



**Development of internationalized and
multidisciplinary PhD programmes:
The TUM Graduate School System
at Technical University of Munich**

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HERE/TAM Site Visit, Banja Luka
7 June 2016

Short Biography

- Diploma in Aerospace Engineering, 1993
• Engineering Doctorate, 2000
University of Stuttgart,
Germany
- Researcher and PhD Candidate, 1994-1998
German Aerospace Center
(DLR), Cologne, Germany
- Managing Director, 1998-2003
HOPE worldwide
Deutschland, Berlin, Germany
- Consultant, Space Power Systems, 2003
European Space Agency
(ESA), The Netherlands
- Scientific Advisor to the President, 2003-2006
• Head, Office of the President, 2006
• Managing Director, International Graduate School of
Science and Engineering (since 2006)
• Managing Director, TUM Graduate School (since 2009)
• Member, Gender and Diversity Board (since 2012)
Technical University of
Munich, Germany

Outline

1. Introduction to TUM
 2. Doctorates in Germany
 3. The TUM Graduate School System
 - Conception & implementation
 - Structure & governance
 - Scientific training
 4. Summary and lessons learnt
-
5. Principles and examples of 'Innovative Doctoral Training'
 6. The TUM Graduate School System (cont.)
 - Transferable skills training
 - International exchange & networking
 7. Innovative... and beyond?

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TUM key data I

39 000 Students, 34% female, 22% internat'l

8 200 Graduates per year

1 000 PhDs per year

528 Professors, 17% female, 16% internat'l

6 200 Scientific Staff

5 000 Publications, peer-reviewed per year

47 ERC Grants (since 2008)

49 Humboldt Senior Research Fellows (2010-14)

13 Nobel Prize Laureates

51 Rank in the Shanghai Ranking
(Chemistry: 14, Informatics: 21)

11 Rank in the Global Employability University Ranking
(Europe: 3)



Source: TUM

TUM key data II



Source: TUM

TUM key data III

165 Degree Courses

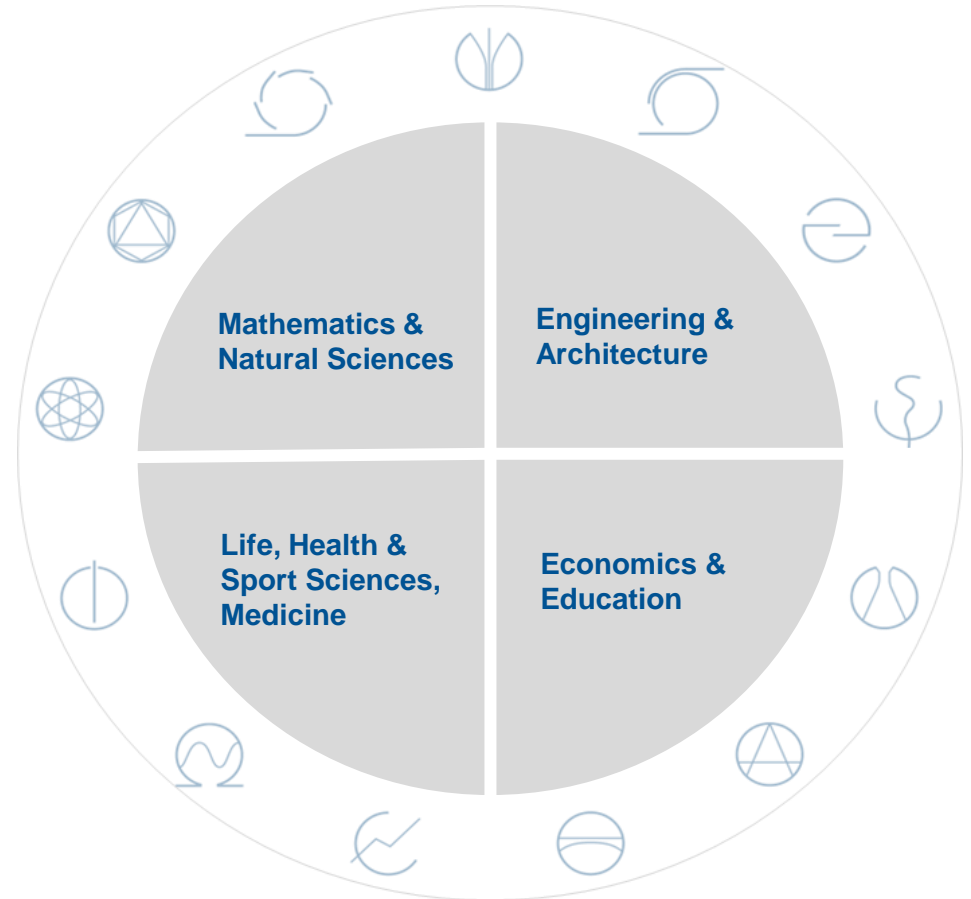
13 Departments

7 Corporate Research Centers

- Research Neutron Source FRM II
- Nutrition and Food Research
- Semiconductor Physics
- Medical Engineering
- Cancer Research
- Agricultural Sciences
- Catalysis Research

3 Integrative Research Centers

- Institute for Advanced Study (TUM-IAS)
- Munich School of Engineering (MSE)
- Munich Center for Technology in Society (MCTS)



Source: TUM

TUM in Bavaria

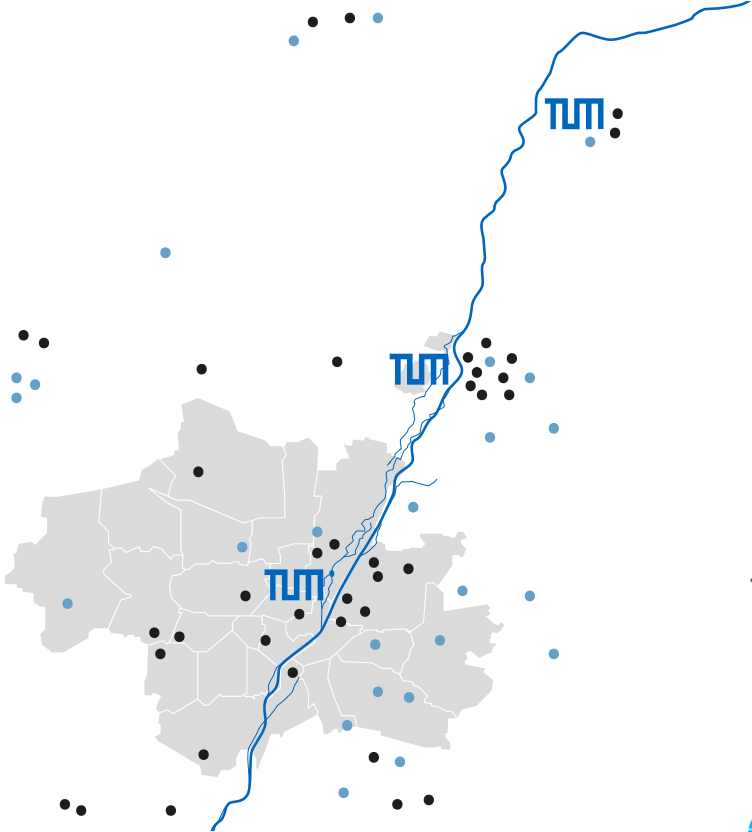


Source: TUM

TUM in Munich

Research Network

TUM
LMU
UNIA Universität Augsburg University
IHS Hochschule für Philosophie München
HELMHOLTZ GEMEINSCHAFT
DLR
LPRZ
 der Bundeswehr
Universität München
Deutsches Museum
Helmholtz Zentrum münchen
 Deutsches Forschungszentrum für Gesundheit und Umwelt
acatech DEUTSCHE AKADEMIE DER TECHNIKWISSENSCHAFTEN
ES+O



