Attracting More Students and Educating Well-Trained Engineers: Sensible Ways to Advance the Field of Engineering Education
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Solid mathematical background is indispensable for engineers
Growing need for mathematical competence of engineers
Teaching of mathematics is the task of mathematics departments
Joint design of curriculum by mathematicians and engineers
Potential conflict: Reduce dropout rates vs. need for high level of mathematical competence
SZMA: Unit within the Faculty of Mathematics, responsible for the mathematics education of science and engineering students.

Tasks of the SZMA:
- Curriculum development in cooperation with individual departments
- Quality control to ensure high quality teaching
- Coordination of training and coaching of lecturers and tutors
- Mathematical consulting service for students and researchers
- Encouraging interdisciplinary research projects

SZMA’s courses are taken by more than 2500 students annually.
SZMA Structure

**Board of Directors**

**Engineering**
Prof. Christiane Helzel

**Sciences**
Prof. Gerhard Knieper

**Computer Science**
Prof. Eberhard Bertsch

**Didactics**
Prof. Bettina Rösken

**Consulting Service**
Prof. Holger Dette

**Software Development**
Prof. Gerhard Röhrle

**Advisory Board**

Representatives from
- Electrical Engineering
- Mechanical Engineering
- Civil Engineering
- Physics
- Chemistry
- Biology
- Geosciences
- Psychology

**SZMA**
Director: Prof. Hubert Flenner
Benefitting from Clear Structures

- Annual report of the SZMA is discussed by the advisory board and forwarded to the Rector of the Ruhr-University
- The transparent structure creates clear responsibilities
- Intensive exchange between the SZMA and the Engineering and Science departments helps solve problems at an early stage

Work of the SZMA is viewed by all parties involved as a success story.
Examples of synergy effects made possible by the SZMA:

- **Training of Tutors**
  - Compulsory training for all new tutors
  - Instructors: Team from mathematics and didactics
  - Two-day training before the start of semester
  - Focussing on the needs of mathematics teaching
  - Hospitation during the semester, reflection seminars

- **Mathematics Learning Center (MLC)**
  - Open daily from 13:00 to 16:00
  - Staffed by tutors who hold their office hours in the MLC
  - Available for all questions concerning the mathematics courses
  - Much better accepted than individual office hours
  - Very popular during exam preparations
The MP² project: Math/Plus/Practice

Contribution to the Stifterverband contest
Nachhaltige Hochschulstrategien für mehr MINT-Absolventen

- Developed by the SZMA, in cooperation with the vice rector for teaching of the Ruhr-University Bochum
- Project coordinators: Eva Glasmachers, Jörg Härterich, H.D.
- Grant by Stifterverband für die deutsche Wissenschaft and Heinz-Nixdorf Stiftung (2010–2012)
- Continuation by resources from Ruhr-University until 2016
MP² philosophy

MP² is guided by two working hypotheses:

- First-year university students often lack proper ways of learning - high school learning strategies are insufficient at the university.
- Engineering students lose their motivation because they do not see the need for the theory taught in first-year courses.

Mathematics is not part of the problem in engineering education, but it can be part of the solution!
MathPlus: Rules of the Game

- Students at risk are identified after 4 weeks by a short quiz
- Application for the MathPlus program by motivation letter
- Students commit themselves to active participation in all aspects of the program by signing a learning contract
- Students who fail to comply are expelled from the program
Elements of MathPlus

- Weekly Meetings aimed at improving learning skills
- Learning groups
- Mathematics Learning Center
- Special weekly office hours in the Mathematics Learning Center
- Learning-Log
- Reflection on personal learning style
- Additional Exercises with feedback, integration with social networks
- Exam Training
- Specially designed mock exams
- Study Guide
- Weekly chapter addressing learning strategies
- Exam Preparation Class
- Repetition of lecture
- Mentoring
- Former MP2-students share their experience
- eLearning
Final Exam: 71% of students in the program passed, compared with 59% of all students and 53% in a control group.

Challenge: The program is very labor intensive (small learning groups) and requires highly trained staff.

Accompanied by Ph.D. research evaluating effect of different elements (Advisor: Prof. Bettina Rösken-Winter)
MathPractice: Real-Life Problems Solved with Math

- **Excursion or Practice Day**
  - Using trigonometry to prevent swinging: A sway control system
  - Comparison of theoretical results with experiments

- **Extracting information from references and Leittext**
  - Balancing with Differential Equations: The Segway transporter
  - Presentation of final results for a broad audience

- **Math Practice**
  - Keep calm: The Mass Damper
  - Stay cool: optimal design of a ribbed cooler
- Students work on their projects in small study groups, directed by a self-study guide and assisted by a tutor.
- Study guides prepared by mathematicians in cooperation with civil and mechanical engineers.
- Students present their results in a public presentation at the end of the semester.
- Students learn soft skills: Team work and presentation skills.
- Student’s feedback: Participation in the project increases awareness of the relevance of mathematics.
Further Projects Initiated by the SZMA

- **MathPlus for Mathematics students**
  Project within *InStudies* (BMBF)
  Dr. Eva Glasmarkachers, Dr. Jörg Härterich, Prof. Bettina Rösken-Winter, H.D.

- **Modellierung der mathematischen Kompetenz von Ingenieurstudierenden**
  Project within *KoM@ING* (BMBF)
  Prof. Bettina Rösken-Winter, Prof. Marcus Petermann, et al.

- **MathMatters**
  Development of new classroom material for the mathematics curriculum of civil and mechanical engineers
  Project within *TeachIng-LearnIng* (Mercator Foundation)
  Dr. Jörg Härterich
Conclusions

- Appropriate administrative structures are an important prerequisite for excellence in teaching.
- Mathematical training of engineers is the task of mathematics departments: Connection with state-of-the-art mathematical research.
- Mathematics curriculum has to be developed in close contact with the engineering department, to meet the needs of the students.
- Assisting students in the transition from high school style teaching and learning to university style can help reduce dropout rates.
- Projects featuring applications of mathematics to engineering problems increase awareness of relevance of mathematics.
References


