approaches in rock engineering practice: analytical (including computer modeling), empirical and observational. The empirical approach is still predominant today in mining engineering and tunneling. In spite of significant advances in analytical/numerical techniques and in field measurements during construction, there is a major problem with the integration of all the activities leading to an effective design of excavations in rock. For example, rock mass classifications form an integral part of the empirical approach and were never intended as the ultimate solution to design problems, but only as a means toward this end. They were not intended to replace analytical procedures, field measurements or engineering judgment; they were simply additional design aids, forming a part of the rock engineer's "bag of tools".

A major challenge in rock engineering is that the design process in that field is governed by considerable uncertainty about the material involved - rock masses - often resulting in design decisions based on precedent and incomplete knowledge of all the factors influencing the design. To overcome this situation, a systems design methodology is needed for rock engineering in the same way as a design process methodology was incorporated in mechanical engineering in Germany or in tunneling in Austria (Ö-normen, 2004) and in Spain ("diseño estructural activo" (DEA, Celada, 2005).

Engineering Design Process

Design: the very word epitomizes creativity, innovation and the essence of engineering. Derived from the Latin word – *designare* – to map out, engineering design is defined as a decision-making process of devising a product to meet desired needs. It is now realized that a good designer needs not only knowledge *FOR* design (technical knowledge that is used to generate alternative design solutions for selecting the best among them) but also a good designer must have knowledge *ABOUT* designing (appropriate principles and a systematic methodology to follow).

Poland has been in the forefront of research in this area. I was particularly motivated by reading the work of Professor T. Kotarbiński who in 1965, proposed a 'theory of systems' directed to solution of problems of methodology in applied science. In 1969 the Polish Academy of Sciences created a Section of Design Methodology in the Department of Praxology (the science of effective action) under the direction of Professor Wojciech Gasparski. The purpose of this group was to study the science of design. When I visited Poland in 1989, I met with Professor Gasparski and established an exchange of our research findings. He visited America a year later. In subsequent years I proposed design principles and methodology specifically for projects constructed in geologic media. This includes ten design stages and six principles which found particular applications in the design of nuclear waste repositories in deep rock formations because legal requirements for licensing of such structures in the USA by the Nuclear Regulatory Commission specified providing a formal design methodology as a guarantee of the "quality assurance procedure". The significance of this design methodology is that it specifies a creative and systematic decision-making process which provides specific principles for distinguishing between good and unacceptable designs.

Figure 1 presents a chart of Design Methodology for rock engineering which, in concept, also applies to other engineering disciplines at the AGH.