Industry Network

Giesecke & Devrient
KNORR-BREMSE **EPCOS**
BR **BMW** **BayWa** **BAUER**
SGL GROUP THE CARBON COMPANY **SIEMENS** **WACKER**
BAUINDUSTRIE BAYERN **Audi** **MAN**
KUKA **EADS** **MTU** Aero Engines
Clariant **PUMA**
ROHDE & SCHWARZ **Allianz**
Munich RE
TDK **OSRAM**
eurocopter an EADS Company
Infineon

Source: TUM

TUM support & career system for junior scientists



Doctoral Candidates

TUM Graduate School
TUM.Junge Akademie
Entrepreneurship education

Postdocs

Research Opportunities Week
TUM University Foundation Fellowship
TUM Junior Fellow (Fund)

Early Career Scientists

TUM Faculty Tenure Track
System and Academy

TUM Research Opportunities Week

- One Week at TUM
- Travel grants for 50 international postdocs
- Possibility for chairs to recruit junior researchers
- Eligible for TUM University Foundation Fellowship

Upcoming date:

➤ **March 20-24, 2017**

application opens July until September 30, 2016:

www.tum.de/postdocs



Source: TUM

TUM University Foundation Fellowship

- For participants of the Research Opportunities Week
- Funding similar to Alexander von Humboldt-Foundation (2,650 € p.m.) for one year
- Postdocs encouraged to apply for own funding within the year

Qualification program for fellows

- Mentoring from the Emeriti of Excellence
- Individual consultation about funding options
- Proposal writing workshops
- Networking meetings



Source: TUM

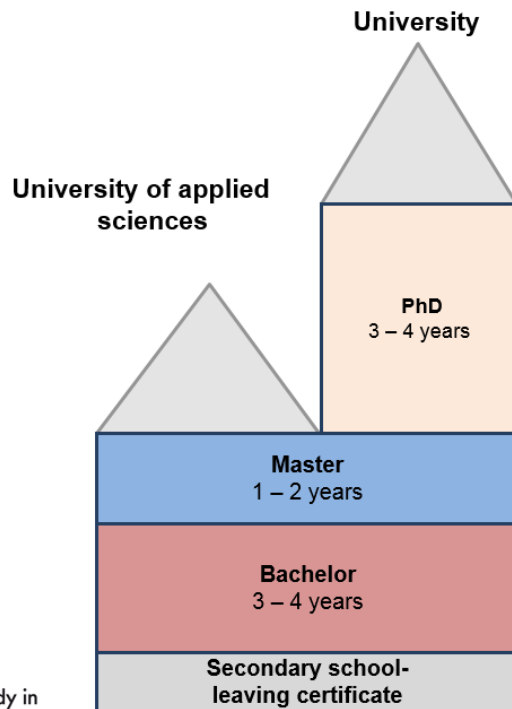
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Doctorates in Germany I

The German university system

Degree programmes



- Bachelor's, master's, doctoral degrees
- State examination (certain subjects only)
- Traditional German degrees *Diplom, Magister* (sporadic)

Doctorates in Germany II

General remarks

- value, standards and demands of a doctorate differ:
 - sciences and humanities: needed for careers in academia, 3-4 years
 - chemistry: needed for all careers, 2-3 years
 - engineering: needed for careers in academia, 3-6 years
 - architecture: not even needed for careers in academia, 4-6 years
 - medicine: needed maybe for the door label, 0.25-2 years
- increasing number of doctorates:
 - 1990: 18,500
 - 2000: 25,800
 - 2014: 28,100
- issues of good scientific practice (plagiarism, fraud)

Source: Wikipedia

Doctorates in Germany III

History (until ~2005)

- Predominantly **apprenticeship model**, professor being the supervisor, examiner and boss
 - **Doctoral candidate** not a ‚student‘ but a ‚young researcher‘ in the first career phase
 - Candidates **employed** at the university (20-100%), either government or third-party funding
 - **Degree regulations** differ from department to department
-
- + High degree of **freedom**
 - + **One-one-one** relationship with a specialist
 - + Preparation for **careers** in academia and outside
-
- **International** orientation lacking in some cases
 - Strong **dependence** on one person
 - No personal and **career** support
 - Low level of **transparency**
 - Rather long **time-to-degree**

Doctorates in Germany IV

Recent developments (from ~2000)

- **research training groups** (DFG, EU, foundations)
 - discipline-specific, sometimes with wider focus
 - 12-30 doctoral candidates, mostly funded by scholarships
 - training program (scientific & transdisciplinary skills)
 - international & career orientation (exchange, publications)
- **Bologna third cycle** discussion (Berlin Communiqué, 2003)
- (university-wide) **graduate schools** with very wide focus (Excellence Initiative, 2006/2012)
- **joint doctorates** (joint/dual/double degrees, joint supervision)
- **collaborative doctorates**: University of applied sciences, extra-university research institutions & industry as new players



Doctorates in Germany V

Graduate Schools of the Excellence Initiative (2006/2012))

- Graduate schools (GSC) play a key role not only in developing internationally competitive centres of **top-level research** and scientific excellence in Germany but also in increasing their **recognition and prestige**.
- They serve as an instrument of **quality assurance** in promoting young researchers and are based on the principle of **training** outstanding doctoral students within an excellent research environment.
- GSC offer ideal conditions for doctoral students within a broad scientific area and, as integrative institutions with **international visibility**
- GSC encourage (international) students to be **active members** of their academic and social communities.

Further Characteristics

- **cooperation** with non-university institutions
- **professional management** integral part of programs
- **gender equality standards**

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The TUM Graduate School system I

The preliminary phase – driven by the Excellence Initiative (2005-2008)

- Funding line ‚Graduate Schools‘ (2005): Decision to propose graduate school ‚bridging the gap between science and engineering‘
- Approval and launch of the ‚IGSSE - International Graduate School of Science and Engineering‘ (2006)
- Reviewers advise to go for university-wide graduate programs (2006)

The conception phase – scaling up and getting everyone on track (2008-2009)

- Define the **mission**: university-wide, for all doctoral candidates
- Propose a **structure**: central and subsidiary elements, direct affiliation with TUM Management Board, involvement of doctoral candidates
- Determine **curriculum**: best international standards, career perspective
- Provide **information** and search for dialogue with ‚many‘, esp. supervisors, doctoral candidates
- Write and publish **statutory documents**
- Set up **management** office, recruit & train staff
- **Launch** of TUM Graduate School (2009)

Source: TUM

The TUM Graduate School system II

The mission of TUM-GS (2009)

