IGIP Philosophy - Effective Basis for Contemporary STEM Teaching and Learning

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The quality of STEM (Science, Technology, Engineering, and Mathematics) crucially depends on the quality of teaching of these subjects. If we want to improve the quality of engineering and STEM teaching we should improve the quality of teacher education in these fields.
The Klagenfurt School of Engineering Pedagogy represents the basic scientific ideas of IGIP. Melezinek proposed the aims, methodology, object and the subject of Engineering Pedagogy Science as follows [1]:

- Aims – to implement integral interdisciplinary thinking for effective engineering teaching.
- Methodology – to search for new ideas and theories, contents and structures for effective engineering teaching.
- Object – to develop a pedagogical system of engineering education.
- Subject – to design and realize contents, organization forms, new methodologies, and the process of engineering educators' development.

According to the Klagenfurt School of Engineering Pedagogy teaching of engineering is a process which like any others, is a subject to specific regularities and determined by a series of components throughout its course. Taking account of the named components, a technical teacher can build up an effective model of engineering pedagogy for teaching engineering. Engineering Pedagogy teaching of engineering is influenced by a number of variables [1]:

- Instructional objectives (O) and relevant learning outcomes - teaching is a goal-directed process (designed according to Bloom's or Feisel-Schmitz Technical Taxonomy.
- Course content (C) – what should be taught to students - a lecturer has to select subject matter according to the aimed instructional objective and point out the main phenomena, laws and concepts and to structure the chosen subject matter, using the main principles of understandability. Course content should support and frame students' learning.
- Psycho-structure (P) – students' individual differences, learning theories (Constructive, Experiential, Cognitive, Perry's, Humanist , Frank and Riedel's Learning Theories), psychological conditions of effective learning etc. should be taken into account.
- Socio-structure (S) - characterizing socio-cultural environment of origin of the students, and socio-cultural environment where the process of instruction is carried out. Important factors are the age, gender, sphere of activities, etc. It is also advisable to know students' prerequisites.
- Teaching Aids, Technology & Learning Environments (T) - teaching assumes presenting of different information. All technical devices, equipment and systems, which facilitate the process of teaching are considered (Real labs with hands-on practical problems, Virtual and remote labs, Distant and e-labs, Homelab kits, Simulations and serious games, online platforms for e-learning, flipped classroom and blended learning, Contemporary IT resources, etc, etc, etc).

- Teaching Methodology (TM) - correctly chosen teaching methods facilitate the optimal way which helps students to reach aimed learning outcomes. Teaching process is based on communication processes. Oral and visual communications are also important. But of especial importance is easily understood (clear) communication. Contemporary effective teaching methods should be used (PBL, PjBL, TBL, active learning structures, interactive lectures, group work, etc). Effective assessment and feedback methodology for educative assessment should be chosen taking account of learning outcomes and relevant teaching methodology (group examination, self and peer assessment, tests, portfolio, etc.).Teaching could be changed significantly when the variables are altered. The teacher's main didactic task is to find an optimal teaching method (TM – how?) which can achieve a given instructional objective (O – why?) for a given subject matter (C – what?) with the available media (T – with what?) for the students (P – who?) under the influence of a certain socio-cultural environment (S – where?). The teaching method is thus a function of different influential factors and can be expressed mathematically as follows: TM = f (O, C, T, P, S)

This functional equation describes very complicated relations as all factors act together. Individual factors can act with or against others. The educational process as a whole, taking account of teaching and learning and the mutual interplay of all pedagogical variables, represents an extraordinary complex construction.
According to Melezinek, a lector should choose teaching methods accordingly to the general system of communication: formulate instructional objectives, choose appropriate subject matter, assess psycho-structure and socio-structure of students, choose adequate media and teaching methods (Figure 1).

