Problems and Challenges in Education in ICT at the Poznan University of Technology

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Outline of the presentation

• Introduction
  • Some facts about Poznan University of Technology (PUT)
  • Recent reform of universities and academic life in Poland
  • Methods of verification of scientific quality of academic units
  • How ICT (Information and Communication Technologies) is positioned among scientific disciplines
• Admission process in ICT studies
• Description of fields of studies in ICT offered at PUT
  • Computer engineering, Bioinformatics, Electronics and Telecommunications, Teleinformatics, Artificial Intelligence
• Artificial Intelligence – a new study field offered at PUT
• Relations with Industry – Cooperation or Competition on student and scientists’ levels
• Conclusions
Introduction

- Some facts about Poznan University of Technology:
  - Established in 1919 as the school of mechanical engineering
  - Full university rights since 1955
  - Currently 9 faculties:
    - Architecture
    - Chemical Technology
    - Civil and Transport Engineering
    - Computing and Telecommunications
    - Control, Robotics and Electrical Engineering
    - Engineering Management
    - Environmental Engineering and Energy
    - Materials Engineering and Technical Physics
    - Mechanical Engineering
  - Over 16000 students and 1300 academic staff members

View of the main PUT campus
Recent reform of higher education and science in Poland

- The aim: to make our universities more competitive in the world,
- Limited number of scientific disciplines from over 100 to 43.
- Information and Communication Technologies – the official name one of the disciplines (Computer engineering and telecommunications)
- Computer Science – another scientific discipline associated with more theoretical and algorithmic version of informatics
- PUT has reacted to the ministerial reform – the new structure of university faculties has been established (shown in the previous slide)
- Doctoral students who are grouped in doctoral schools and receive scholarships funded on the basis of the ministerial subvention
• There is high flexibility in division of the received subvention among different costs covered by a university

• Academic rights and the height of ministerial subvention will depend on the results of categorization of scientific disciplines present at the given university:
  • Categories: A+, A, B+, B, and C
  • Full academic rights will be given to the disciplines of categories A+, A and B+
  • Academic rights are e.g. promotion of PhDs, Dr. of Science (habilitation), defining own curricula of the fields of studies
  • There is a national level contest for, so called, scientific universities, the best units which should be the leaders in science and academic education
  • So far our faculty consists of units of category A
• Doctoral schools – important element of the academic reform
  • So far performing PhD was done within doctoral studies - a PhD student could be supported by scholarship or not
  • Changing organization from many doctoral studies specific for each former discipline to unified doctoral schools:
    • University decides about the fund supporting doctoral school
    • There is a single doctoral school at PUT
    • Each PhD student admitted to the doctoral school receives a scholarship which is attractive for humanists (art students) but not for ICT PhD students
    • Candidates are accepted from all over the world
    • There is high competition in admission as the number of scholarships is limited
    • My opinion: Insufficient number of PhD scholars to maintain the number of academic staff members and replace those who will be retired
Admission process at PUT is fully computerized and centralized

The results from a state level matriculation examination are converted to the ranking points according to the following formula

\[ W = 0.5 \cdot J_P + 0.5 \cdot J_O + 2.5 \cdot M + 2 \cdot X \]

where:
- \( J_P \) – the basic exam score (in percent) in the Polish language
- \( J_O \) – the basic exam score (in percent) in a foreign language
- \( M = M_{\text{basic}} + M_{\text{extend}} \) – the sum of percentage scores obtained in exams in basic and extended levels in mathematics
- \( X = X_{\text{basic}} + X_{\text{extend}} \) – the sum of percentage scores obtained in exams in basic and extended levels in an additional subject (physics, informatics, chemistry, biology)

- Maximum \( W = 1000 \) points can be obtained
The candidates declare the priority list of their preferred study fields.

The computer system sorts the candidates according to their preferences and admission limits at particular fields of studies.

The candidates can apply for admission to other universities at the same time.