- ensure high scientific **quality** of doctoral education at TUM
 - give an **international** perspective
 - foster **interdisciplinary** collaboration – across disciplines, institutions
 - strengthen scientific and transferable **skills** of candidates
 - increase visibility and **networking** of doctoral candidates
 - provide **career** orientation and promote **social responsibility**
 - increase **diversity** amongst doctoral candidates
-
- ✓ **Individual original research remains in the center**
 - ✓ **Key responsibility stays with doctoral candidate, supervisor and faculty/department**
 - ✓ **TUM Graduate School creates a corporate environment with optimum conditions for outstanding research**



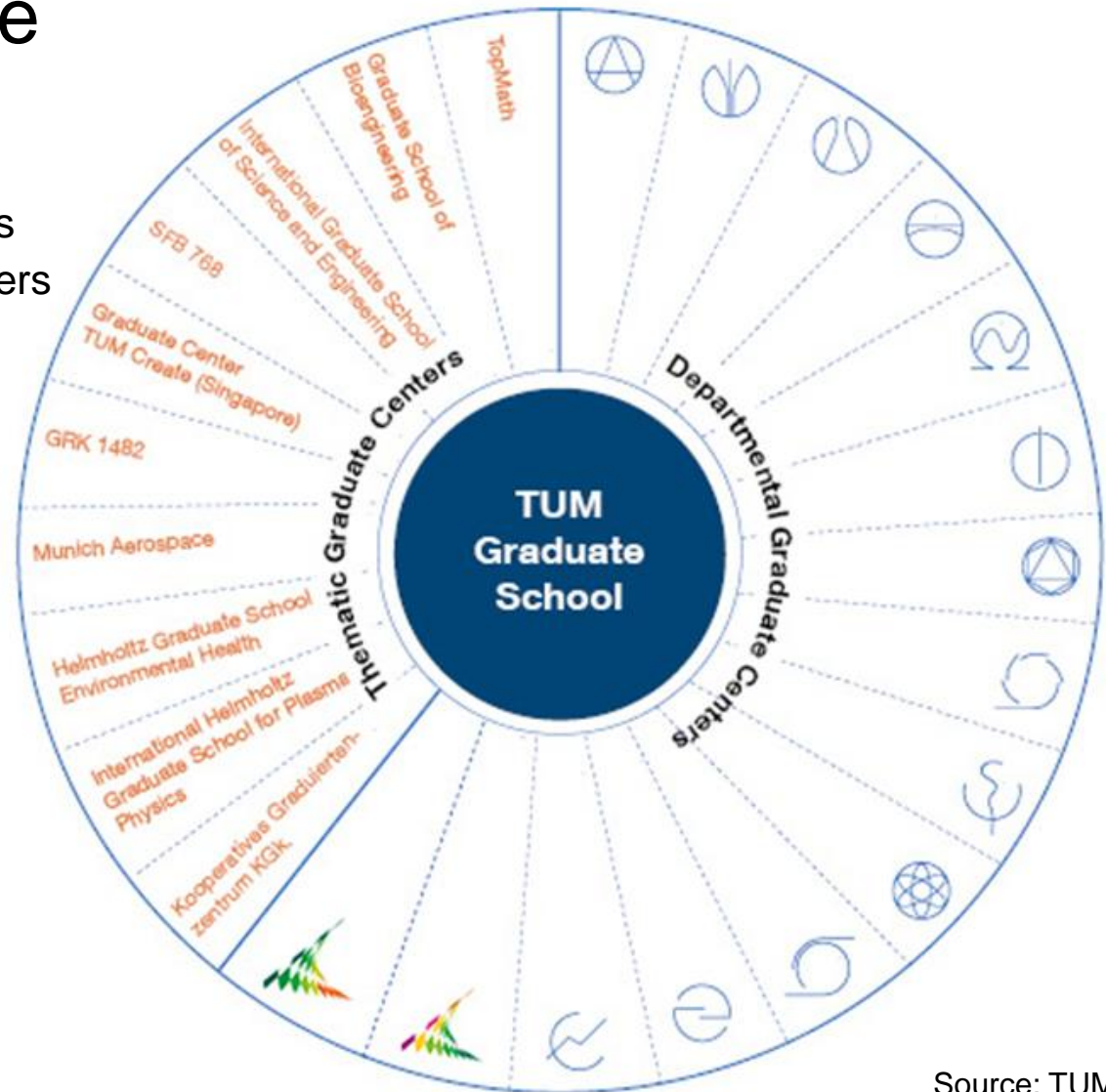
Source: TUM

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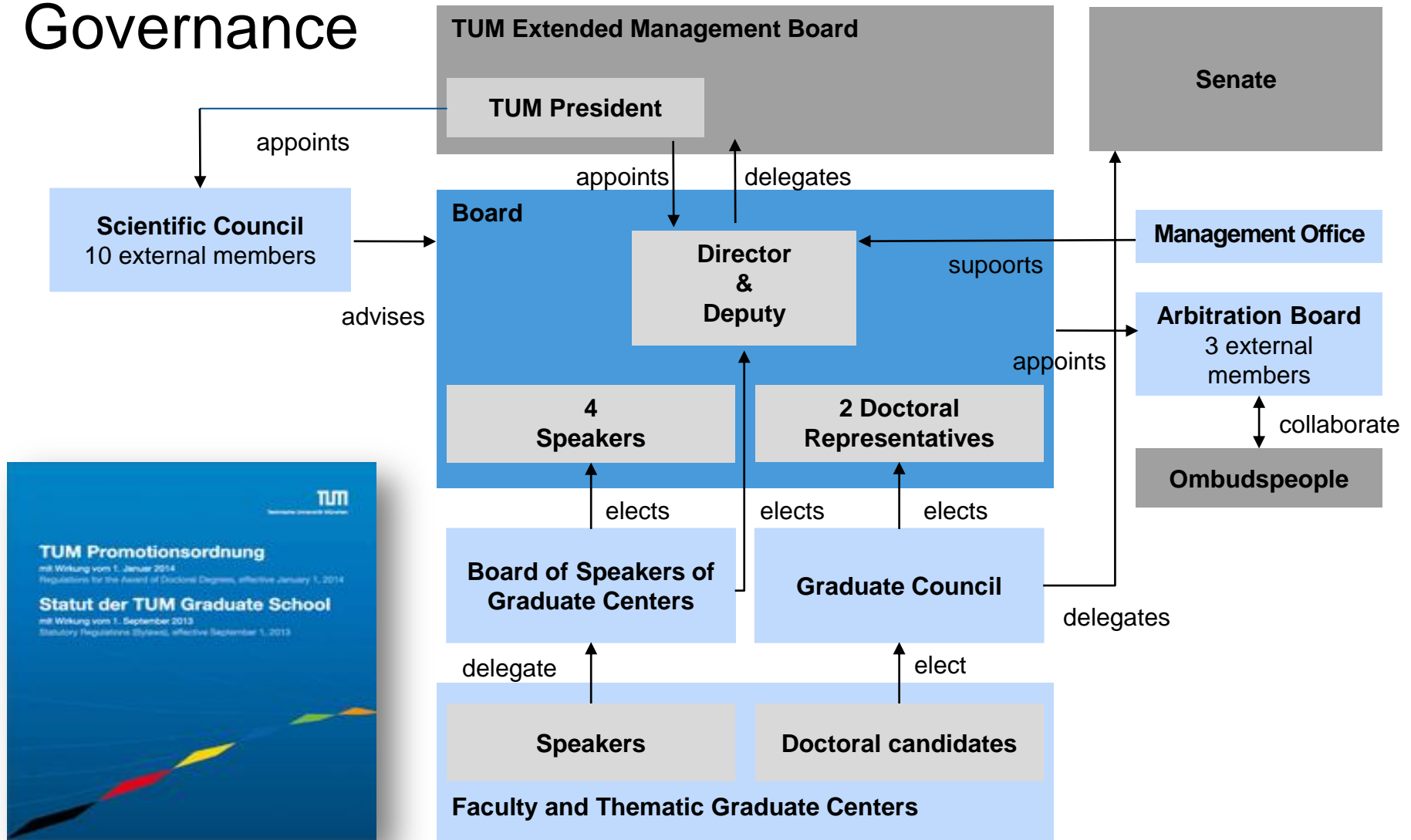
TUM-GS: Structure

