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WORKSHOP ON "MODELLING REAL SYSTEMS: A HANDS-ON FIRST ENCOUNTER WITH INDUSTRIAL MATHEMATICS

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"ICIAM 99 Minisymposium CSE"

presented by:

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ICIAM 99
Minisymposium CSE

Industrial Mathematics Curricula in Europe - Some Examples

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"Technomathematics": mathematics in technical (=engineering) applications, curriculum and name invented by Helmut Neunzert

First curriculum: Kaiserslautern, spread quickly, now at 18 universities all over Germany: TU Berlin, Bremen, Chemnitz, Clausthal, Cottbus, Darmstadt, TU Dresden, Duisburg, Erlangen, Hamburg, Kaiserslautern, Karlsruhe, Kiel, Magdeburg, TU München, Paderborn, Rostock, Siegen.

Some unification by GAMM resolutions 1989/1992 on minimum requirements:

1. Mathematically oriented courses on:

- Continuous and discrete optimization
- Modelling with and analytical methods for differential and integral equations
- numerical methods for differential and integral equations - theory and implementation
- discrete mathematics
- systems and control
- statistics

(of course after usual basic mathematics courses in analysis and linear algebra)

2. Strong computer science courses in areas like

- CAGD
- object-oriented programming
- expert systems
- computer networks

(world has changed since then!)

3. Existence of enginering departments is a must, students have to attend engineering courses in e.g.

- mechanical engineering
- electrical engineering
- fluid dynamics
- chemical engineering

Of course, elementary physics is required!

Math. - Comp. Science - Engineering = 60 : 20 : 20

Question not only what to teach, but how to teach?

Problem - driven, i.e., in problem sessions: smaller and then larger modelling problems, ideas for algorithms, numerical implementation.

But: we train mathematicans, courses have to reflect that (no recipes, but rigor!)

Essential: Modelling skills, teamwork, presentation skills

→ Modelling seminars: problems from industry (or engineering departments) presented in non-mathematical terms; students (in teams and under guidance) develop and discuss models, algorithms, implement, interpret, present results (in mathematical terms and as executive summary) in writing and orally.

→ Diploma thesis: in most cases on a real industrial problem, supervised by university.

Cooperation with industry is essential, either directly (preferable) or via engineering departments.

There is no Industrial Mathematics without industry!

Austria: parallel development of modelling seminars (Hj. Wacker), now: Industrial Mathematics curriculum (Linz)

From the beginning: international dimension within ECMI:

2-year international graduate program ''Mathematics for Industry''

- 8 core courses (see above) according to coordinated curricula
- 8 special courses (different at different centers)
- students have to spend one semester at another center for special course or industrial projects
- students have to work on an industrial project in form of a thesis
- modelling week: like modelling seminar, but whole week, one larger problem for each group, international teams of 4-6

Funding of exchance (students and lecturers): EU (Erasmus, Comett, Leonardo, Socrates).

Graduates of all curricular are highly employable both at universities and expecially in industry!

- Univ. Kaiserslautern (D)
- J.K.Univ. Linz (A)
- TU Eindhoven (NL)
- Univ. of Oxford (UK)
- Techn. Univ. of Danmark (DK)
- Rolf Nevanlinna Institute (Helsinki, SF)
- TU Dresden (D)
- Univ. Grenoble (F)
- Univ. Trondheim (N)
- Univ. di Milano (I)
- Univ. Lund (S)
- Univ. di Firenze (I)
- Univ. of Glasgow (UK)
- Techn. Univ. Graz (A)

Different program with emphasis still more on science than on engineering, but in the same interdisciplinary problem-driven spirit:

Computational Science and Engineering, ETH Zürich

- 4-semester basic curriculum in mathematics or computer science or physics or engineering ...

- 4-semester interdisciplinary curriculum:
  - optimization
  - numerics of differential equations
  - parallel computing
  - computational quantum mechanics
  - computational statistical mechanics
  - software engineering
  - visualization
  - case studies

and one elective out of

- atmosphere physics
- computational chemistry
- CFD
- control engineering
- robotics
- theoretical physics

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Summary

- Successful curricula
- we teach mathematics, no compromise on rigor; breadth necessary
- problem-driven teaching, modelling activities
- international dimension
- involvement of industry!