IGIP Co-Plenary - Present and Future Challenges in Engineering Education and the Strategies of IGIP

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Present and Future Challenges in Engineering Education and the Strategies of IGIP

Abstract

Never has the speed of development in the area of engineering been as accelerated as it is today, as we observe the enormous and driven growth of the area of engineering as well as a shortening of innovation cycles. On the other hand a mayor shift happens in educational processes in general. Both tendencies require concerted new efforts in engineering education - or in other words, the importance of pedagogy in the field of engineering is growing enormously. These changes strongly demand new didactic and pedagogic paradigms. The International Society of Engineering Education (IGIP) offers to contribute to the relevance and pedagogical aspects related to developing educational concepts in engineering education.

IGIP and Engineering Education

IGIP has a more than 40-year tradition of contributing to engineering education and its members and many activists have contributed to making IGIP a leading global engineering association. IGIP presently has a worldwide membership of about 1.750 members (individual, affiliate, institutional). More than 1.200 professionals all over the globe at this moment bear the title of "IGIP International Engineering Educator - Ing.Paed.IGIP ". IGIP also works in good partnerships with international associations as IFEES, ASEE, IEEE Education Society, SEFI, and IELA, to name just a few.

The aims of the International Society for Engineering Education - IGIP are:

- To improve teaching methods in technical subjects
- To develop practice-oriented curricula that correspond to the needs of students and employers
- To encourage the use of new media in technical teaching
- To integrating languages and the humanities in engineering education
- To foster management training for engineers
- To promote environmental awareness
- To support the development of engineering education in developing countries

It is important to consider that humankind has never faced such a rapidly changing and dynamic global environment which demands so much of engineers as we are witnessing today. And as our environment changes, it is imperative we better learn to adapt, which requires us to question and, when necessary, be open to changes regarding our:

- Educational systems
- Pedagogy
- Methods and processes

Never before have the challenges in education and pedagogy been as challenging as today.

Never has so much been demanded of engineers. The work of ASEE, IGIP, IEEE ES, and other associations focuses on improving the quality of Engineering Education. But what is exactly is engineering?
In the literature we can find different definitions of the term Engineering. In Wikipedia we can find:

„Engineering is the application of scientific, economic, social, and practical knowledge, in order to design, build, and maintain structures, machines, devices, systems, materials and processes. It may encompass using insights to conceive, model and scale an appropriate solution to a problem or objective." [1]

ABET has defined engineering as:

"The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation or safety to life and property".

In sum a short definition of engineering might be: "Exploiting basic principles of science to develop useful tools, objects and processes for society." This means that engineering is the link between science and society, which can include almost anything that people come into contact with or experience in real life. The concept of engineering existed long before recorded history and has evolved from fundamental inventions such as the lever, wheel, and pulley, to the complex examples of engineering today.

The new millennium opened simultaneously a new phase in the history of engineering. This phase is characterized by the following facts:

- We observe the enormous and driven growth of the area of engineering. Besides the traditional fields of civil engineering, construction engineering, electrical engineering, etc. many new engineering disciplines occur.
- And new tasks requiring new competencies within traditional engineering disciplines have grown in number and complexity.
- Never has the speed of development in the area of engineering been as accelerated as it is today. We can observe a terrific acceleration of the life cycles of technical (or engineering) products Competition in the field of technology is now measured in month and weeks.
- Furthermore the focus of the engineering disciplines is shifting from pure technical subjects to subjects directed to Information Technologies and the daily life of mankind.
- Engineering issues, either in industrial products or in engineering projects, are quickly becoming increasingly complicated and most of these issues cross disciplinary lines.

- The size of the systems developed or designed by engineers grows continually. A good example for this is the concept of the “Smart City”, which includes two assets – the social and the environmental capital. The smart cities concept is based on regional competitiveness, transport and ICT economics, natural resources, human and social capital, quality of life, and participation of citizens in the governance of cities.

- The working environment of engineers is becoming more and more internationalized due to the globalization of the world economy. Products are fabricated by worldwide cooperation and manufacturing resources are linked by international supply chains. Nowadays, engineers have to know how to work in multi-cultural environments with people from different countries.