- **25 doctoral programs:**
 - 15 Faculty Graduate Centers
 - 10 Thematic Graduate Centers



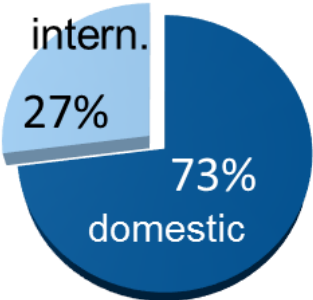
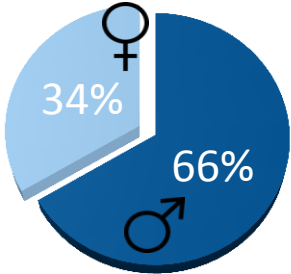
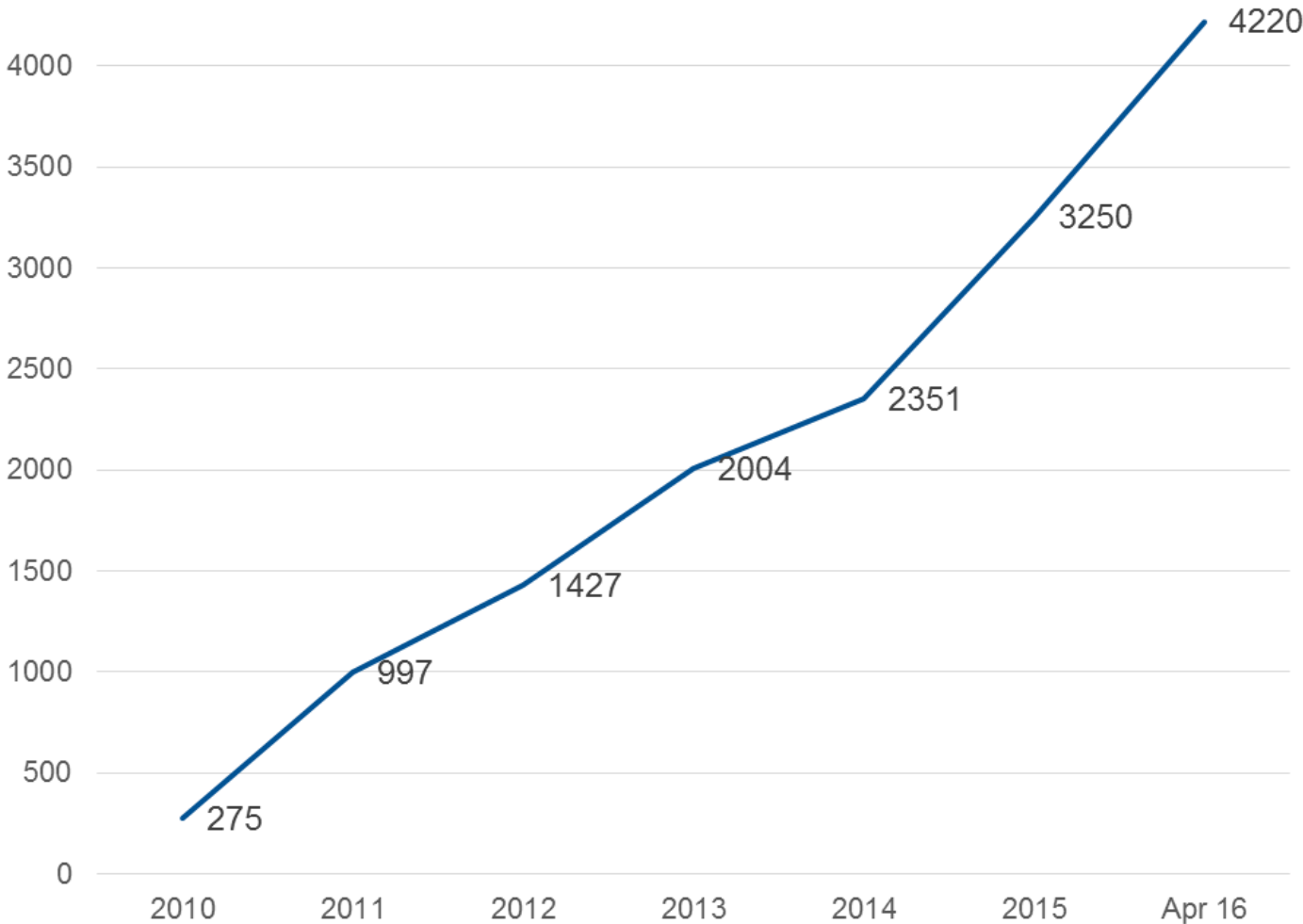
Source: TUM