To become a PUT student in the ICT area in 2019/2020 academic year admission it was required to obtain at least:

- 850 points in case of computer science/engineering (informatics)
- around 650 points in case of teleinformatics
- more than 550 points in case of electronics & telecommunications

**Conclusion:** Studies in ICT are highly desirable and popular.
Admission process in ICT studies

• Problems faced by freshmen in the ICT studies:
  • High competition among students who have been used to be among the best in their high schools – sometimes consulting of a psychologist is even desired
  • Mathematics, programming and learning skills can be problems for freshmen
    • High school students are taught how to pass tests and matriculation exams but not how to think creatively
    • Insufficient abilities to think in an algorithmic way needed in programming – the results of poor education in computer science in less advanced high schools
    • Easy finding of solutions to the stated problems on the Internet is another negative factor
  • Preparatory courses in math and physics are organized before the start of academic year for those freshmen who had lower scores
• Studies in Poland are organized in conformance with the Bologna process
  • B.Sc. – 7 semesters (Engineer)
  • M.Sc. – 3 semesters (Master of Science)
  • One to two semesters can be spent on Erasmus+ exchange programs at foreign universities
  • Previously: unified 10 semester studies finishing with M.Sc. Degree
  • After obtaining B.Sc. students can change the field of their studies
  • **In case of ICT the labor market is a serious competition against the decision of undertaking M.Sc. studies**
  • Separate admission process for the second level studies
  • Part time job is popular among M.Sc. students - „collecting the job experience” to enrich CVs and become more competitive
  • PhD programs are the third level studies
Fields of studies offered by the Faculty of Computing and Telecommunications:

- **Computer Science** (B.Sc. and M.Sc. in Computing) – B.Sc. studies in Polish and M.Sc. studies in Polish and English – 180 admitted persons on the BSc level
- **Bioinformatics** (B.Sc. and M.Sc. studies in Polish) – 60 admitted persons
- **Electronics and Telecommunications** (both B.Sc. and M.Sc. In Polish and English) – 150 admitted persons + 30 international students (in English) – on the BSc level
- **Teleinformatics** (B.Sc. and M.Sc. in Polish) – 150 admitted persons.
- **Artificial Intelligence** (since October 2019, B.Sc., in English only) – 30 admitted persons – probably the first field of studies devoted to AI in Poland at this moment.
Fields of studies in ICT at PUT

- Long tradition of ICT studies at PUT:
  - Studies in electronics and telecommunications since 1975
  - Studies in computer engineering/science since 1976
  - Studies in teleinformatics since 2015 – the response of the Faculty of Electronics and Telecommunications to the demand of the region for ICT engineers – inter-disciplinary studies and telecommunications and computer engineering
  - Studies in bioinformatics – inter-university studies led by PUT and the Faculty of Biology at Adam Mickiewicz University in Poznan – specialization in genomic calculations
  - Studies in AI – since 2019 – response to the AI development and applications in several disciplines of science and economy
Fields of studies in ICT at PUT

• Profile of the teleinformatic studies:
  • The studies merge knowledge in telecommunications and IT programming
    • Graduates are competent in computer and communication systems and networks
  • Graduates are able to:
    • write programs performing engineering calculations,
    • write software for modeling of communication systems, protocols and algorithms
    • understand digital systems, methods of encoding and transmission of multimedia,
    • write mobile applications for Android and iOS,
    • understand data bases, computer graphics, operating systems, etc.
Selected subjects taught in the field of Teleinformatics

<table>
<thead>
<tr>
<th>Semester 1</th>
<th>Semester 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>Algorithms and data structures I</td>
</tr>
<tr>
<td>Mathematical analysis 1 (Calculus)</td>
<td>Mathematical analysis 2</td>
</tr>
<tr>
<td>Foundations of measurement techniques</td>
<td>Physics</td>
</tr>
<tr>
<td>Basic internet services</td>
<td>Local ICT networks</td>
</tr>
<tr>
<td>Introduction to telecommunications</td>
<td>Computer system architecture</td>
</tr>
<tr>
<td>Foundations of ICT networks</td>
<td>Probability and statistics in telecommunications</td>
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</tbody>
</table>
Selected topics taught in Teleinformatics (cont.)

<table>
<thead>
<tr>
<th>Semester 3</th>
<th>Semester 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algorithms and data structures 2</td>
<td>Devices in ICT networks</td>
</tr>
<tr>
<td>IP networks</td>
<td>Introduction to radio techniques</td>
</tr>
<tr>
<td>Foundations of electronics</td>
<td>Object programming languages</td>
</tr>
<tr>
<td>Signals and systems</td>
<td>WWW and script languages</td>
</tr>
<tr>
<td>Operating systems</td>
<td>Digital techniques</td>
</tr>
<tr>
<td>Optical fiber networks</td>
<td>Digital signal processing</td>
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<td></td>
<td>Digital communication systems/Digital modulations (Elective course)</td>
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</tbody>
</table>
# Fields of studies in ICT at PUT

