Teaching Computational Science and Engineering: A KTH Perspective

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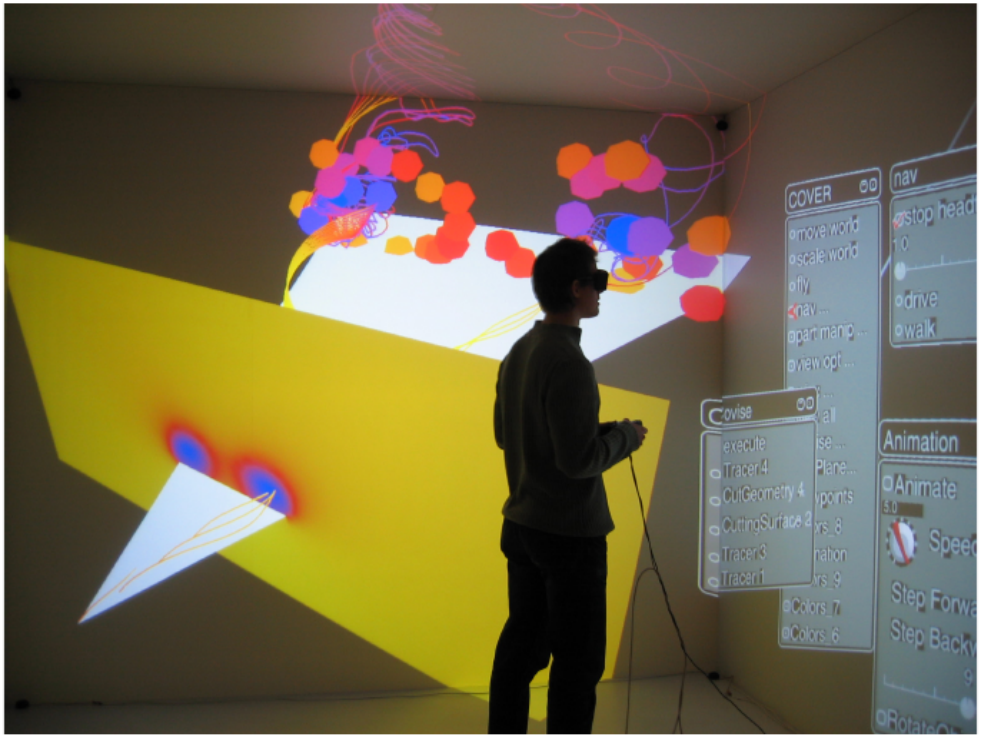
Why Computational Science & Engineering



C Stefan Görtz 2005

Computational Science and Engineering has become the third pillar of the scientific enterprise, a peer alongside theory and physical experiment.

