Master Research Program
Electrical Engineering and Information Technology

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Index Terms: Master Program, Research Projects, Electrical Engineering, Information Technology.

Abstract

Research is more and more important for industry, society and universities. Therefore a Master Research Program was designed primarily as a training course in advanced work in the field of research and development. It is a joint program of three faculties, the Faculty of Electrical Engineering (Würzburg-Schweinfurt University of Applied Sciences), the Faculty of Engineering Sciences (Aschaffenburg University of Applied Sciences) and the Faculty of Electrical Engineering/Informatics (Coburg University of Applied Sciences). The students can achieve a Master of Engineering (M.Eng.) degree within three academic sessions (semesters).

The program does not consist of typical course work only: The candidates thoroughly have to take part in the research activities at their faculty in the field of electrical engineering, information technology or a closely related field. They have to work continuously on a sophisticated R&D-project for 1.5 years (48 credit points), report in seminars (6 cp) and summarize their work in a final Master thesis (16 cp). Additional courses (20 cp) have to be related to the field of research. The project work is done in three parts: During the first academic session a project team is formed, the scientific background and the state of the art are evaluated, project work is planned and first steps are undertaken. During the second academic session, most of the work is done, experience is achieved, progress is evaluated and important milestones are reached. During the third academic session the final results are achieved, evaluated and documented. In the final master thesis the complete project work and the originality of the work is described and continuative questions are identified.

Projects always have a close relation to R&D projects in industry. The candidate learns the fundamentals of research and project management and acquires certain new techniques. She / he must undertake an original investigation but this would be more limited in scope and degree of originality than a doctorate. The supervising professor is a leading expert with research background in her / his field and she / he has the responsibility to act as a personal coach for the candidate. Therefore project work is performed in the laboratories of the faculties. The students acquire sophisticated technological, methodological and personal abilities, mainly by training on the job. The three faculties acquire a significant improvement of research activities, research quality and industrial cooperation. The joint program of three faculties allows to provide a broad selection of interesting project themes covering the whole spectrum of electrical engineering and information technology.

I. INTRODUCTION

A. Background

German Universities of Applied Sciences (Hochschulen für angewandte Wissenschaften / Fachhochschulen / FH) are the innovative answer to the requirements of highly developed industry and society. They educate approx. 2/3 of all engineers in the field of electrical engineering and information technology. Their special profile consists of a sophisticated theoretical education, a full academic session (semester) to be spent in industry and a thesis, normally performed in close cooperation with industry. Thereby graduates are very well prepared for a professional career in industry, their unemployment rate is the lowest among all professional categories.

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Originally, the Universities of Applied Sciences were restricted to four-year academic programs and their activities were limited to teaching mainly. This was not enough to keep up with the requirements of fast changing technologies, economics and societies. Therefore important improvements have been achieved during the last two decades: Research activities grew up successfully, both in quantity and quality. Additionally to the degrees of a first academic level (Bachelor of Science, Diplom-Ingenieur (FH)) programs of a second academic level (Master of Science, Master of Engineering) can be offered. There are important advantages for our students, for the employers and for our academic institutions:

1. After the first degree, graduates have the choice either to start a career in industry or to develop their scientific, technological and personal skills in a Master program, according to their individual abilities and interests.
2. Employers can find engineers, educated on different levels according to different professional tasks.
3. Education on the Master’s level combined with research projects keeps the knowledge and the abilities of professors and staff members up to date, much better than it was possible before.

In addition to these advantages a serious danger should be mentioned: Master programs will only be offered for a minority of students. Education of the majority will be reduced from today’s minimum level of eight semesters (Diplom-Ingenieur) to six or seven semesters (Bachelor) with negative impacts on students’ workload, student mobility, thesis quality, overall qualification and scientific position of the universities. Therefore it will be most important for all academic institutions to develop their profile by means of Master programs.

**B. Basic Idea of the Master Research Program**

According to this background, a Master Research Program was developed. Fig. 1 shows the basic vision: Faculties in the fields of electrical engineering and information technology with successful research and development activities intend to involve their postgraduate students in R&D project teams, much more than it is usually done within a conventional curriculum [1] [2]. With the help of individual project experience, coaching and academic reflexion, the students shall acquire sophisticated skills, i.e. methodic, personal and problem-solving competences. Within the projects students automatically deal with the newest technologies. The students shall be qualified both for high level project work in industry and for further scientific studies, e.g. in PhD programs.

![Diagram](image)

**Fig. 1.** Improvement of education quality and synergetic intensification of research activities by integration of postgraduate students into R&D project teams.