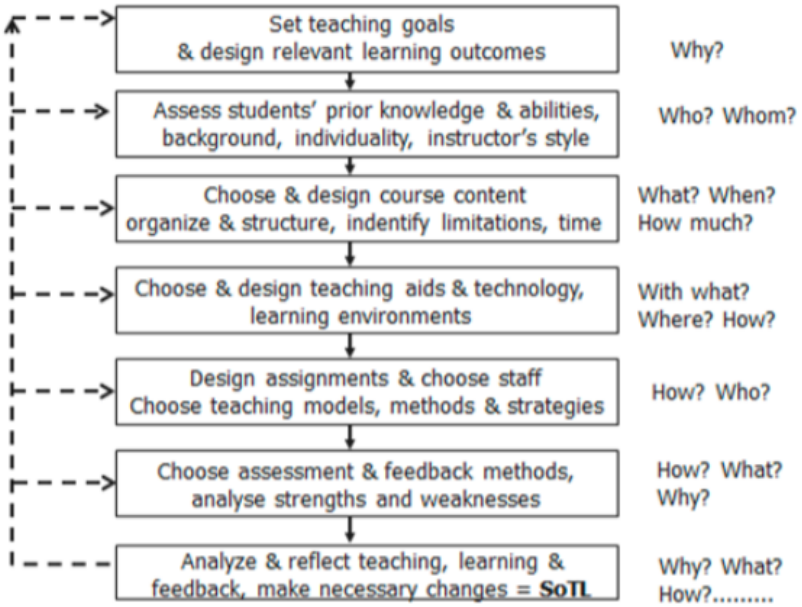

Figure 1. - Model of the Klagenfurt School of Engineering Pedagogy [1]

Analysis of teaching, learning and feedback for improvement of the quality of teaching and learning should be carried out regularly taking account of different possibilities to gear up during lifelong learning:

• Mentoring and coaching.
• Collegial Feedback.
• Teacher Portfolio

• Teaching Philosophy Statement.
• Self-analysis.
• Video-analysis of teaching.
• Peer-analysis.
• Student feedback analysis.

The Philosophy of Engineering Pedagogy has been determined by a range of questions about teaching:

• Why do we teach?
• What do we teach?
• Who do we teach?
• Who will teach?
• Where do we teach?
• How do we teach?
• With what technology do we teach?
• When do we teach?
• How much do we teach?
• How do our students learn?
• How to interact with students?
• How to manage the course?
• How to enhance learning?
• How to learn and develop as teachers?
• Etc, etc, etc.

In times of increasing European integration and academic mobility it has been necessary to formulate a common minimum standard or well-balanced competence profile for technical teachers. The International Society for Engineering Education has created a register of "International Engineering Educator ING-PAED IGIP". The engineering pedagogy program is generally an independent course of studies after an engineering program. But it can also be an integral part of an engineering degree program [3, 4].
At the major "Second European Conference on the Assessment and Accreditation of Engineering Training and Qualifications" in December 1994 in Paris, the register of ING-PAED IGIP was officially recognized as a basic qualifications profile for lecturers in technical subjects. On the suggestion of UNESCO Paris, the register was presented in May 1995 in Sao Paulo and Rio de Janeiro and met with and enthusiastic response [2].
The aim of the curriculum is to strengthen the quality of engineering education for the 21st century targeting on effective and contemporary teaching of engineering.
IGIP curriculum is built on the knowledge from traditional education 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. The engineering pedagogical competences acquired on the basis of IGIP curriculum are to be summarized as follows [3,4]:

- Pedagogical, social, psychological and ethical competences;
- Didactic skills and subject expertise;
- Evaluative competences;
- Organizational (Management-) competences;
- Communication and social competences;
- Self-reflexive and development competences.

- Entrepreneurial competences.

The education is completed by the final exam held by a commission of at least 3 members (having ING.PAED IGIP qualification). During the exam the candidates must show that they have acquired the skills of an engineering pedagogue. The final individual exam consists of the presentation and discussion of the candidate's portfolio and teaching philosophy statement, and an examination interview, in particular about the portfolio's components. In final Group Examination a final innovation project or problem according to students' choice should be solved designed and implemented.
IGIP defines minimum criteria which must be met for the accreditation of engineering pedagogy centers and programs for the following areas:

- Entrance qualifications for first-year students;
- Competencies/skills of the graduates;
- Engineering pedagogy curriculum;
- Lecturers and professors;
- Institutional resources;
- Quality control and feedback.

Technical teachers have to be able to do engineering and to teach engineering. We expect engineers to undergo rigorous training to become proficient. It is logical to require similar rigorous training in the art teaching of technical teachers. As Professor Adolf Melezinek said, "Professional-level engineering teaching is both an art and a science".

REFERENCES

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[3] IGIP Recommendations for Studies in Engineering Education Sciences, Decided by IGIP International Monitoring Committee on September 11th 2006, Approved by IGIP Executive Committee on September 11th 2006, 37 p., Available on www.igip.org
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