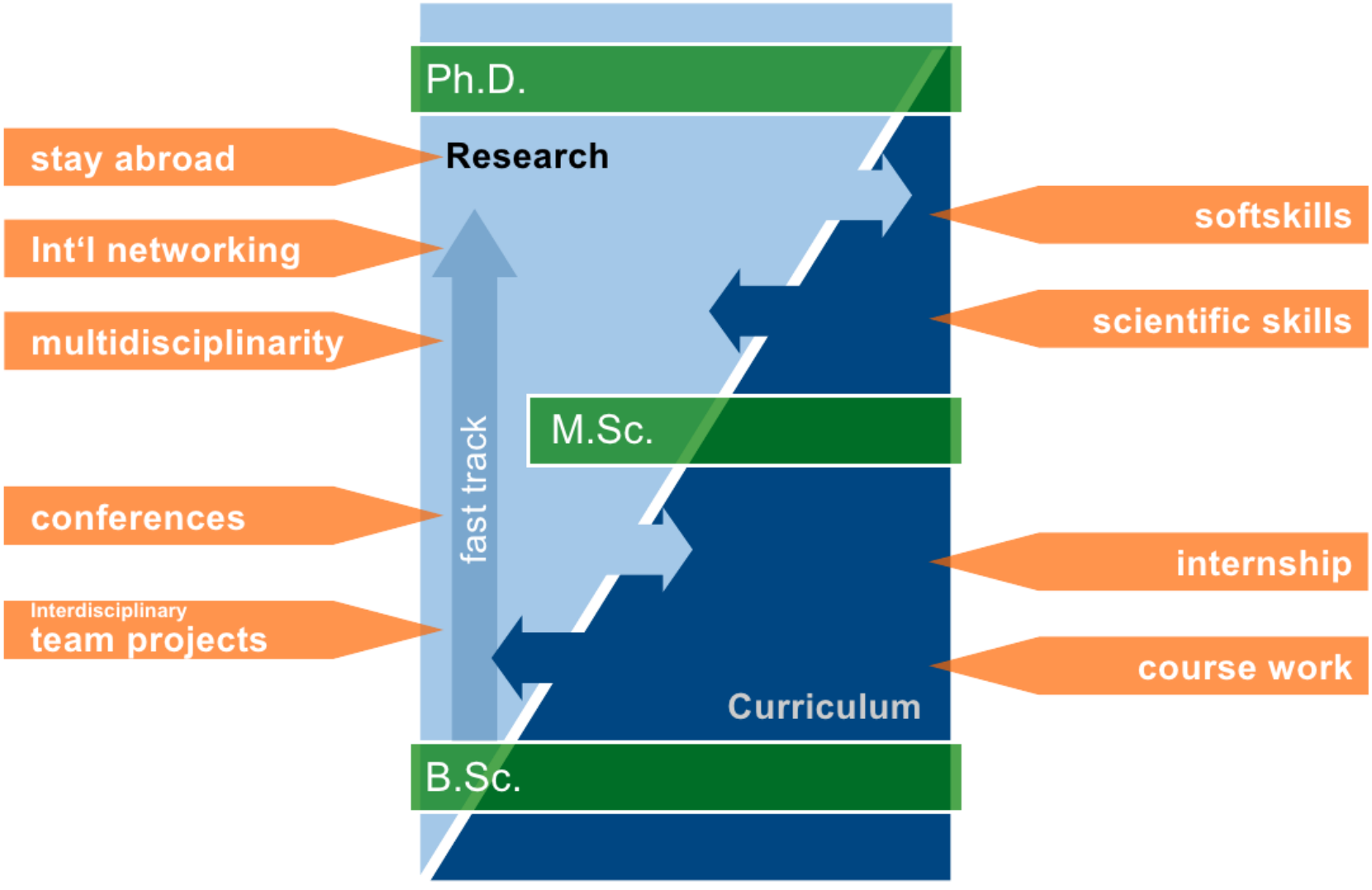
A Threat

Conclusion of recent asessments of education and training in CSE:

- the demands for CSE educated personnel exceeds supply;
- inadequate education and training threatens the growth of CSE.

WTEC Panel report on "International Assessment of Research and Development in Simulation-Based Engineering and Science" 2009; EU Project PRACE report "Training and Education Needs for Petascale Computing"

CSE Education Track



Martin Ruess, Max Gunzburger, MH 2011

Scientific Computing at KTH: The Environment

- In 1995-2005, the institution was the host for PSCI, the Parallel and Scientific Computing Institute
  - VINNOVA Centre of Excellence
  - Jointly financed by Vinnova, an industrial consortium (including ABB, Alfa Laval, Comsol, Pharmacia, SAAB Military Aircraft, DEC Sweden, Volvo Aero, IBM Sweden, Ericsson, ...), KTH (Uppsala U)
  - A total budget of 211 MSEK (~25 MEUR)
- Since 2005, KTH Centre for Computational Science and Engineering (KCSE)
  - A centre joining all CSE activities at KCSE
  - Starting from 2008, a graduate school is attached to that centre
  - Financed by VR (ca 2.5 MSEK/year, but no stipends)