Additionally it is expected that the quality of R&D projects in the faculties will improve tremendously, with very positive impacts on technological and educational competences. The whole process will be intensified synergetically within a closed loop. All research teams, institutes, laboratories and professors performing active research can be integrated. No one will be excluded because of his specific scientific profile. Thereby all of the scientific strengths of the faculties will be strengthened continuously during a sustainable development.
II. History

The Master Research Program was designed at the University of Applied Sciences Würzburg-Schweinfurt (Fachhochschule Würzburg-Schweinfurt) in the Faculty of Electrical Engineering in Schweinfurt in 2003. The first students started their studies in March 2004. It turned out that one faculty alone could not cover the whole field of electrical engineering and information technology with sophisticated research activities and with related project themes. Therefore it was decided to extend the program to the faculties of our neighbor universities in Aschaffenburg (since March 2006) and Coburg (since October 2007), see Fig. 2:

(1) Faculty of Electrical Engineering, University of Applied Sciences Würzburg-Schweinfurt, Schweinfurt.
(2) Faculty of Engineering Sciences, University of Applied Sciences Aschaffenburg.
(3) Faculty of Electrical Engineering / Informatics, University of Applied Sciences Coburg.

![North-western area of Bavaria with the only postgraduate Master Research Program in Electrical Engineering and Information Technology in Schweinfurt, Aschaffenburg and Coburg.](image)

Now the three faculties offer a joint Master Research Program with research projects covering the complete field of electrical engineering and information technology. Each of the three faculties has its own specific profile in science and technology and contributes to the program just with its specific strengths. The program is the first and – as far as the author knows – the only Master Research Program of this type in Germany.

Furthermore the program is the only postgraduate program for electrical engineering and information technology in the vast area of north-western Bavaria/ Frankonia. This region is located directly in the south of the central German low mountain range, it is the economically important link between the metropolitan areas of Frankfurt and Nürnberg.

Four years of experience in Schweinfurt and two years in Aschaffenburg clearly show, that the aims, which are visualized in Fig. 1, are fully achieved. Recently the three faculties applied for the accreditation of the Master Research Program, the result is expected for autumn 2008.
III. DESCRIPTION AND PROGRAM DETAILS

A. Program Requirements

The Master Research Program provides opportunities for qualified graduate students to undertake courses of advanced study. The degree requires the submission of a thesis embodying the results of an original investigation or design. Satisfactory performance in course work subjects is also required. Whether a candidate qualifies or not for the degree will be based on examinations of the course work, of the project work and of the thesis.

The program is designed primarily as a training course in advanced work in the field of research and development project work. The candidate learns the fundamentals of research and project management and acquires certain new techniques. The work is performed in the laboratories of the faculties according to no. II. which belong to the research faculties in German Universities of Applied Sciences. Projects always have a close relation to R&D projects in industry.

The candidate must undertake an original investigation but this would be more limited in scope and degree of originality than a doctorate. Although originality is to be encouraged as much as possible, careful supervision is necessary at all times: the work is closely supervised in the early stages and whenever a new technique is being used. The supervising professor is a leading expert with research background in her / his field and she / he has the responsibility to act as a personal coach for the candidate. Therefore project work is performed in the laboratories of the faculties.

The candidate has consecutive project experience of three full-time academic sessions (1.5 years) combined with deep technical knowledge and with personal competences in the field of team work, project management, communication, languages and problem solving. All of the competences are far beyond the level of a Bachelor degree.

B. Program Details

The Master Research Program does not consist of typical classroom lessons only. Fig. 3 shows the curriculum of the program:

1) Project Work and Thesis

The candidates thoroughly have to take part in the research activities of the faculties. Students mainly have to work on a sophisticated R&D-project for 1.5 years (48 CP), report in seminars (6 CP) and summarize their work in a final Master thesis (16 CP). This work is done in three parts: During the first academic session the project work is started, i.e. the project team is formed, the scientific background and the state of the art is evaluated, project work is planned and first steps are undertaken. During the second academic session, most of the project work is done, significant experience is achieved, progress of the project is evaluated and the most important milestones of the project are reached. During the third academic session the final results are achieved, evaluated and documented. In the final master thesis the complete project work and the originality of the investigation or the design is described and continuative scientific or technical questions are identified. Project work, thesis and presentations are done in German or English language.

2) Seminars

Within the seminars students regularly have to report about progress, difficulties and further steps of their work. At least one of the seminar presentations has to be given in English. Additionally students have to organize a poster session. Regardless of their individual semester, all students are together in the same seminar class. Thereby experiences, questions and problems are discussed among different levels of qualification. Furthermore the students can monitor the progress of other projects and the development of personal abilities of their fellow students. Last but not least it should be mentioned that the students from all three faculties are together in the seminar.