On the other hand a mayor shift happens in educational processes in general. Some of these tendencies for the future of learning are:

- The future of learning will require the conceptualization and implementation of a new learning model. We need to be focusing more 21st century competencies and expertise such as critical thinking, complex problem solving, interactive collaboration, etc.

- The future of learning will be a balanced approach between E-Learning and Face-to-Face Learning; between Formal and Informal Learning. A modern approach of teaching and learning is a blended one. This is my deep belief. We have to better exploit synergies from traditional and non-traditional education.

- The future of learning will revolve more around context than content. Our age is the Information Age. We live in the Knowledge Society where data, information, knowledge are easy to access 24/7. We need a radical change from teaching facts and knowledge to convey skills and creativity (to find necessary data, facts, and knowledge) in a global context. Therefore, learning is presently undergoing great transitions.

- The Future of Learning will be a global one, characterized by open content, open knowledge, open technology for all. Global education is the next distance-learning leap. Especially from this the necessity of a new business model in education arises.

- The future of learning is characterized by serious changes in the social position of learning. According to some estimates, more than 80% of all learning occurs on the job rather than in tertiary and post-tertiary education. Learning in the future has to be an integrated part of the job! People of all ages have to renew their knowledge in decreasing cycles. This is what we understand as "Life Long Learning".

New Questions of Today’s and Future Engineering Education

All these realities require a concerted effort to evolve engineering education into what today’s reality is demanding of practicing engineers. In other words, many traditional educational

models and practices are no longer functional. For this reason, the importance of pedagogy is growing at an enormous pace. The need to innovate and apply new paradigms to the teaching-learning process is an absolute necessity.

Some of these important questions to consider include:

- What learning approaches have to be used to effectively response to these changes?
- What are the pedagogies that provide the most effective learning experiences for engineering students of the 21st Century?
- What learning skills in engineering education need to be developed and how can engineering teachers succeed in guiding their students to achieve them?
- What pedagogical approaches have been found to support the different phases of the present life-long learning continuum, or is more research necessary?
- What are the approaches that enable competence in leadership skills in a multi-cultural working environment, and what is the best way for these competencies to be delivered?
- Ambient technology is becoming a reality. What does ambient learning in Engineering Education look like? How can it be designed, delivered and assessed?
- How can engineering education support individualized and personalized learning to compensate for individual differences (learning styles, learning strategies, learning preferences, field dependency, etc.)

These are some of the reasons why the relevance and importance of engineering pedagogy is growing so enormously.

IGIP's International Engineering Educator Title

This paper, up to now, has attempted to show that dramatic changes are necessary in engineering education and that these changes strongly demand a new look at the didactic and pedagogic concepts that presently form the basis of engineering education. IGIP offers a space for professionals to look into, debate, and put into practice different concepts related to engineering education.

IGIP has established a prototype curriculum for engineering pedagogy which is already used in several countries. In contrast to ABET, FEANI, or EUR-ACE, IGIP is not an accreditation body for engineering curricula. By passing the curriculum as proposed by IGIP in any accredited or other institution worldwide, IGIP states that a given engineering educator with an "International Engineering Educator" title has all the competencies needed to teach to the highest standards with the best available teaching technologies. Interested engineers can continue their education in accordance with the IGIP Curriculum and obtain a diploma that will provide the knowledge and skills necessary for engineers to become better teachers. IGIP, worldwide, already has 46 approved educational centers and more than 1200 approved

“International Engineering Educators” (Ing.Paed.IGIP).

The IGIP model’s point of departure is that individual engineering lecturers initiate and are responsible for teaching and learning concepts that train engineers and technicians. The quality and success of engineering studies are decisively influenced by teacher competencies in the area of pedagogy as pedagogical skills represent a network of knowledge and skills that transmit knowledge and experience, much like Web 3.0. For this reason, technology and educational practice must go hand in hand when we are dealing with the education of engineers.
Engineering educators expand their typical engineering subject competence by acquiring teaching and learning skills in theoretical and practical coursework corresponding to the objectives of the Ing.Paed.IGIP model. Students taking engineering education training should acquire the necessary professional skills which technical teachers must have to be able to exercise their profession effectively and creatively.