Governance



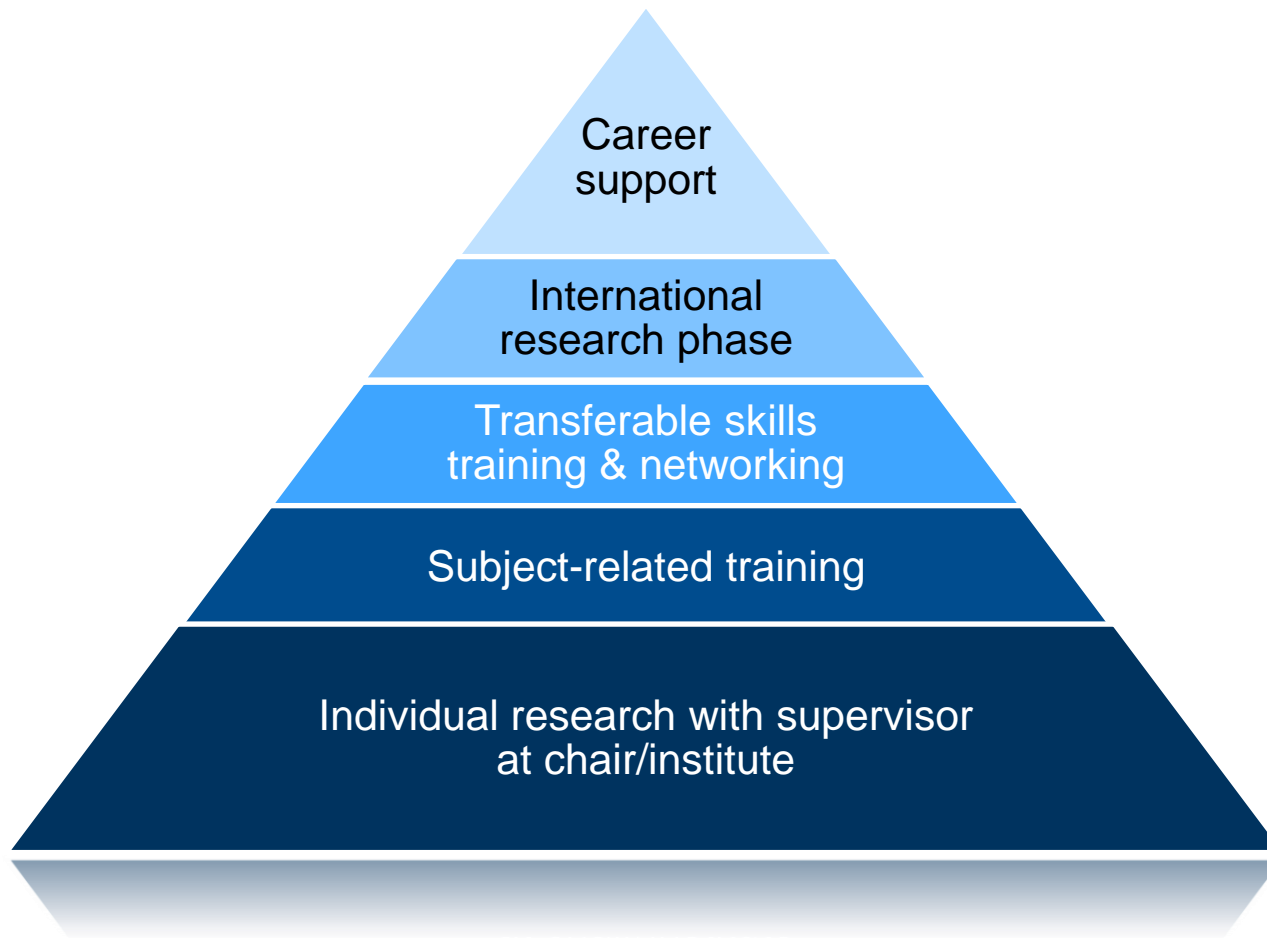
Source: TUM

TUM-GS: Membership



Source: TUM

The TUM model of a doctorate



Source: TUM

Elements of a doctorate at TUM

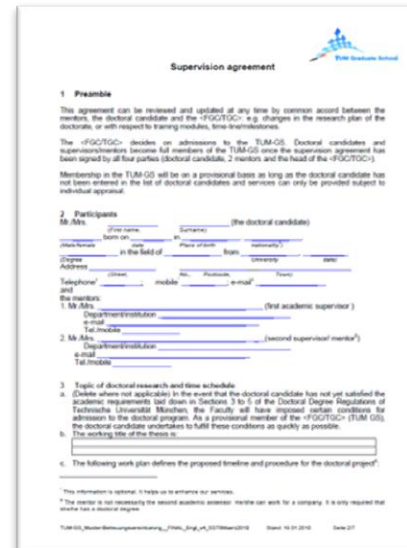
Basic elements

- Registration and 2-year membership in the TUM Graduate School
- Supervision Agreement + Exposé
- Double Mentoring
- Kick-Off Seminar
- Scientific Training (6 SWS)
- Publications: Book/journal/conference article, peer-reviewed
- Integration into academic environment
- Feedback talk
- Certificate

+ requirements of the individual Graduate Center

Optional elements

- Transferable skills training
- Coaching and career services
- International research phase
- Graduate Council
- Social and networking activities



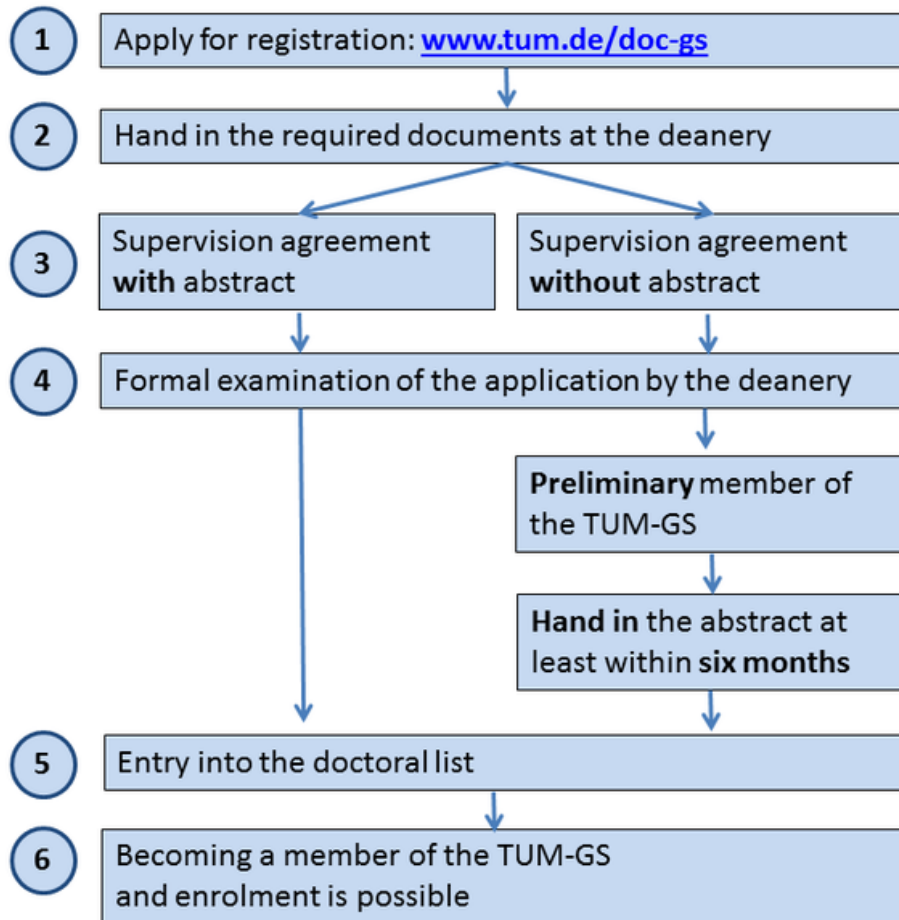
The image shows a 'Supervision agreement' form from TUM. It contains several sections: 1. Preamble, 2. Participants (with fields for M.A.s and supervisors), and 3. Topic of doctoral research and time schedule. The form is partially filled out with blue ink.



The image shows a 'CERTIFICATE' from TUM, awarded to Dr.-Ing. PETRA LIEDL on 20 July 2016 in Heiden. It certifies that she has successfully completed the IGSSe RESEARCH TRAINING PROGRAM. The certificate also mentions the interdisciplinary IGSSe project team 'Interaction Climate-Human-Building' and lists completed courses and trainings.

