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# The International Society for Engineering Pedagogy (IGIP) and the New Pedagogic Challenges in Engineering Education

**Abstract.** *The article outlines the new tendencies and prospects in engineering education and engineering pedagogy. The new trends and questions result in a need to evolve new educational practices, especially in engineering pedagogy in order to provide the most effective learning experiences for engineering students of the 21st century. A new look at the didactic and pedagogic concepts that presently form the basis of engineering education is required. IGIP has proposed a Prototype Curriculum for engineering pedagogy and has developed the accreditation criteria for engineering pedagogy programs*

**Keywords:** *engineering education, engineering pedagogy, International Society for Engineering Education IGIP, IGIP engineering pedagogy programs, IGIP Prototype Curriculum, IGIP accreditation criteria, International Engineering Educator – ING.PAED.IGIP*

IGIP – the International Society for Engineering Pedagogy – has almost a 42-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 one thousand individual, affiliate and institutional members. More than 1.300 professionals all over the globe at this moment bear the title of "International Engineering Educator – ING.PAED.IGIP".

IGIP works in good partnership with other international associations and has cooperation agreements signed for example with:

- American Society for Engineering Education (ASEE),
- IEEE Education Society,
- European Society for Engineering Education (SEFI),
- Indo US Collaboration for Engineering Education (IUCEE),
- Latin American and Caribbean Consortium of Engineering Institutions (LACCEI),
- International Association of Online Engineering (IAOE),

to name just a few.

IGIP is a long-standing member of the International Federation of Engineering Education Societies (IFEES) and plays there an important role especially regarding issues of the pedagogic qualification of engineers.

The aims of the International Society for Engineering Pedagogy (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 integrate 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.

## Present Trends in Education

Education and pedagogy are thousands of years old. In fact, education is as old as the human race itself, as our species is characterized by its ability to learn, and learning is a key in our evolutionary process.

However, it is important to consider that humankind has never faced such a rapidly changing and dynamic global environment, which requires so much of engineers as we are witnessing today.

And as our environment changes, it is imperative we better learn to adapt our:

- Educational Systems,
- our Pedagogy (or Pedagogies?) and
- all our methods and processes in teaching.

Never before have the challenges in education been as challenging as today. Never before engineers have so much been demanded.

Peter F. Drucker, the well-known Professor of Politics and Philosophy and author of the book "Management Challenges for the 21st Century" [1] has identified the most important 21st Century Challenge: "The most important contribution management needs to make in the 21st Century is similarly to increase the productivity of KNOWLEDGE WORK and of the KNOWLEDGE WORKER."

If we replace «KNOWLEDGE WORK» and «KNOWLEDGE WORKER» by EDUCATION and EDUCATOR (or teacher), we have a more exact dimension of the challenges we face, especially in engineering education.

Why do we have to increase the productivity (or efficiency) of our work as teachers?

Let us have a look at the new aspects in engineering today. The work of IFEES, ASEE, IEEE, IGIP, and many other associations focuses on improving the quality of engineering education. But what exactly is engineering?

We can find a lot of different definitions of engineering. Two of them are:

***Engineering*** represents creative thought and skilled actions associated with the use or adaption of natural materials and natural phenomena in the conceptualization, planning, designing, and disposing of devices [2].

***Engineering*** is the application of scientific, economic, social, and practical knowledge in order to design, build, maintain, and improve structures, machines, devices, systems, materials and processes [3].

A short definition of engineering might be: **exploiting basic principles of science to develop useful tools and objects for society**.

This means that engineering is the link between science and society, which can include almost anything that people come into contact or experience in real life. The concept of engineering has 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 history of engineering shows different periods and evolutionary as well as revolutionary developments.

For a long time science and the daily life of the people happened more or less in parallel. Today we have a close interweaving. By its very nature engineering is bound up with society and human behavior. More or less, every process, product or construction used by modern society will have been influenced by engineers.

## New aspects of today's and future engineering education

**Firstly**, we can observe an enormous (and accelerated) growth of the area of engineering. Besides the traditional fields of civil engineering, construction engineering, electrical engineering, etc. new engineering disciplines occur, such as:

- Bioengineering,
- Software engineering,
- Information engineering,
- Data engineering,
- Medical engineering,

- Neuro engineering,
- Gene engineering,

…

- Social Requirement engineering,
- Systems engineering as an integrating discipline.

And new tasks requiring new competencies within traditional engineering disciplines have grown in number and complexity:

Online engineering;
Remote engineering;
Virtual engineering;
Reverse engineering;
Sustainable engineering.

Now the field of engineering covers near all areas of society.

**Secondly**, we can observe a terrific acceleration of the life cycles of technical (or engineering) products.

How many years does it take to reach a market audience of 50 Million?

- Radio – 38 years,
- TV – 13 years,
- Internet – 4 years,
- iPod – 3 years,
- Facebook – 2 years,
- Tablet PC – 1 year.

The exponential time we also see in the increase of parameters of selected electronic devices in the last 40 years:

- Hard Disk capacity – by $10^6$,
- Computation speed – by $10^6$,
- Memory capacity – by $10^4$,
- Connection speed – by $10^5$,
- Cost reduction – by $10^4$.

The field of engineering has never seen such growth and suffered such reduced times to bring innovations from concept to market. Competition in the field of technology is now measured in months and weeks.

**Thirdly**: The focus of the engineering disciplines is shifting from pure technical subjects to subjects directed to Information Technologies and the daily life of mankind.

**Fourthly**: There are serious changes in the social position of learning.

According to some estimates, more than 80% of all learning occurs on or during 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».