3) Course Work

Additionally the candidates have to choose technological and interdisciplinary courses at the University of Applied Sciences (10 CP) and sophisticated scientific courses in the field of engineering, information tech-
ology or science at an external university (10 CP). All courses have to be related to the project work, they are chosen together with the candidate’s R&D-supervisor and with the board of examiners. In the case of scientific courses there is a close cooperation with universities in the neighborhood, e.g. with the Faculty of Physics at the University of Würzburg.

Fig. 3. Curriculum of the Master Research Program in Electrical Engineering and Information Technology; joint program in Schweinfurt, Aschaffenburg and Coburg.

IV. ORGANISATION AND ADMINISTRATION

A. The board of examiners

The Master Research Program is supervised by the board of examiners, Fig. 4. The members are elected by the three faculty boards. Since October 2007 each of the three faculties is represented by two professors, one member is professor at the Faculty of Physics at the University of Würzburg.

The board of examiners is the only common institution of the three faculties. It plays an important role for the administration of the joint program therefore: Projects are approved, students are selected, course tables, test results and expertises are approved. Fig. 4 is a flow chart explaining the different steps in the program. They are discussed in the following chapters.

B. Definition of Project Themes

The professors of the three faculties propose projects and give an agreement to supervise their project. Project proposals must contain a theme, a short description of the problem, of the aim of the project, of the intended work to be done and of the scientific quality of the proposal.

The board of examiners has to discuss the proposal and to decide whether the proposal is accepted as a new project or rejected. In the case of approval examiners are appointed.

Approved projects will be put into the project pool, from which students can select their project themes.

C. Application Procedure and Admission

During the application procedure students are selected who fulfill the following access requirements:

(1) First degree (Bachelor degree or equivalent degree with 210 CP) in Electrical Engineering, in Information Technology or in a closely related field with a good grading (Local numerical value 2.5 or better).

(2) The applicant needs to have a high grade of personal abilities and has to look for a project work and a project supervisor on his/her own initiative. She/he has to apply for one of the available research projects, an interview with the supervisor is required.

(3) Aptitude test in order to proof qualification for the chosen research project.
The following steps are recommended:

1st step: The applicant should gather information about the research fields of the professors in the faculties.

2nd step: The applicant should contact the professor(s) in his/her field(s) of interest, introduce him/herself and ask whether the professor is currently able to define, offer and supervise an R&D project. It should be noted that due to numerous obligations, professors have a limited capacity for supervising additional projects.

3rd step: If a professor is interested in supervising a project, the applicant will be asked to meet with the professor (project supervisor) to discuss the technological background, the prerequisites, the aims and qualification requirements of the project. After this consultation an application must be submitted for the project as discussed in the meeting. The project has to be approved by the Examination Board before.

4th step: It is obligatory for the applicant to take part in an oral examination (aptitude test) to proof sufficient levels of academic / scientific knowledge and personal abilities regarding the intended project. The professor (project supervisor) will be one of two examiners. Certified copies are required of the first degree diploma and transcript listing all credit points and grades as well as an official certification of equivalence to German degrees from universities (including total credit points and grading). If access requirements are not complete, the case will be discussed in the board of examiners. In some cases, e.g. if the number of credit points is insufficient, admission is possible, if additional obligations are taken over.

5th step: If the oral examination is successful, the applicant can complete the standard admission procedure (inscription) at the universities’ offices, depending on where the supervising professor is located.

D. Definition of Curriculum

The student has to complete his individual table of courses together with his supervisor. The table has to be approved by the board of examiners. Courses shall be related to the project work, they can be chosen from very many courses at the three Universities of Applied Sciences and at several other universities. Thereby the students do not only improve their knowledge, they also learn to move in different academic cultures. Furthermore they can come into contact with other scientific communities which might offer PhD programs.
E. Project Work and Master Thesis

Primarily the Master Research Program is a training course in advanced work, especially in the field of research, development and project management. Thereby the candidates learn the fundamentals of research and project management, get a deep scientific insight in a selected field of electrical engineering and information technology, acquire certain new techniques and improve personal abilities by training on the job.

Although originality and responsibility is to be encouraged as much as possible, careful supervision is necessary at all times: The work is closely supervised in the early stages and whenever a new technique is being used. The supervising professor is a leading expert with research background in his field and she/he has the responsibility to act as a personal coach for the candidate. Therefore project work is performed in the laboratories of the faculties. Nevertheless projects always have a close relation to industry and students take part in greater R&D activities among their universities and external partners.