Source: TUM

TUM-GS: Management of doctorates with DocGS



The screenshot shows the TUM DocGS Progress page. At the top, the TUM logo and name 'Technische Universität München' are displayed. A navigation bar includes links for HOME, DOWNLOADS, SUPPORT, TERMS AND CONDITIONS, and PROGRESS. The main heading is 'Progress' with a reference number of 87207. A list of progress items follows, each with a folder icon and a status indicator (green checkmark for completed, red exclamation mark for pending):

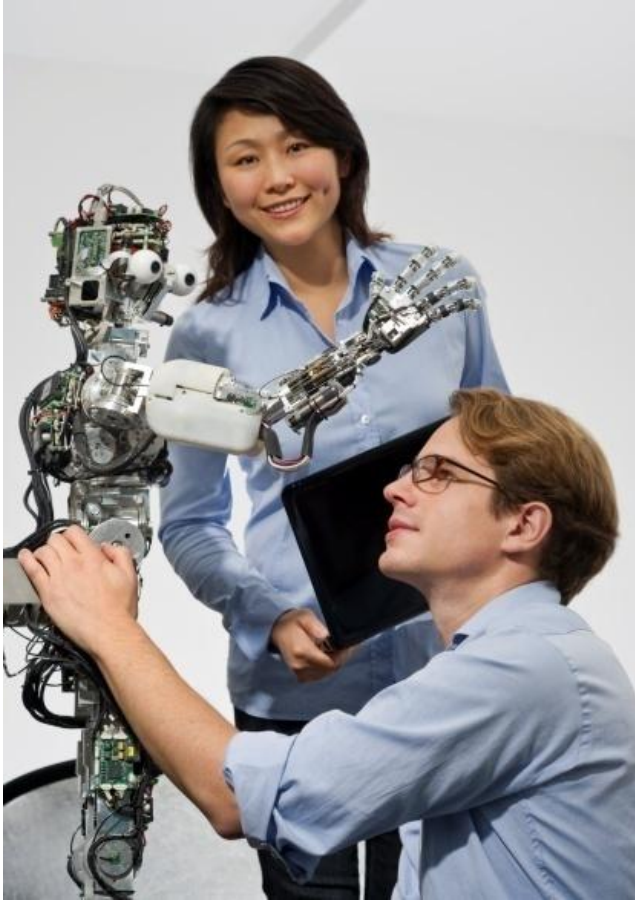
- Application for the acceptance as doctoral candidate (Completed)
- Application (Completed)
- Application completed (Completed)
- Bewerbung (Pending)
- Application handed in and formally reviewed (Completed)
- Verification of the qualifying degree (Completed)
- Approval for a German degree (Completed)
- Content assessment of application (Completed)
- Addition to the doctoral list (Deanery) (Completed)
- Qualification program (Completed)
- TUM-GS training program (Completed)
- Kick-off seminar (Completed)
- Subject-specific courses (Completed)
- Pymol Workshop (Completed)
- G-NMR School (Completed)
- Active participation in the scientific environment of the TUM (Completed)
- Feedback session (Completed)
- Publications / discussion of the research project in the international scientific community (Completed)
- Project plan / exposé (Completed)

Source: TUM

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TUM-GS: Subject-related training



- Quantitative and qualitative research methods and instruments
- Regular doctoral colloquia
- Self-organized journal clubs
- Visiting scholars programs
- Research retreats
- Symposia and conferences
- Summer and winter schools
- Doctoral days
- Prizes
- Certified project and quality management courses
- ...

Source: TUM

Excellence Initiative: Subject-related training

Scientific Competences to be promoted at a German Graduate School of Excellence

- The intellectual capability to **analyze complex situations** and problems in a **methodologically and scientifically sound** and reliable manner
- Expert knowledge in the application of **modern research instrumentation and computer-assisted methods** in the area of XXX development, quality control and safety issues
- Broad and general knowledge in the area of XXX science which forms the basis of products and devices to be used in and developed for **advanced technologies** where XXX act as drivers of **innovation**
- **Socio-economic and ecological aspects** of XXX science in the context of developing and maintaining national and international wealth.

Source: Dr. Sybille Reichert, Reichert Consulting (2007)

TUM-GS: Sport and Health Sciences I

Doctoral candidates

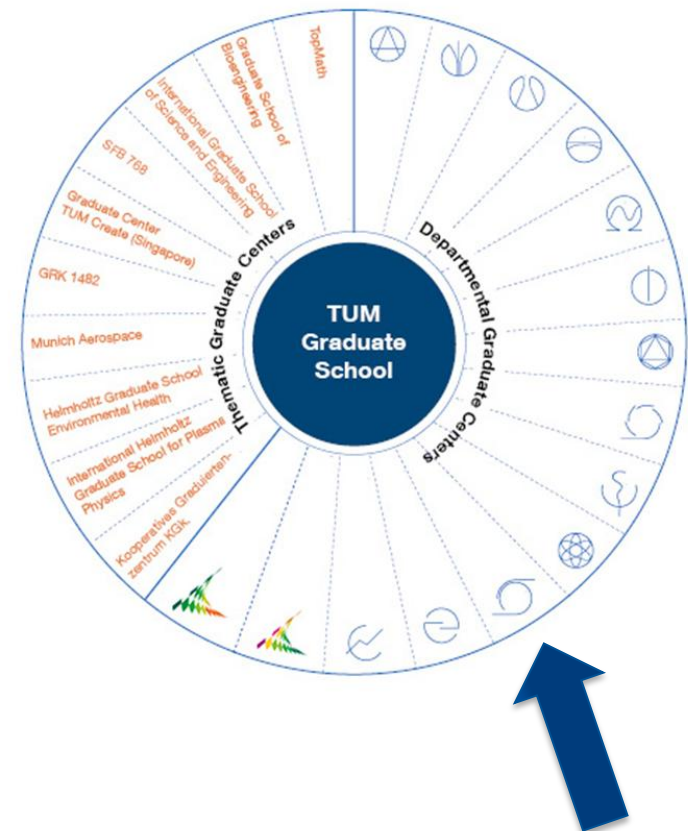
- about 20 per year, 50% female
- 13% international, 50% from TUM
- 16% study for Dr. rer. nat.

Program

- 80 Credit Points
- Core program of
 - Doctoral Colloquium – participation and presentation
 - Winter School
- Selection of Workshops, Presentations, Colloquia

Highlights

- “Editor Series” – editors from renowned journals present their journals, offer workshop on publishing and preparing manuscripts
- Poster Presentation as part of departmental dies academicus



Source: TUM

TUM-GS: Sport and Health Sciences II

Winter School

Doctoral candidates of department strive to the top – and once a year meet on top of the mountains!