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<table>
<thead>
<tr>
<th>Semester 5</th>
<th>Semester 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Databases</td>
<td>Security in ICT systems</td>
</tr>
<tr>
<td>Microprocessor programming</td>
<td>Computer graphics</td>
</tr>
<tr>
<td>Monitoring and performance assessment of packet networks</td>
<td>Software engineering</td>
</tr>
<tr>
<td>Signaling and management systems</td>
<td>Passive optical networks/Optical access links (elective course)</td>
</tr>
<tr>
<td>Introduction to multimedia</td>
<td>Programming of mobile terminals / (Android)</td>
</tr>
<tr>
<td>Synchronization of ICT devices and networks/Reference time and frequency</td>
<td>Programming of mobile terminals (iOS) (elective course)</td>
</tr>
<tr>
<td>signal distribution (elective course)</td>
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</tbody>
</table>
### Semester 7

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming and configuration of network nodes/Network operating systems/Cybersecurity</td>
<td>(elective course)</td>
</tr>
<tr>
<td>Distributed systems for data acquisition/interfaces in measurement systems</td>
<td>(elective course)</td>
</tr>
<tr>
<td>Basics of entrepreneurship</td>
<td></td>
</tr>
<tr>
<td>History of telecommunications and computer science</td>
<td></td>
</tr>
<tr>
<td>Diploma seminar</td>
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<tr>
<td>Engineering thesis</td>
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</tbody>
</table>

- Joint number of teaching hours: 2596
- Number of ECTS points: 210
- Additional courses: sport, English language (3 semesters), Elements of philosophy/Elements of sociology and ethics

In general:
- **Tuition fees cannot be requested from EU students, unless they are part time or evening students, or have arrived from outside EU**
Studies initiated in the academic year 2019/2020
First program of studies entirely devoted to AI in Poland
Study language: English
Knowledge obtained during B.Sc. studies in in Artificial Intelligence:
- theoretical knowledge associated with the key problems of computer science related to artificial intelligence,
- Practical competence in algorithmics, machine learning and neural networks, data analysis and data mining, acquiring and processing of information, optimization techniques, decision analysis, and applications of artificial intelligence in robotics.
- The studies prepare the student for efficient programming according to the art of programming rules using popular programming languages.
- The studies teach how to use operational systems, databases, computer networks and a wide spectrum of information systems.
# Introduction to mathematics for computer science

<table>
<thead>
<tr>
<th>Semester 1</th>
<th>Semester 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to mathematics for computer science</td>
<td>Linear algebra</td>
</tr>
<tr>
<td>Calculus I</td>
<td>Introduction to probability</td>
</tr>
<tr>
<td>Introduction to Artificial Intelligence</td>
<td>Calculus II</td>
</tr>
<tr>
<td>Discrete mathematics</td>
<td>Computer architecture with low-level programming</td>
</tr>
<tr>
<td>Introduction to programming</td>
<td>Algorithms and data structures</td>
</tr>
<tr>
<td>Introduction to computing</td>
<td>Operating systems with concurrency programming</td>
</tr>
<tr>
<td>Artificial life with cognitive sciences</td>
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</tr>
<tr>
<td>Semester 3</td>
<td>Semester 4</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Statistics</td>
<td>Software engineering</td>
</tr>
<tr>
<td>Information theory / Data compression methods</td>
<td>Computer networks</td>
</tr>
<tr>
<td>methods (elective course)</td>
<td>Machine learning</td>
</tr>
<tr>
<td>Object programming</td>
<td>Elements of convex optimization / Optimization methods for data analysis</td>
</tr>
<tr>
<td>Database systems</td>
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</tr>
<tr>
<td>Artificial intelligence</td>
<td>Data mining</td>
</tr>
<tr>
<td>Combinatorial optimization / Discrete</td>
<td>Data visualization / Graphics (elective course)</td>
</tr>
<tr>
<td>optimization (elective course)</td>
<td>Robotics I</td>
</tr>
</tbody>
</table>

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Artificial Intelligence – a new study field
Artificial Intelligence – a new study field

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<table>
<thead>
<tr>
<th>Semester 5</th>
<th>Semester 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep learning</td>
<td>Natural language processing</td>
</tr>
<tr>
<td>Internet applications</td>
<td>Decision analysis / Decision support (elective course)</td>
</tr>
<tr>
<td>Operational research/ Industrial engineering</td>
<td>Big data and distributed processing / Theory and practice of processing big data (elective course)</td>
</tr>
<tr>
<td>Information retrieval</td>
<td>Reinforcement learning and multi-agent systems/Computational intelligence (elective course)</td>
</tr>
<tr>
<td>Innovative entrepreneurship</td>
<td>Robotics II</td>
</tr>
<tr>
<td>Problem classes I: data analysis / artificial intelligence (elective course)</td>
<td>Problem classes II: machine learning / artificial intelligence</td>
</tr>
<tr>
<td>Computer vision / Signal processing</td>
<td>Ethics and research</td>
</tr>
<tr>
<td></td>
<td>Vocational internship (4 weeks)</td>
</tr>
</tbody>
</table>
### Semester 7