The Environment (cont)

- In 2010, the Swedisch e-Science Research Centre (SeRC) has been established
  - Cooperation of KTH, Stockholm U, Linköping U, Karolinska institutet
  - Strategic Research Area funded by VR
- The Centre for Parallel Computations (PDC), founded in 1990
  - Hosts almost half of Swedish high-performance computing power (2011)
  - Lindgren held rank 31 on the TOP500 list (2011)
  - Financed in part by Swedish National Infrastructure for Computing (SNIC)

International Master Programme in Scientific Computing

- The KTH Master's Programme Scientific Computing was established in 1997
- When founded, it was exotic in an engineering teaching environment (civilingenjör = Dipl.-Ing.)
- Graduated around 250 students to date
- Master's thesis in academia and at companies like ABB, Volvo PV, SAAB, Comsol, Biovitrum, Ericsson
- Cooperation with graduate school KTH Centre for Computational Science and Engineering (KCSE), FLOW (Linné center), Swedish e-Science Research Center (SeRC)

TSCCM: Curriculum

Year	Semester 1	Semester 2
1	Math Models Appl Numer Meth Finite Elements Appl Comp Sci Electives	Numer Diff Equ Parallel Comp Electives (applications)
2	HPC Philosophy Electives	Degree project

Lessons Learned: Part I

- Steep increase in the number of students from 7 (1997) to 25 (170 applications, 2003-4)
- The programme was very successful in the sense that all graduates found immediate jobs (very often as PhD students, not only at KTH)
- Many job offers from industry (somehow dependent on economic situation)
- Problem: Coordination with existing curricula (lack of Swedish students in the programme)
- Need of a persistent basis on bachelor level.
- Problem: Coordination with some departments (interdisciplinary nature of the programme)
- Advertising is a necessity!
- Since 2004, the number of applications has reduced dramatically.
- Tuition fees are counter-productive.
- Degree provided: MSc in Mathematics

Why a Double Degree Programme?

The double degree programme is more than the sum of two excellent programmes:

- It combines the best of two, or more, universities
- Provides much broader opportunities with respect to course contents
- It provides international experience both with respect to research and intercultural exchange
- It provides a coordinated curriculum
- The student obtains two degrees of the two universities
- The student gains competitive advantage for careers in industry and academia
- At the partners, you will find a long experience with international programmes in CSE

The Double-Degree Programme With FAU Erlangen

- Informal contacts even before the programme started
- This programme started in September 2008
- The programme contains both a student and teacher exchange
- Supported by Erasmus LLL
- The German was supported generously by DAAD (both stipend programme and teacher exchange)
- Part of Elite Network Bavaria (BGCE)

Lessons Learned: Part II

- The interest of German students is overwhelming
- The students and teachers on exchange contributed a lot to the success of our courses/programmes
- Enhancing of the quality in education
- During the first three years, the student exchange was almost balanced

- For success, you need a firm basis at the partners
- A general problem at KTH: Swedish students do not move – at least not to Germany
- The administrative routines are more a hinder than a support
- Ad Bologna: The "interface problem" must be solved by flexibility, not formalization. Modules is not the way out
- Success depends on the committment of the teachers

Erasmus Mundus Master's Programme COSSE:

