FACHBEREICHSTAG MECHATRONIK

Position Paper

on the Bachelor and Master Degree Programs
at German Universities of Applied Sciences in the Field of

Mechatronics

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1. Introduction

In Germany the recognized high quality standard of engineering education in the field of mechatronics is ensured by the different profiles which are constituted at universities and technical universities on the one side, and at universities of applied sciences on the other side.

The professional claim in engineering education in the field of mechatronics may be described in a comprehensive way by the definition of the field of Harashima, Tomizuka, and Fukuda (as published by the The Association of German Engineers as VDI Standard 2206):

"[Mechatronics is] ... the synergetic integration of mechanical engineering with electronics and intelligent computer control in the design and manufacturing of industrial products and processes." / VDI2206; HTF96/

The Bologna Conference resolutions of 1999 required introducing a two-tier system of graduation in the form of Bachelor and Master Degrees. Since the beginning of implementing these resolutions, the institutions of higher education have modernized the structures of their study programs, and have specified the thematic orientation of their mechatronics programs. The implementation of the Bologna Process did not only aim at ensuring a high level of professional quality, but also at providing the comparability of the students' academic performances in an international context. Moreover, it was seen as a tool for increasing the international mobility of students. Since then, almost all institutions of higher education have adopted the structure of a two-tier degree system for their mechatronics study programs. They have gained experience in the subject-specific and organizational implementation of the new structure.

This position paper aims at offering an orientation for the education in mechatronics in the Bachelor and Master Degree study programs at institutions of higher education. This will be carried out under full consideration of the described experience and the general framework for those institutions which has been altered with the introduction of the two-tier system of education.

The mentioned terms refer to the content of education, not courses. The individual institutions of higher education are intended to allocate the ECTS credit points within modules in an autonomous way. Creating modules (and naming them) resides with the responsible faculty of the study programs; this paper is in no way intended for narrowing the own profiling. The Master Degree programs especially profit from their individual qualities as they derive from the respective focus and research of the individual colleagues involved. They thus use the opportunity to shape an individual profile of their study programs. The creation of a multitude of different, independent Master Degree Programs in the field of mechatronics is intentional.

The aim of this position paper is presenting minimal requirements which are necessary to ensure high-quality study programs in the field of mechatronics. They may also serve as guidelines for the accreditation of study programs in the field of mechatronics. The combined percentage details in respect to the structure of the curricula do **not** sum up to 100%. This is based on the fact that room was intentionally left for an individual structure of the study programs according to the individual institution of higher education.

2. Structure of the Bachelor Degree Study Program

The following details are minimal requirements which may be exceeded at the individual institutions of higher education but not undercut. They refer to the workload of students.

2.1 Entry Requirements

- Diploma presenting the prospective student's qualifications for access to an institute of higher learning (the German Fachhochschulreife or Abitur)
- For study programs with limited admission, an admissions commission to be formed at the own institution for higher education will consider the prospective student's eligibility for the study program.
- A basic practical work experience of 12 weeks before entering the study program, or to be concluded until the end of the 3rd semester

2.2 Basic Structure

The recommended basic structure of the study program consists of 6 semesters of studying and 1 practical semester with a total amount of 210 ECTS credit points. There should be the option of completing the semesters of studying as well as the practical semester abroad.

2.3 Modules

1. Basics of Mathematics-Natural Sciences **≥ 20%**
   (mathematics, physics, computer science, chemistry, materials and/or comparable content)

2. Basics of Engineering **≥ 25%**
   Evenly distributed from the fields of electrical engineering/electronics, mechanics, and information technology
   (without any implied importance of the order: microcomputer technology, engineering mechanics, electronics, programming/software technology, construction/production, metrology, thermodynamics, basics electrical engineering, automation technology, fluid mechanics/hydraulics, electric drives and/or comparable content)

3. Specialization in Mechatronics **≥ 20%**
   (mechatronic systems, simulation technology, control engineering, mechatronic design, sensor technology, actuator technology, system theory, mechatronic materials, product/production process design, and/or comparable content)

4. Interdisciplinary Content **≥ 10%**
   Interdisciplinary content (such as economics, project management, team and personnel management, presentation technology, foreign languages, so-called soft skills, etc.) might be presented through independent courses or as integral parts of specialized courses.