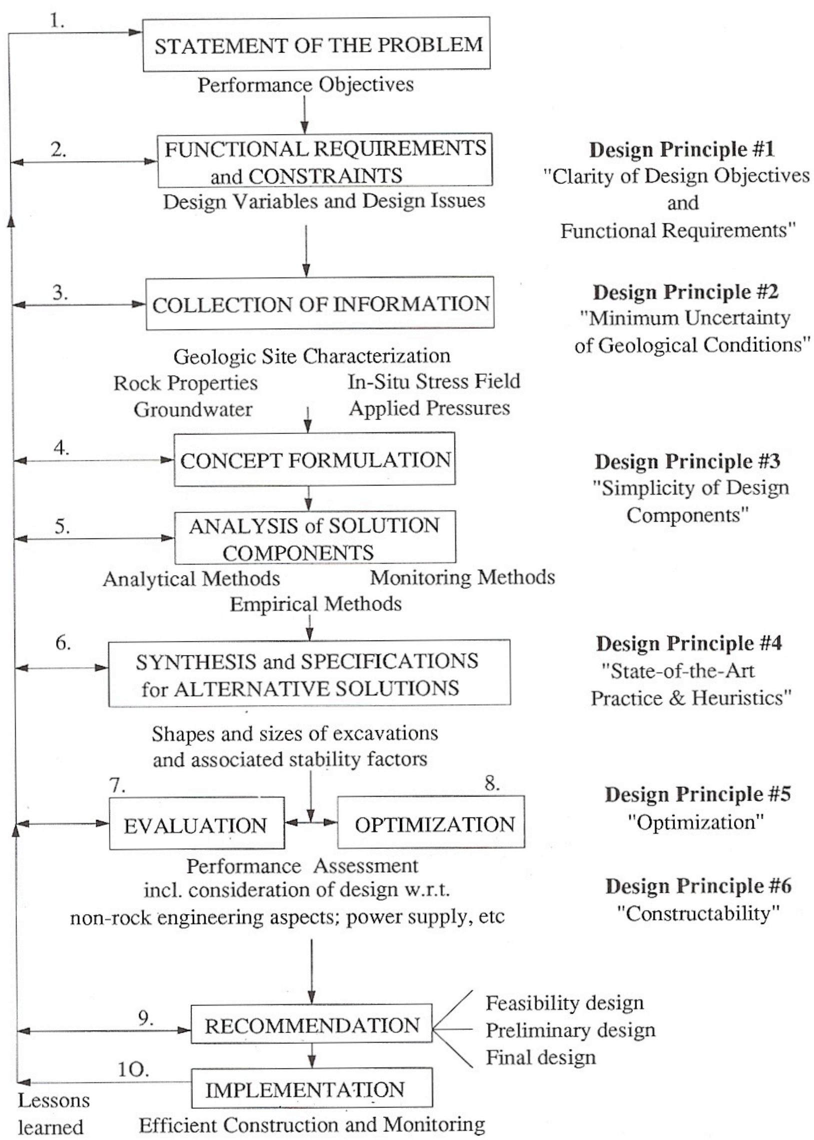

Figure 1 **Systems Design Methodology** for rock engineering, including the use of design principles

To illustrate this point, one special principle may be singled out: the *Constructability Principle:* "The best design facilitates the most efficient construction of the rock engineering structure by selecting the most appropriate construction method and sequence". This Principle, is a unique innovation in rock engineering. In mechanical engineering the concept of "design for manufacture" has led to highly streamlined production processes. The "design for construction" concept advocated here encompasses innovation as the essence of engineering practice, following the lead of J. Matson in his book "Innovate or Die" (1996).

In essence, one should visualize design methodology as a checklist (not unlike the one used by a pilot before take-off) or a road-map guiding the designer to fulfillment of the project objectives by evolving the best design option.

Finally, to emphasize the importance of incorporating a design methodology in engineering practice, the best institution of higher learning in the world, Harvard University, many years ago incorporated its Graduate School of Design, where engineers, architects and constructors study theoretical and practical aspects of design methodologies.

Reflections from EUROPE: Value of Industrial Experience

I had the opportunity to work as a professor at three European universities, Technische Hochschule Karlsruhe in Germany (1972), University of Cambridge in England (1997) and the Superior School of Mines, Universidad Politécnica de Madrid, Spain (2001, 2003), spending a sabbatical year at each. In all three cases, I was very impressed that the professors who invited me, all had extensive industrial experience. This was impressive because they could teach their students the latest developments in engineering practice, not just material out of a textbook.

How was this possible? It transpired that in terms of university policy, each of the professors involved did a lot of private consulting on university time and received handsome remuneration for their services. How much consulting was permitted varied widely. ***In Spain***, professors may spend 80% of their time consulting, teaching only one course per semester, and their university pay will be reduced proportionally to reflect pay per hour but retaining their full time status, title and other privileges. Currently, an assessment of teaching effectiveness is performed but didactic activities have limited impact on promotion or salary increments. ***In Great Britain***, the rules are very vague as long as professors fulfill their minimum teaching duties. If he or she is an administrator as well, they may have no teaching duties at all. Professors do not have to keep "office hours" for meeting with the students. ***In Germany***, a professor usually directs his own research institute, run as an independent business and employing a substantial number of graduate students ('Dipl.-Eng.') studying for a doctorate, which sometimes takes six to seven years. "Cheap labor" this is called but once the students obtain their doctorates, the professor finds them excellent jobs through his contacts with the industry.

In America, where everything must be organized and regulations are plentiful (though there are always exceptions!), the rule is that a professor may spend one full day per week on consulting, plus of course weekends and national holidays. As senior (tenured) professors teach only one course per semester when they have a full research load from industrial contracts, this arrangement works well, and I was able to do a substantial amount of industrial consulting. This kept me up to date with engineering practice. I could test my new research findings and provide my students with case studies from actual mining and tunneling projects.

In essence, I believe that professors should be not only teachers and researchers but also practitioners in their field, developing and teaching new techniques which can be used in practice. I would be interested to know how industrial consulting by professors and university staff in Poland compares with practices in the rest of Europe, particularly with respect to the European Community initiatives under the Bologna Declaration.