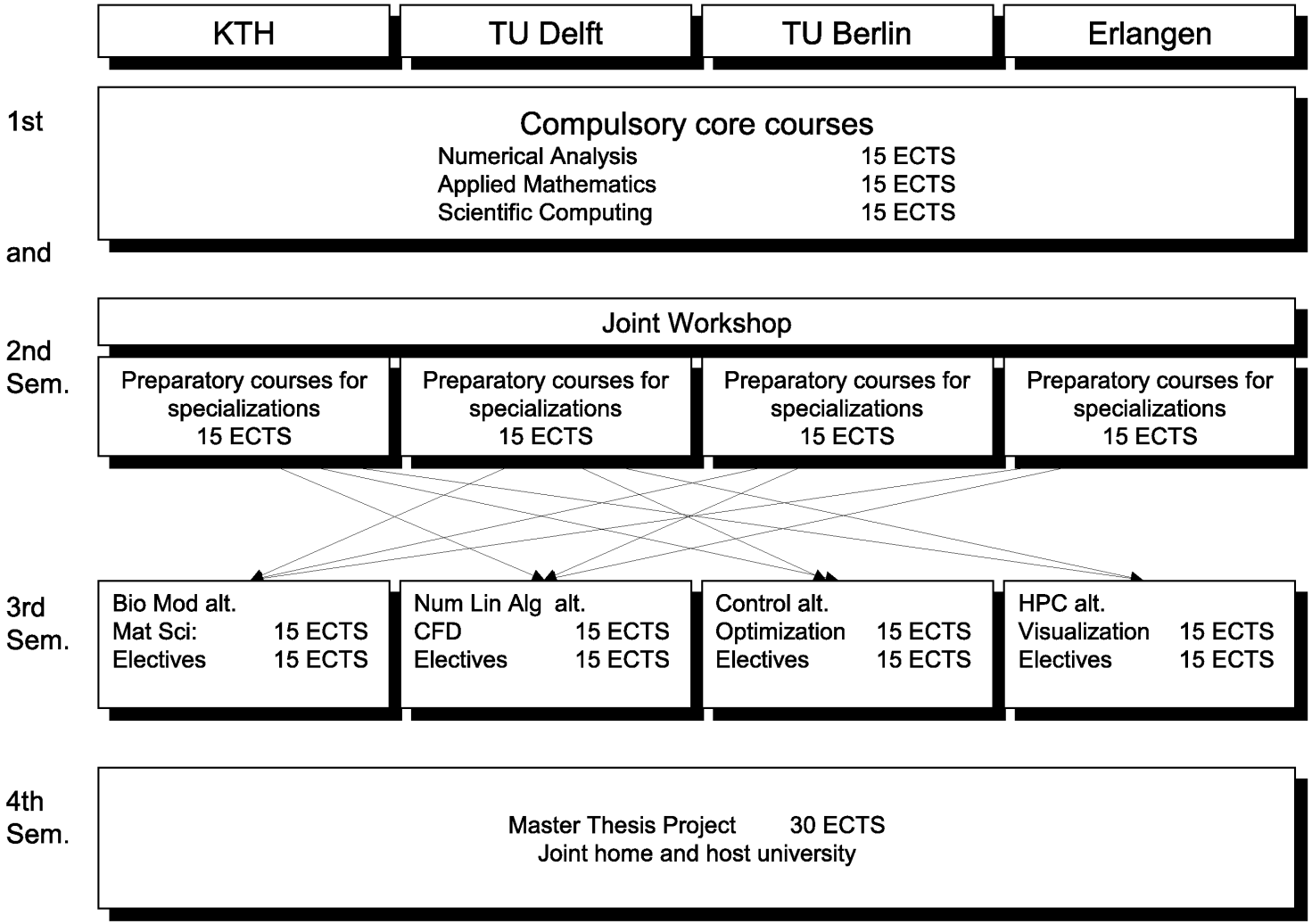
"Computer Simulation for Science and Engineering"

- KTH Royal Institute of Technology Stockholm
- Friedrich-Alexander-Universität Erlangen-Nürnberg
- Technical University Berlin
- Delft University of Technology

Erasmus Mundus

- Co-operation and mobility programme within higher education to promote EU as academic "Centre of Excellence"
- Promote dialogue between and understanding of different societies and cultures through co-operation among higher education institutions and people-to-people contacts.
- Promote EU external policy objectives and contribute to the sustainable development of third countries in the field of higher education.
- Overall budget 2009-2013 approx 1 billion EUR
- Action 1: EM Master's Courses and EM Doctoral Programmes
- Action 2: Partnerships with third country higher education institutions
- Action 3: Enhancing attractiveness of European higher education