<table>
<thead>
<tr>
<th>Course</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cybersecurity</td>
<td></td>
</tr>
<tr>
<td>Semantic web and social networks / Man-machine interaction / Declarative programming and expert systems (elective course)</td>
<td></td>
</tr>
<tr>
<td>AI and games / Evolutionary computation (elective course)</td>
<td></td>
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<tr>
<td>Internet of things / Spiking neural networks (elective course)</td>
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</tr>
<tr>
<td>Diploma seminar</td>
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<tr>
<td>Preparation for scientific research</td>
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<tr>
<td>Diploma thesis preparation</td>
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<tr>
<td>Bachelor's capstone project</td>
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</tbody>
</table>

- Joint number of teaching hours: 2508
- Number of ECTS points: 210
Sources of funding research at PUT:

- **A part of ministerial subvention** (maintaining research capabilities, participation at conferences, payment for journal publications and monographs, maintaining the university library and purchase of new books, paying for the access of databases, such as IEEExPlore, Web of Science, Elsevier and Wiley journals, etc.)

- **National Science Center** (NCN) – distributes funds on a competitive bases to perform basic research (investigations).
  - Accepted projects receive funding for a time interval not longer than three years (direct costs: materials, books, travel, etc., and indirect costs, such as administrative costs),
  - special funds for young doctoral students and postdocs who work in projects - one of the methods to keep young and intelligent students, graduates and newly graduated doctors at the university.
  - Obtaining funding for a project is a difficult task. The average success rate: 15–20 percent.
Sources of funding research at PUT (cont.):

- **National Center for Research and Development** (NCBR):
  - Mainly an administrative tool to activate innovations in the Polish industry.
  - Calls for particular project proposals are frequently announced.
  - Typically enterprises (small, medium and large) are to be attracted and they often build consortia with academic units.
  - Another solution: to perform subcontracting of an academic unit within a project funded by NCBR.
  - Such research has practical importance, as it often has to finish with a model or prototype of a device.

- **European Commission** (EC): the source of substantial funding with restrictive rules of covering direct costs
  - The projects are performed in scientific consortia with a substantial participation of industry.
  - In telecommunications and ICT, the main policy of the EC is to make European industry more competitive with respect to Chinese and American companies,
  - Academic partners have problems with joining or being invited to a consortium built for the project application.
Sources of funding research at PUT (cont.):

Projects funded by industry (domestic or international):

- Require special discipline of the whole team and full time engagement
- Fast response to industrial needs is necessary,
- Short time scale projects
- Examples of cooperation with international industry in our faculty in telecommunication area: Nokia Networks, Huawei Sweden, ETRI (South Korean research institute)

Cooperation or competition with industry?

In telecommunication area:

- although jobs in the industry offer better salaries, motivated young scientists do not leave their teams if interesting projects are performed,
- Projects result not only in developing new ideas while obtaining new scientific degrees, but also lead to additional salaries.
- An additional aspect: a positive atmosphere of cooperation within the team created mostly by the team leader leads to maintaining the team.
Relations with industry – cooperation or competition?

• Cooperation or competition with industry?
  • In computer science area:
    • The job market demand is even stronger than in telecommunications due to the salary level on it.
    • Universities have serious problems with keeping young scientists at the academia.
    • Despite that, highly motivated young scientists will remain at the university if it offers highly innovative research topics supported with additional royalties resulting from the performed projects.
    • In Poland, further academic career for the majority of PhDs in telecommunications and computer engineering has so far been almost guaranteed.
    • As the innovative industry develops, more and more PhDs will find jobs in R&D industrial centers.
    • We need to accept that the labor market is basically internationally open, so our graduates, if they represent appropriate scientific and social level, can find jobs basically in the whole EU and outside of it.
• **Conclusions:**
  
  • Both computer science and engineering, as well as telecommunications courses offered by PUT attempt to satisfy the current high demands from industry for the employment of graduates.
  
  • All graduates find good jobs, however, it also leads to substantial problems with attracting the best students to academic research and pursuance of scientific degrees.
  
  • Solving the latter problem strongly depends on governmental academic funding and the level of salaries offered to scientists.
  
  • The solution also depends on the level of activity of particular research teams in acquiring research projects which are attractive from the scientific and financial points of view.
Thank you for attention!

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