ENGINEERING EDUCATION

"College is where you learn how to learn"
Socrates (469-399BC)

Most of you in this audience are very busy implementing the Bologna Declaration of June 19, 1999, by the European Ministers of Higher Education (and signatory countries) which established the European Higher Education Area this year. Its aim is to consolidate European higher education and adopt a system of readily comparable degrees so that citizens can effectively use their qualifications, competencies and skills throughout Europe. As an honorary professor at the Universidad Politécnica de Madrid, I have been closely associated with the developments in Spain for some ten years and am aware of the problems encountered.

The major problem of conversion to the Bologna plan of the European Credits Transfer System (ECTS) in Spain is that their engineers graduate with diplomas in two distinct specializations: senior engineer (superior) and technician engineer (técnico), the first being of 6-year duration and the other of four years. Now – as from September 1, 2010 – both grades will be completing Cycle I after four years as the "entry qualification into the work force", and both masters (*técnicos* and *superiores de investigación*) will last two years. There is also a third type of master called *'titulación propia'* that can be given with lesser duration for specialization. Still unresolved is legal licensing of engineers, by the Spanish *colegios*, authorizing professional engineers to sign technical documents.

Concerning Poland, I read with much interest a recent article by Bianka Siwinska entitled "The problems of internationalization in Poland" (*Perspektywy,* nr.55, Spring 2009). She reviews the Bologna Process and laments the lack of a coherent national policy to stimulate integration of Poland into the international community. For example, within the Erasmus exchange program, for every three Polish students who go abroad only one exchange student travels to Poland. The reason: the world is not sufficiently aware of the fine opportunities for studying in Poland. Most of all, little effort is apparently made to attract non-Polish citizens to academic positions or use scientists from abroad with Polish background as independent reviewers of research proposals by the KBN (Komitet Badań Naukowych).

I have noted that rating Polish universities has been undertaken recently. In America this has been debated and done for decades, in spite of the uncertainties involved in the process, because being independent and – mostly – self-funded, the universities and colleges compete for the best professors, most talented students, and any lucrative endowments. Knowledge of ratings can serve a useful purpose to ensure that top rated Polish academic programs are not linked to third or fourth-tier institutions in the USA and Europe. Moreover, exchange agreements at the institutional level, so common in Europe, are not as beneficial as one-on-one linkages between individual professors or groups of professors and their research programs, which prevails in America.

It is, however, somewhat of a mystery to me why the European universities which I know very well and respect their standards get such mixed results by comparison with American universities. For example, in the class of 'Engineering Institutions in the World', *The Times* of London and *World Ranking Guide 2009* rated the University of Cambridge as no. 4 in the world (after MIT, Berkeley and Stanford) but Technische Hochschule Karlsruhe is no.71 and Universidad Politécnica de Madrid is no. 150.

In my opinion, having been a visiting professor at the above three universities and being very proud of my Polish lyceum and university education, I do not think that the rating of the Polish institutions reflects the reality by comparison with other European or American universities. This is so because the rankings are a function of the criteria used in the process. My latest information is that, after the May 2005 conference of Polish Rectors, considerable strides were made in strengthening internationalization, with the number of foreign students at Polish universities having increased by 30% by 2009. The latest surveys show that graduates of Polish high schools and universities compare well with their peers from other countries in academic preparation and achievement. I know from my own experience that Polish-educated scientists and engineers work and achieve remarkable successes at major universities, research organizations and industrial corporations around the world.

Of course, you are best equipped to decide what further improvements might be needed but allow me to make a few comparisons with the American system, which may be of interest.

The Status of American Higher Education

While Europe introduced profound changes with the Bologna Declaration of common European credits, American higher education, has been using a similar credit system for decades.

Before describing these changes for a European audience, it is important to mention a paradox in American education: we believe that our public secondary education (high schools) are generally underperforming and are not as good as their European counterparts but our higher education colleges and universities in the first tier of 100 are excellent. How is this possible?