The project work consists of three parts of half a year. At the end of each phase the candidate is examined in an oral examination. Finally the candidate has to prepare a Master thesis which contains a review of the whole project. The candidate must describe an original investigation and has to point out the originality of his work, but this would be more limited in scope and degree of originality than a doctorate.

V. Quality Control

The Master Research Program is a joint program of three Universities of Applied Sciences. Therefore quality control can not only be performed locally. I.e. quality control is an important task of the board of examiners which is the only common institution.

Fig. 4 shows that the board is responsible for the approval of projects, for the selection and admission of students, for the approval of the individual course tables, for the supervision of project work (by means of seminars and examinations) and for the approval of reviews of Master theses. Additionally the evaluation processes of seminars and project works are supervised. I.e. quality control is very strict: Every project is discussed and approved in the board. Every student is discussed several times by the board (admission of students, approval of course tables, decisions about individual questions, recognition of examination results and approval of theses reviews).

The board of examiners consists of two elected members from each of the three faculties. These two members are responsible for the Master Research Program within their home faculty. Thereby it is guaranteed that all faculties are equally involved, and that the same standards and guidelines are used in the three faculties.

A seventh member of the board of examiners has to be professor at an external university. He/she is proposed by the board of examiners and confirmed by the three faculty boards. Thereby external expertise from a different scientific and academic culture is involved and the quality control process is improved significantly.

The influence of the individual members is strengthened by veto laws in some cases. I.e. it is guaranteed that minority opinions have an acceptable position against majorities. E.g. a Master thesis has to be reviewed by two reviewers and the reviews have to be presented and discussed in the examination board. Then every individual member has the right to demand for a third review, if he/she has any doubt about the presented expertises.

VI. Experiences

Four years of experience in Schweinfurt and two years in Aschaffenburg clearly show that the aims, which are visualized in Fig. 1, are fully achieved. The candidate acquired consecutive project experience of three full-time academic sessions (1.5 years) combined with deep technical knowledge and with personal competences in the field of team work, project management, communication, languages and problem solving. All of the competences are far beyond the level of a Bachelor degree.

Up to now more than 80 project themes and more than 60 students were carefully selected and approved, approx. 30 students were successfully graduated, only 3 gave up. At the moment more than 20 students per year are approved for the program which is not designed for a high number of students.

Meanwhile at least three graduates are working on their PhD thesis, several others intend to follow. Interestingly the mentioned PhD students all are working in their former faculty at their University of Applied
Science within their former research area during the Master program. The PhD theses are already accepted for presentation at big universities with PhD courses.

This example perfectly shows the intensification of research activities and research quality in a “closed loop” as shown in Fig. 1.

VII. CONCLUSIONS

The Master Research Program was introduced in Schweinfurt in 2004. Many projects were successfully performed and the “Schweinfurt Model” was extended to Aschaffenburg in 2006 and to Coburg in 2007. All the aims were completely achieved. There are many advantages for graduates, for the universities and for the industry.

**Advantages for the students/graduates:** The candidates learn the fundamentals of research and project management, acquire certain new techniques and improve scientific knowledge in the fields of the research projects. The students acquire sophisticated technological, methodological and personal abilities, mainly by training on the job. They are directly coached by the supervising professor, who is a leading expert with research background in his field. The cooperation of three faculties allows to provide a broad selection of interesting project themes covering the whole spectrum of electrical engineering and information technology. Project work and research automatically guarantees that the contents of the program are up to date and at the front end of technological development.

Graduates are perfectly prepared for ambitious scientific or industrial careers.

**Advantages for the universities/faculties:** Due to the Master Research program the three faculties acquire a significant improvement of research activities, research quality and industrial cooperations. Already existing strengths are further strengthened, research profiles are sharpened and enlightened. All professors with research activities can contribute to the program, no one is excluded, the whole research potential of the faculties can completely be involved.

Personal resources of the faculties are not stressed very much: The time for the coaching of the students is directly proportional to the number of students. It is not necessary to offer special courses for a small number of students. Classroom courses are chosen by the students out of existing programs. Furthermore Master students are an important help for the progress of research projects. Therefore the Master Research Program provides a classical “win-win situation” both for the students and for the universities and faculties.

**Advantages for the Industry:** Graduates are very well educated, far beyond the level of a Bachelor degree. They acquire sophisticated project experiences and can directly be involved in industrial projects without long training and coaching phases.

There is another advantage especially for the industry between the metropolitan areas of Frankfurt and Nürnberg: The Master Research Program provides a new and urgently needed source for highly qualified engineers in the field of electrical engineering and information technology. Furthermore the industry will find three Universities of Applied Sciences which have significantly improved their abilities for research, project work and cooperation with industry.

REFERENCES

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