Engineering students have to learn to work in teams. Engineers tend to spend the majority of their working week (around 60%) engaged in activities, which involve interaction with others (meetings, supervision, writing reports etc), and only around 40% is devoted to technical engineering activity.

This shows also the NACE's Job Outlook 2012 survey [4]. Survey participants rated "ability to work in a team structure" and "ability to verbally communicate with persons inside and outside the organization" as the two most important candidate qualities, followed by candidates' "ability to make decisions and solve problems," "ability to obtain and process information," and "ability to plan, organize, and prioritize work."

**Fifthly**: There are also new organizational aspects in engineering education.

On the one hand, engineering issues, either in industrial products or in engineering projects, are quickly becoming increasingly complicated and most of these issues cross disciplinary lines.

On the other hand, the working environment 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.

This means the next generation of engineers will need to possess the ability to work seamlessly across cultures, have outstanding communication skills and be familiar with the principles of project management, logistics, and systems integration.

**Sixthly**: The size of the systems designed and developed by engineers grows continually. A good example for this is the concept of the "Smart City", which includes additional to the technical solutions also the social and the environmental aspects.

And the vision is the Global Village including the Internet of things!

**Seventhly**: To face current real-world challenges, higher engineering education has to find innovative ways to quickly respond to the new needs of engineering education, and that at low costs.

This means it is necessary to improve the agility of engineering education in the future. One of the approaches in this direction is the creation of virtual educational units, which can be flexible adapted to new requirements in engineering education.

Another conclusion is that engineering education has more to focus on basic knowledge and skills and in this way to prepare for a life-long-learning.

In this context, also public-private partnerships in education play an increasing role.

**And finally**: All these trends result in new questions and the resulting need to evolve educational practices, especially in *Engineering Pedagogy*. Some of these important questions to consider include:

- What learning approaches have to be used to effectively response to these changes in engineering and society?
- 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 there more research necessary?
- What are the approaches that enable competence in leadership skills in a multicultural 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?

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

We demand that plumbers and kindergarten teachers are certified to do what they do, but there is no requirement that university or college professors know how to teach.

Logically the European Commission stated in its Report on improving the quality of teaching and learning in Europe's higher education institutions (JUNE 2013):

"There is no law of human nature that decrees that a good researcher is automatically a good teacher, or that a first class honours student in biochemistry with a brilliant PhD will automatically be a good teacher of biochemistry."

In most EU Member States, an academic career is still more strongly linked to research than to teaching in terms of initial selection at job interview and subsequent promotion and performance related reward. A change of mindset in many countries and their higher education institutions with regard to the prioritization of academic teaching and learning in comparison to research is urgently needed.

And the European Commission's recommendation is:

"All staff teaching in higher education institutions in 2020 should have received certified pedagogical training. Continuous professional education as teachers should become a requirement for teachers in the higher education sector."

## IGIP's International Engineering Educator Title

Up to now, I have attempted to show that dramatic changes that 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 and pedagogy [6–8].

IGIP has established a Prototype Curriculum for engineering pedagogy which is already used in several countries. In contrast to ABET, FEANI, or others, 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 –ING.PAED.IGIP" 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 Prototype 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 1300 approved "International Engineering Educators" (ING.PAED.IGIP).

The IGIP model's point of departure is that the individual engineering lecturers initiate and are responsible for the teaching and learning concepts for the training of engineers and technicians. The quality and success of the engineering studies are decisively influenced by the teachers' personalities and how they are trained.

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.

The proven IGIP Prototype Curriculum is based on the knowledge of traditional pedagogy in philosophy and the liberal arts but respects the particular character of the technician and the analytical-methodological approach in the fields of engineering science [5].

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 purposes of IGIP accreditation are:

- To assure that graduates of the accredited engineering pedagogical programs are well prepared to perform their teaching duties in engineering subjects and meet the criteria for IGIP registration as an International Engineering Educator, ING.PAED.IGIP.
- To promote the quality assurance, quality improvement and modernization of the engineering pedagogy programs.
- To create public awareness of the high quality of the programs for engineering pedagogues.

The accreditation is a voluntary process, which educational institutions must apply to the IGIP.

The heart of the qualification process is an educational program with a clearly defined curriculum designed according to the IGIP Prototype Curriculum.

The curriculum defines the teaching process (the coordinated sequence of lectures and seminars), the testing process (the evaluation of the students' achievements) and the process of practice transfer (the practical

implementation of those competencies and the development of skills).

The Accreditation Criteria for IGIP Training Centers 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.

Interested institutions and engineers, teachers, and students are welcome to contact one of the IGIP National Monitoring Committees or the IGIP headquarters in Austria.

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**АУЭР М.А. МЕЖДУНАРОДНОЕ ОБЩЕСТВО ПО ИНЖЕНЕРНОЙ ПЕДАГОГИКЕ (IGIP) И НОВЫЕ ВЫЗОВЫ В ИНЖЕНЕРНОМ ОБРАЗОВАНИИ**

*В статье Президента IGIP рассматриваются актуальные вопросы развития инженерного образования и задачи инженерной педагогики на современном этапе. Представлена деятельность Международного общества по инженерной педагогике (IGIP), разработавшего базовый стандарт для международной сертификации преподавателей инженерных вузов и Регистр ING-PAED IGIP, содержащий квалификационные требования к преподавателям технических дисциплин.*

Ключевые слова: *инженерное образование, инженерная педагогика, подготовка научно-педагогических кадров, Международное общество по инженерной педагогике, профессионально-педагогические компетенции преподавателя, программы подготовки преподавателя инженерных дисциплин, критерии IGIP по аккредитации инженерных программ, Регистр ING-PAED IGIP, национальные мониторинговые комитеты, центры инженерной педагогики*

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