There are many reasons for this seemingly contradictory situation. The main one is the uniqueness of the U.S. higher education system which has no equal in other countries: the total independence and flexibility of American universities. In Europe and Japan, universities are answerable to a Ministry of Education which sets academic standards and distributes money, as well as appoints the rectors and professors. American universities are different in that each can run their own institution as they like and can devise their own programs and educational materials without any government interference. ***There is no Ministry of Higher Education in the USA.*** There is a federal Department of Education but its purpose is mainly to assist primary and secondary schools while leaving the educational standards, requirements and funding to each of the 50 states, indeed to the local district school boards. The downside of this independence is that our universities charge high tuition fees.

Out of over 3000 universities in the United States, engineering universities number over 270 of which some 200 are regularly evaluated and rated each year by *U.S. News & World Report.* The top 25 represent a very high standard constituting the leading institutions of higher learning in the world. The Pennsylvania State University is no. 15 on that list in the category of public universities.

Concerning mining education, America is experiencing a shortage of engineers in the coal industry. In 2009, 84,160 employees, of whom 940 were mining engineers, produced 1.2 billion tons of coal. Our 11 mining universities graduated only 123 BSc engineers after 4-years of study. Current total enrollments stand at 821 undergraduate students. I note that the AGH alone produces more mining engineers (237) than the whole of the USA!

Reflections from AMERICA: A Lesson for Professors

I learned a painful lesson as a professor in America. Arriving in that country with great expectations to be an enthusiastic teacher enjoying my students' undivided attention, as I remembered from my years in Poland admiring my beloved professors, I found instead that ***teaching*** - as an academic activity - was considered absolutely secondary in the American system. It was ***research*** that mattered most because this was the way to bring funds to the university to pay its overheads. In fact, professors are paid on a 9-months basis and the balance must be earned from research or consulting. Imagine you have a monthly salary which you think is quite adequate and then discover that it is paid only nine months of the year. Accordingly, professors must dedicate themselves to research and the ultimate dictum to advance one's career is: "*Publish or Perish!*"

On arrival in America, having spent 15 years in scientific and industrial research, published more papers than any other professor I knew at the Pennsylvania State University, I wanted to concentrate on teaching. I became a source of dismay to my colleagues. Why, with my reputation, did I not want to acquire large research grants rather than rely on my meager salary from teaching? Well, this was a heart breaking situation and initially my wife and I struggled financially in America. Clearly, I had to adapt to the American system because the university would not provide travel funds or meet the costs of books and periodicals, let alone buy equipment or employ technicians and assistants for my teaching and research.

"To beat the system", eventually I spent long hours writing project proposals and won large research contracts becoming independent both financially and activity-wise (teaching the subjects I preferred). Recognition and promotion came from writing books and publishing refereed papers. Research funds also enabled me to hire my own graduate students, buy equipment and travel to important conferences and industrial sites. Moreover, not being well off in America for a few years taught my wife and I better family budgeting and vacation planning, which we promptly passed to our three sons, much to their disgust! America is indeed a wonderful land of opportunity but one needs to work hard, learn the system ("if you can't beat them, join them") and in time of hardship it pays to have a good wife who can grow vegetables on a rented lot... In truth, none of our early problems with settling down would prove insurmountable to any <u>*krakowiak*</u> with determination and the fine education such as I received in

Poland. After two years, I advanced to a position of supervising ten American professors and educators, and nobody thought it was unusual at all.

The main lesson I learned was that to be a successful professor in America, one must indeed "know the rules of the game", keep close contact with industry, avoid the bureaucrats, and keep one's students interested and inspired.

STUDENTS - THE ESSENCE OF UNIVERSITY

Having discussed the interaction and interdependence of Universities, Industry and Society, it remains to focus on the very essence of the academic endeavor: the Students whom we serve with education and training. Ever since the ancient *Academia* of Plato and *Lyceum* of Aristotle in the years B.C. to the medieval times of the first universities in Bologna (1119), Oxford (1168) and Paris (1200), it was the students who organized themselves to hire teachers (and not the other way round) leading to the term *universitas,* meaning a guild or corporation, in essence, a *university of students*.

Consequently – as professors – we ought to define and provide the standards and subjects which will fulfill the students' "investment" in us and our institutions of higher learning.

So, with what qualities should we be arming the future generation of engineers? I would like to present you with three views: one from ***academia***, one from ***industry***, and one from ***society*** – all by mining engineering alumni.