5. Projects in Engineering **≥ 3%**
   These should be interdisciplinary and integrated into the study-program. They are thus intended for motivation to enter the discourse in the field as well as bettering societal competencies.

6. A Practical Segment, including, for instance **1 Semester**
    - A semester abroad
    - A vocational semester
    - Project studies/project phase
    - Bachelor thesis

3. Structure of the Master Degree Study Program

3.1 Entry Requirements

- Vocational qualification through an academic degree above average in engineering or the natural sciences
- It is recommended to form an admissions commission which will consider the prospective student's eligibility for the study program and also a possibly necessary stage of adaptation.

3.2 Basic Structure

The recommended basic structure of the study program consists of 3 semesters of studying with a total amount of 90 ECTS credit points.

3.3 Modules

1. Advanced scientific basics **≥ 15%**
   (e. g., mathematical methods, applied computer science, advanced mechanics/ electrodynamics/system theory, simulation theory, or comparable content)

2. Specialized and interdisciplinary content of education **≥ 25%**
   Advanced engineering and specialization or combination
    - The institution for higher education is responsible for shaping the profile
    - The level of the courses has to be noticeably above the basic study programs

3. Interdisciplinary Content **≥ 5%**
   (for instance, scholarly work, leadership quality, multi-lingual competency, or comparable content of education)

4. Scientific Projects **≥ 5%**
   These have to be integrated into the fields of education and research.

5. Master Thesis (including the scholarly graduation colloquium) **≥ 25%**

A study phase of adaptation in the first semester of the Master Degree study program may individually be arranged with the students. This may enhance the students' equal starting conditions for non-consecutive graduate students or for career changers. The differences among the students should however also be seen as an opportunity for mutual complementation and inspiration in the study programs.

4. Quality Requirements for the Bachelor and Master Study Programs in the Field of Mechatronics

Introducing the two-tier degree programs in engineering seeks to structure the Bachelor degree as the first professional qualification in such a way that the graduates' necessary professional qualifications meet their international and intercultural competencies on a high level. For the majority of graduates of the mechatronics study programs, the Bachelor degree will at the same time open direct access to the professional lives as engineers.

In order to enable graduates to pick up a career and work independently as engineers in the field of mechatronics it is essential to have skills, abilities, knowledge about methodology and insights into the backgrounds of tasks. All of this has to be based on a working knowledge of the fundamental principles of mathematics, natural sciences and technology. Such skills and knowledge have to be provided in a way that allows students not only to acquire the familiarity with engineering but also to be guided toward independent work, and employability in the field. Students need to become familiar with business and social aspects of being engineers at home or abroad. They thus have to broaden their international and intercultural competencies. Non-technical courses prepare future engineers for the complex professional requirements that reach beyond the technological essence of the field. Being methodologically savvy and skilled (e. g., by learning how to learn efficiently), as well as societal competencies, the so-called soft skills, are also needed with ever increasing importance.

The study programs in the field of mechatronics especially have to meet expectations of being interdisciplinary, international, and – first and foremost – practical. In order to achieve this, institutions of higher education have to develop their own pronounced features of quality. If possible, those quality features should be evaluated on a regular basis and developed further.

The foundation of high-quality and valuable education is working in research projects at the institutions of higher education. In respect to the Master degree study programs there are opportunities for shaping the individual quality features. Those study programs have to enable the graduates to work independently and with scientific methods. They also have to enable the students to contribute to technological advancement in a flexible and creative way, and through their own initiative and ability to identify new issues in the field of mechatronics.

Literature

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/HTF96/ Harashima, F.; Tomizuka, M.; Fukuda, T: Mechatronics – "What Is It, Why and How?" An Editorial, IEEE/ASME Transactions on Mechatronics 1 (1996) 1, pp. 1/4