EMMC COSSE


KTH
TU Delft
TU Berlin
Erlangen
1st
Compulsory core courses
Numerical Analysis 15 ECTS
Applied Mathematics 15 ECTS
Scientific Computing 15 ECTS
and
2nd Sem.
Joint Workshop
Preparatory courses for specializations 15 ECTS
Preparatory courses for specializations 15 ECTS
Preparatory courses for specializations 15 ECTS
Preparatory courses for specializations 15 ECTS
3rd Sem.
Bio Mod alt.
Mat Sci: 15 ECTS
Electives 15 ECTS
Num Lin Alg alt.
CFD 15 ECTS
Electives 15 ECTS
Control alt.
Optimization 15 ECTS
Electives 15 ECTS
HPC alt.
Visualization 15 ECTS
Electives 15 ECTS
4th Sem.
Master Thesis Project 30 ECTS
Joint home and host university

What's New?

- *Excellence programme*
- At most 15 students per university, initially fewer
- Intense tutoring and mentoring process
- Quality assurance by internal and external evaluation
- Generous scholarship programme (10 + 5 stipends)
- greater focus on student services
- Researching and teaching scholars
- EU Support 2010-2016: approximately 3.5 M EUR

The key components are *excellence, quality assurance, employability, sustainability.*

What do we get

- Excellent students, ensured by a careful selection process
- Enhancement of our programmes
- Deepening of the collaboration with our partners from industry and academia
- Ressources for establishing collaboration with excellent higher education institutions around the world
- Publicity

Scientific Computing: Mentoring and Tutoring

- Aim: Teaching in small groups according to needs
- Done by PhD-students
  - if possible, not the course assistent
  - aim is to early identify and help with problems such that the student passes all courses in time
- even our non-COSSE students shall be included (enhances "genomströmningen")
- Note: Preparatory material has been sent out.
- Start of a new EU-project: "Fit for Master" (October 2012)

Scholars

The EMMC programme includes the possibility of awarding scholarships to scholars. These are the rules:

- The scholar must come from a Cat A-country (which includes even Switzerland).
- A scholarship has a duration between two weeks and three month.
- We have actually 48 weeks of scholarships.
- The weekly scholarship amount is EUR 1200.
- The scholars should take active part in the Master's Course, mainly by teaching activities (at a partner, during the Joint workshop etc)

The selection of the scholar should be done strategically both with respect to enhancing the programme as well as broaden the outreach. Therefore, the PAG decided to use personal contact for recruiting scholars.

Joint Workshop

- Includes courses, scientific lectures, cultural activities
- Leading researchers will be invited
- Workshops
  - in February 2011 in Delft, “Mathematics in Waterland”
  - 2012 Thurnau (near Erlangen), “Simulation in Health Care”
  - 2013 Stockholm, “Mathematics and Papermaking”

Lessons Learned: Part III

- In the first application round, we received only very few applications. Now, we have plenty of them (success rate below 10%)
- Quality of students is above the average: Enhancing our own programme(s)
- We (the teachers) learn a lot from our partners

- Substantial administrative overhead: At KTH, the programme is in the focus of the president (therefore very good support)
- The rules of EM inhibit the interest of European students in the programme
- The application schedule dictated by EU is way too long. Our competitors (USA, UK) are much better
- We (KTH) do not have a clear path from master to PhD
- In order to support the entry (especially of 3rd country students) we have a new EU-project (S3M2, "Fit for Master")
- It is very hard to interest senior staff ("scholars") to join COSSE

CSE Education at KTH

Numerical Analysis
CTFYS, CDATE

Erasmus Mundus
TDTNM (COSSE)

Applied and Comp.
Mathematics

Nordic Master
N5Team

Double Degree
FAU Erlangen