<u>The academic view</u> comes from a recent proposal defining a world-class engineer which has been put forward by the Penn State Center for Enhancement of Undergraduate Engineering Education. The following qualities were proposed for this purpose:

1. *Aware of the World:* sensitive to cultural differences, environmental concerns;
2. *Solidly Grounded:* thoroughly trained in the fundamentals of engineering;
3. *Technically Broad:* understand that real-life problems are interdisciplinary;
4. *Effective in Group Operations*: is team builder and potential leader;
5. *Versatile:* problem solver, decision maker and innovative developer;
6. *Customer Oriented:* effective in the global market place.

<u>The industrial view</u> comes from the leading international authority and consultant in mining and tunneling whom I asked what he would expect from a young graduating engineer he might hire. He replied:

"I would hire immediately a young graduate who is confident of his or her understanding of what they have learned but not arrogant, able to think on their feet, who can look you straight in the eye and talk passionately about what they would like to do with their life. Pure academic education is only a part of what

makes a person; the rest is opportunity that they have seen and taken, hard work, honesty and, in some cases, just plain luck."

The society view comes from an old doctoral student of mine who is today the director of a government office of health and safety in mining. Here are his top five *characteristics* of "a highly successful geo-engineer who would meet the society needs and trust":

Enthusiastic: Stays interested, not easily discouraged, and able to infect others with enthusiasm.

Self-motivated and Innovative: Able to set own goals, doesn't wait for others to set them; can develop new ways of looking at problems.

Practical: Interested in finding real-world solutions to real-world problems. Intimately familiar with the industry and its people,

Scientific and technical knowledge: A solid academic training in a broad range of relevant disciplines, keeps up to date with the latest developments.

Communication skills: Able to transfer research results through speaking, writing, and other media.

The above views represent a wide range of advice to which I would like to add just three words that proved most beneficial for me as a student: *Perseverantia omnia vincit* (perseverance conquers all). This motto has motivated my whole professional life: from student to doctor of science, to professor, to entrepreneur consultant. It simply means that all of us, ordinary people are capable of doing some extraordinary things. So, I tell my students: go into the world and do not be afraid: you can make a difference. That's why you are here!

IN CLOSING

Building bridges between Academia, Industry and Society is necessary to benefit from our interdependence and to learn from one another. I hope that I have demonstrated this from sharing my experience as an engineer, scientist and professor on three continents and visiting many countries in the process.

For me personally, addressing you today on this memorable occasion, was an honor and pleasure. Returning to the place of my birth, this beautiful Kraków, fate has performed a full circle, thanks to this great distinction bestowed upon me by Akademia Górniczo-Hutnicza.

So, in closing, I thank you all and wish to leave you with a guiding quotation from a great scientist and professor: **ALBERT EINSTEIN** who said these words at the University of Princeton in 1941:

Enthusiasm is the greatest asset in the world,
it beats money and power and influence.

Acknowledgements

In preparation of this Dr Honoris Causa Address I requested and received valuable comments from a number of my colleagues and friends which enhanced the ideas expressed in this presentation and informed me of the latest developments. I specifically wish to thank (in alphabetical order) the following persons:

Dr. **N. Barton**, Brazil
Mrs **Elizabeth Bieniawski**, Arizona
Prof. Christopher **Bise**, West Virginia
Prof. Marek **Cała**, Poland
Prof. Dr Benjamín **Celada**, Spain
Prof. Dr José Miguel **Galera**, Spain
Professor Hasan **Gercek**, Turkey
Dott. Ing Remo **Grandori**, Italy
Dr-Inż. Wojciech **Grodecki**, Warszawa
Dr Evert **Hoek**, Canada
Prof. John **Hudson**, UK
Dr Alex **Johannsen**, South Africa
Prof. Kalman **Kovari**, Switzerland
Prof. Paul **Marinos**, Greece
Dr Christopher **Mark**, Pennsylvania
Prof. Jack **Matson**, Pennsylvania
Eng. Anthony **Mihulka**, Missouri
Dr Marek **Mrugala**, Nevada
Dr David **Newman**, Kentucky
Dr Harvey **Parker**, Washington
Ing. Farzan **Rafia**, Iran
Prof. Dr Pedro **Ramirez**, Spain
Prof. Tibor **Rozgonyi**, Colorado
Prof. T. R. **Stacey**, South Africa
Prof. Kot von **Unrug**, Kentucky
Dr. Aleksandra **Waszczuk-Ziń**, Poland
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