The proven IGIP engineering education prototype curriculum is based on the knowledge of traditional pedagogy in philosophy and the liberal arts, but with respect to the particular character of the technician and the analytical-methodological approach in the fields of engineering science.
After many years of experience in industry or research, engineers who are appointed as teachers at a technical school or university are influenced by their professional careers. Their way of thinking is determined by the precision of the technology they work with, by their work with quantifiable and measurable events and objects. The influence of their discipline and the "language" of engineers must be taken into account in engineering pedagogy education, and they must penetrate the engineering education curriculum.

The Ing.Paed.IGIP is a registered program which certifies a certain educational level for teachers, trainers or instructors. Any engineering educator who passes the curriculum at any IGIP accredited training Centre for International Engineering Education, or whose education, training, and professional experience (documented by certificates) meet IGIP standards, may apply to be registered as an "International Engineering Educator - Ing.Paed.IGIP ".

The qualification profile of a specialized engineering pedagogue is based on two pillars:

- Engineering qualifications which were earned through a recognized and/or accredited engineering study program plus relevant professional experience
- Educational qualifications in engineering pedagogy acquired in the course of a comprehensive educational program

The engineering pedagogy program is generally an independent course of studies taken after an engineering program. However, it can also form an integral part of engineering degree programs. Already existing educational programs for engineering pedagogues can be accredited by the IGIP. Importantly, to be accredited, they must meet the accreditation criteria defined by IGIP.
The goal of IGIP accreditation is to insure that graduates of the accredited engineering pedagogical programs are well prepared to perform their teaching duties in engineering subjects and meet the criteria required to become International Engineering Educators. Another goal is to promote quality assurance, quality improvement, and modernization of

engineering pedagogy programs and to create public awareness of the high quality of the IGIP program for engineering pedagogues. Accreditation is a voluntary process which educational institutions must apply for through the responsible IGIP national monitoring committees.
The accreditation criteria defined by IGIP for a program for engineering educators are:

- Organization of the program
- Entrance requirements for the first year students
- Skills/abilities of the graduates
- Engineering pedagogical curriculum
- Lecturers and professors
- Institutional resources
- Quality control and feedback

An "ideal" teacher with a technical background should acquire the necessary professional competences of an engineering educator. These general professional competences consist of two main groups:

- Technical expertise
- Specific engineering pedagogical competencies.

Educational theory offers different lists of competences[7]. The IGIP concept of engineering educational competences is to be summarized as follows:

- Pedagogical, psychological and ethical competences
- Didactical skills and evaluative competences
- Organisational (managerial) competencies
- Oral and written communication skills and social competences
- Reflective and developmental competences

Other categorizations might operate with the terms "technical expertise", "pedagogical competences", and "human competences". Some authors substitute the term "competences" by "virtues" (Helus, Z.[8]).

The IGIP Recommendations for Engineering Pedagogy Studies (in short IGIP Curriculum) are described in detail in [10].
Interested institutions and engineers, teachers, and students are welcome to contact one of the 23 IGIP National Monitoring Committees or the IGIP headquarters in Austria.

Conclusions

Technical university teaching has often been perceived as a poor cousin to research. Few technical universities require any specific technical teacher education for their academic staff. Interestingly, this is the only level of learning where academic staff receives no teacher training. Yet teaching is an art that, at least to some degree, can be taught, if the institutions of higher learning support it as an important element. The International Society for Engineering Education (IGIP) is working to assure that graduates of accredited engineering pedagogical

programs are well prepared to perform their teaching duties in engineering subjects and meet the criteria for IGIP registration as International Engineering Educators, Ing.Paed.IGIP. IGIP's ultimate goal, however, is to promote quality assurance, quality improvement and modernize engineering pedagogy programs and educational practices. Its intention is also to create public awareness of the high quality of engineering pedagogue programs.

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