- 5 days of presentations, discussions and (snow sport) activities
- opportunity to present doctoral projects in their early stages,
- feedback and coaching from peers, professors of the department, invited experts
- International flair: invited experts and doctoral students from international partner institutions



Source: TUM

TUM-GS: Life and Food Sciences

Graduate Center Building (2016)

One-stop service, networking and interaction point for doctoral candidates:

- centrally on campus
- barrier-free
- 2 seminar rooms (for 16 + 24 persons)
- think tank room
- meeting facilities
- doctoral lounge
- administrative offices



Source: TUM

TUM-GS: Electrical & Computer Engineering

Candidates

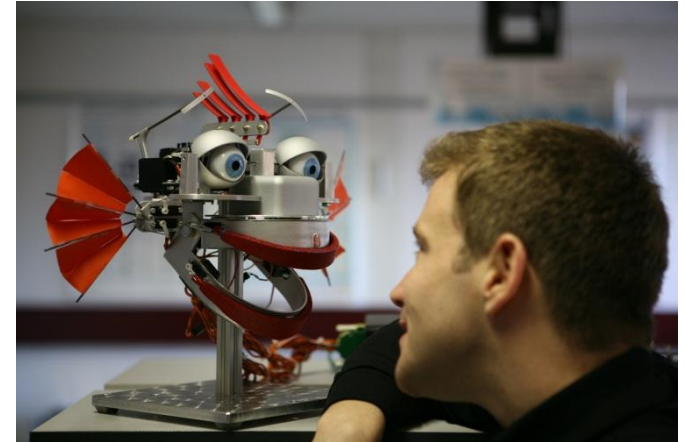
- 318 members
- 17% female
- 44% international

Graduates

- ~85 beginners per year
- ~80 graduates per year
- 37% international graduates in 2015

Highlights/New developments

- 5 prizes for doctorates every year
- Support of interdisciplinary workshops for doctoral candidates
- New in 2016: Doctoral candidates organize a lecture series within the Centers of Competence



Source: TUM

TUM-GS: Electrical & Computer Engineering

Lecture series

Methods, technology and systems developed by electrical engineers are used almost everywhere, spanning from the automotive industry to medicine or from telecommunications to satellite navigation. The TUM Department of Electrical and Computer Engineering addresses this widely spread area by focusing its research activities in nine Centers of Competence (CoCs), where research groups cooperate together on extended research topics.

Goals:

- top lectures from renown international speakers
- networking of doctoral candidates from different chairs within the CoCs
- reinforcement of the scientific and interdisciplinary exchange at the level of the doctoral candidates within the CoCs



Source: TUM

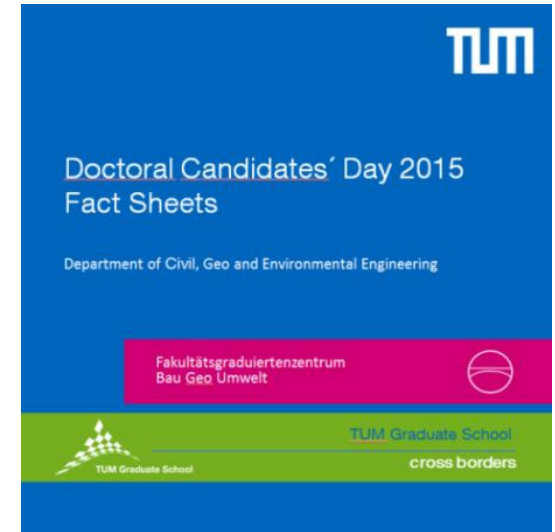
TUM-GS: Civil, Geo & Environmental Engineering

Doctoral Fact Sheets

In order to promote networking and exchange within the department and TUM as well as with current and future project partners, the Graduate Center publishes all fact sheets of doctoral projects on the website.

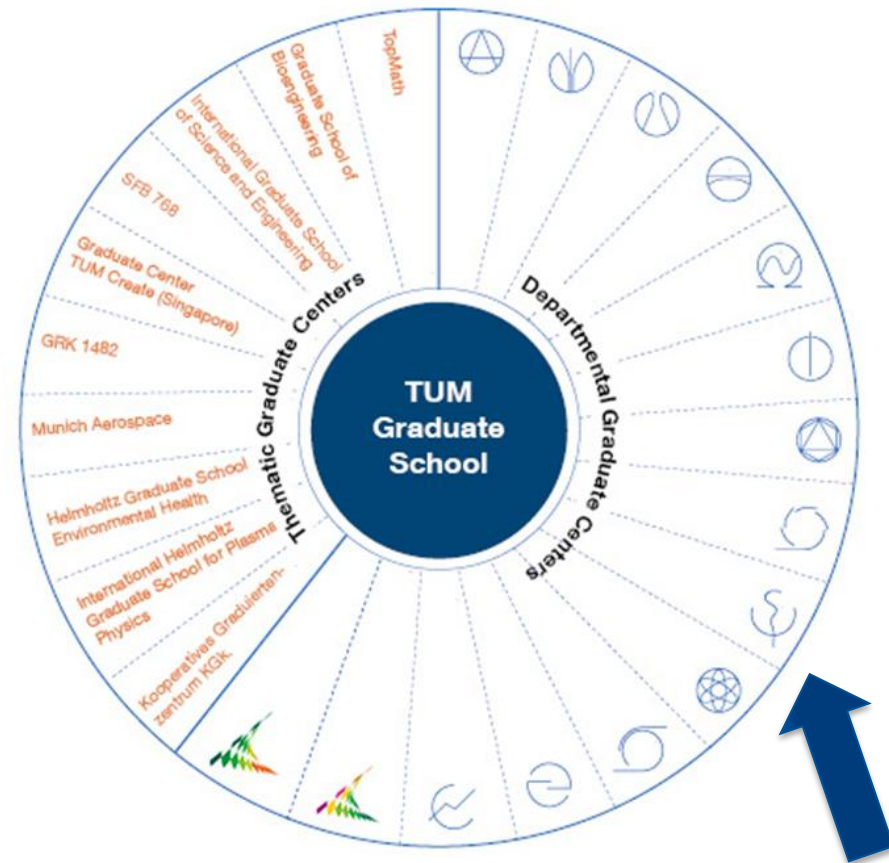
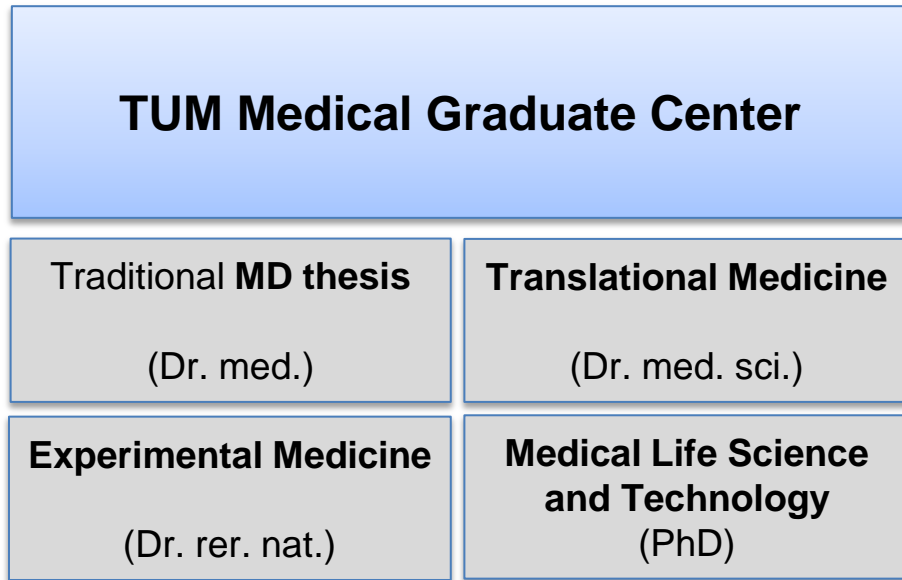
Each fact sheet is assigned to the respective chair within its focus area and can be quickly found on the website.

