Mathematics for Engineering and Science Students

The Ruhr-University Bochum Approach

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Attracting More Students and Educating Well-Trained Engineers:
Sensible Ways to Advance the Field of Engineering Education
HRK Conference, Berlin, 29/30 October 2012

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Engineers Need Mathematics!

- 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

Servicecenter Mathematics and Applications (SZMA)

- 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

SZMA
Director:
Prof.Hubert Flenner

Advisory Board

Representatives from

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

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.

SZMA - Early Didactical Innovations

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 MP^2 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

Stifterverband
für die Deutsche Wissenschaft

Heinz Nixdorf Stiftung

MP^2 philosophy

MP^2 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

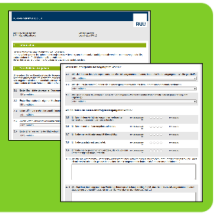
- Students at risk are identified after 4 weeks by a short quiz
- Application for the MathPlus program by motivation letter
- Students commit themselves to active participation in all aspects of the program by signing a learning contract
- Students who fail to comply are expelled from the program

Elements of MathPlus

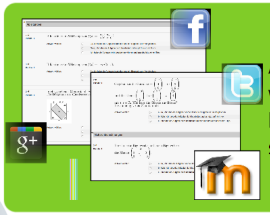
Weekly Meetings aimed at improving learning skills

Special weekly office hours in the Mathematics Learning Center

Reflection on personal learning syle

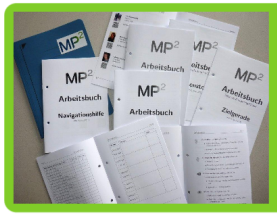


Additional Exercises with feedback, Integration with social networks



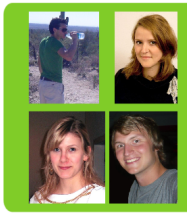
Specially designed mock exams

Weekly chapter addressing learning strategies



Repetition of lecture

Former MP2-students share their experience

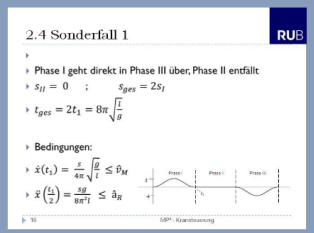


MathPlus: Results

- 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)

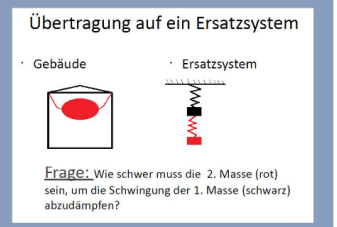
MathPractice: Real-Life Problems Solved with Math

Excursion or Practice Day



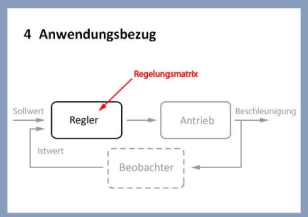
Using trigonometry to prevent swinging: A sway control system

Comparison of theoretical results with experiments



Keep calm: The Mass Damper

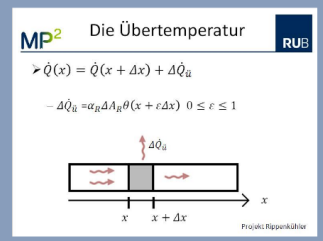
Extracting information from references and Leittext



Balancing with Differential Equations: The Segway transporter

Stay cool: optimal design of a ribbed cooler

Presentation of final results for a broad audience



Math Practice

MathPractice: Details and Results

- 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 Glasmachers, 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

- H. Dehling, E. Glasmachers, J. Härterich, D. Kacso (2011): Das Servicezentrum Mathematik und Anwendungen der Ruhr-Universität Bochum. *Das Hochschulwesen* **2/2011**, 49–52.
- B. Griese, E. Glasmachers, J. Härterich, M. Kallweit, B. Rösken (2011): Engineering Students and their Learning of Mathematics. In: *Proceedings of the 17th MAVI-Conference*, 85–96.
- J. Härterich, C. Kiss, A. Rooch, M. Mönnigmann, M. Schulze Darup, R. Span (2012): Mathe-Praxis - connecting first-year mathematics students with engineering applications. *Europ. J. Eng. Educ.* **37**, 255-266.
- A. Rooch, J. Härterich, C. Kiss (2012): Brauchen Ingenieure Mathematik? - Wie Praxisbezug die Ansichten über das Pflichtfach Mathematik verändert. To appear in: *Mathematische Vor- und Brückenkurse: Konzepte und Perspektiven* (R. Biehler et al., Eds).
- B. Griese, E. Glasmachers, M. Kallweit, B. Rösken (2012): Lerntagebücher als Interventionsinstrument in der Studieneingangsphase. In: *Beiträge zum Mathematikunterricht 2012* (M. Ludwig, M. Kleine, Eds.), Münster WTM, 313–316.