Fact Sheet	
Focus Area Construction	Lehrstuhl für Computergestützte Modellierung und Simulation Automated construction progress monitoring using BIM-based point cloud processing 📄 Mehrskalige Modellierung von Personenstrommodellen 📄
Focus Area Mobility and Transportation Systems	Modelling and Simulation of Holistic Spatial Cognitive Based Pedestrian Behaviour 📄 Representation and Refinement of Multi-Scale Parametric Geometrical Models by Graph Transformation 📄
Focus Area Modeling-Simulation-Processes	
Focus Area Water-Soil-Air	Lehrstuhl für Hydromechanik in Arbeit
Focus Area Geodesy	Professur für Risikoanalyse und Zuverlässigkeit



Source: TUM

TUM-GS: Medical Graduate Center I



Source: TUM

TUM-GS: Medical Graduate Center II

Traditional MD thesis (Dr. med.)

- Eligible: medical students/graduates
- Most commonly awarded degree (~180/year)
- **Flexible duration, no full-time research required**

Translational Medicine (Dr. med. sci.)

- Eligible: medical students/graduates
- **1 year full-time research, 2 years part-time**
- **Project selection, course program and stipends provided**


Promotionsprogramm
Translationale Medizin
**Informationsveranstaltung und
Projektbörse**

- Strukturierte wissenschaftliche Ausbildung
- Vorab geprüfte Promotionsthemen
- Unterstützung durch Stipendien
- Persönliche Betreuung
- Großes Angebot an überfachlicher Qualifizierung

Freitag, 06. Februar 2015, Hörsaal C, 15:00 Uhr s.t.

TUM Medical
Graduate Center

TUM Graduate School
cross borders



Source: TUM

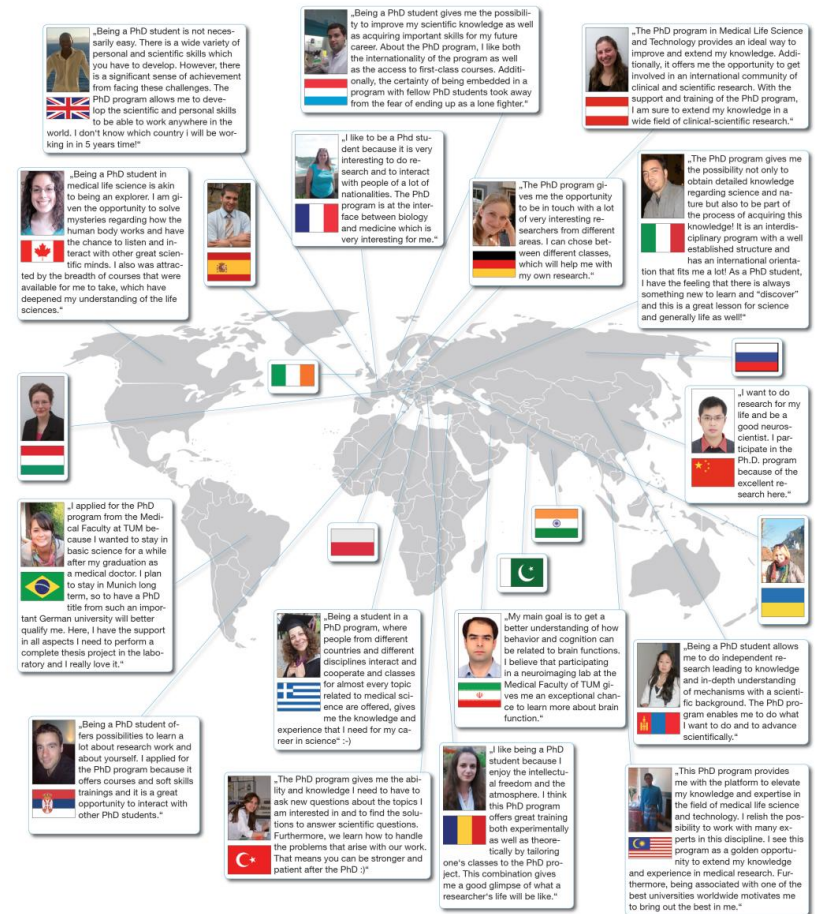
TUM-GS: Medical Graduate Center III

Experimental Medicine (Dr. rer. nat.)

- Eligible: natural science graduates
- **3-4 years full-time research**
- In collaboration with TUM science departments

Medical Life Science and Technology (PhD)

- Eligible: medical students/graduates, scientists, engineers
- Competitive application process:
~15% admission rate
- **3-4 years full-time research**
- Students enrolled in program
- Program language: English
- **Tailored course program (180 credits)**
- 60% international students

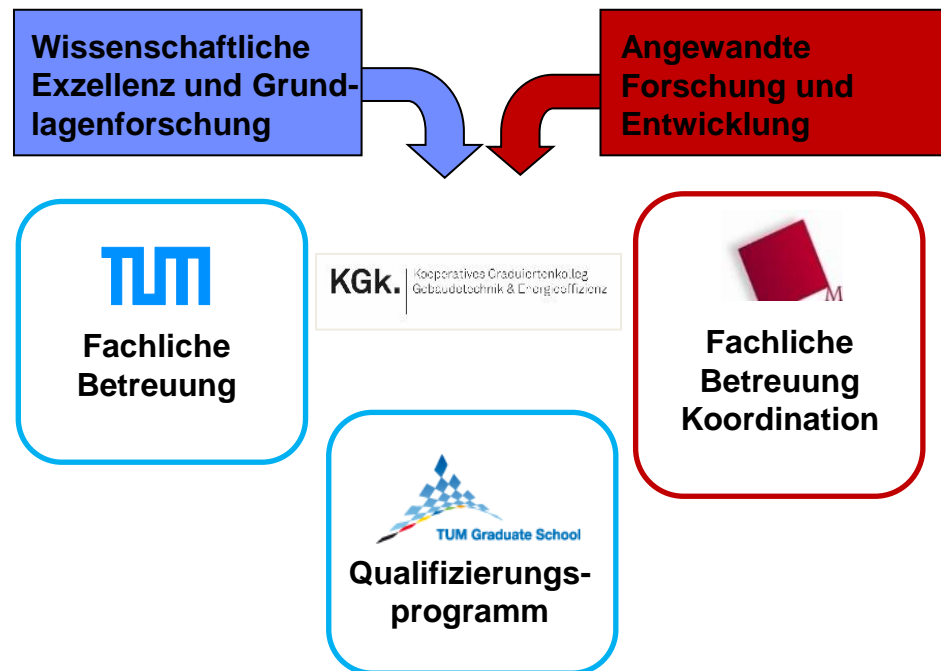


Source: TUM

TUM-GS: Cooperation with Univ. of Applied Sciences

Cooperative Graduate Program ‚Building Technologies & Energy Efficiency‘

- Interdisciplinary research and innovations for application in buildings and power supply
- 15 doctoral candidates, jointly supervised by TUM and AUS professors
- disciplinary and soft skills training program



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Summary and lessons learnt

- define clear and convincing **mission** according to profile of the university
- focus on the **strengths**
- involve **partners**
- incorporate **international** standards
- work with and get backing from university **leadership**
- involve and **communicate** with all parties during all project phases
- prepare a quick **start** with high visibility
- put offers and structures that benefit **doctoral candidates** first
- secure sustainable **funding**
- **adjust** program as needed



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