# MECHANICAL ENGINEERING EDUCATION AND RESEARCH IN US AND GERMAN UNIVERSITIES

*A personal perspective by*
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The following factors significantly affect engineering education and research in general and mechanical engineering in particular. The observations given below are of general nature. Undoubtedly there are exceptions to these general statements

## 1. Engineering faculty (professor)

1.1. **Industry Experience** – The typical faculty in the U.S. universities does not have industry experience (in Germany 10 to 15 years industry experience was a rule until recently). As a result communication between the engineering college and industry (relevance of university education and research for industry) is not very strong. During the last two decades the National Science Foundation (NSF) encourages industry/university relations through the support of Engineering Research Centers.

1.2. **Promotion / Tenure** – Typically, young faculty starts as an Assistant Professor and he/she is promoted to Associate Professor (and later to Full Professor) and granted tenure after publishing "refereed" papers and bringing in research dollars. His/her performance is evaluated by faculty committees.

1.3. **Support / Position** – A new professor does not have any "Institute" or "Chair". He/she may be able to build up an institute or center structure by bringing in external funding. Prominent professors may receive an "endowed chair" based on their reputation and how they negotiate their new position in exceptional cases. For example, if they change universities or they come after many years of research in industry or in an independent research organization.

Faculty support, as in Germany, in terms of assistants or technicians does not exist since there is usually no "Institute" structure. A professor may be assigned teaching assistants when teaching large classes or may have research assistants that he/she supports from research projects.


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## 2. Students

2.1. **High School Graduates** – Studies conducted during the last decade clearly indicate that the U.S. high school students score on math and science, on average and with the exception of those who attend private and selected schools, repeatedly lower than students of other countries. It is estimated that among U.S. high school graduates a relatively small percentage (10 to 12 %) have adequate background to study engineering even if they elect to do so. Many first year college students in the U.S. must have remedial classes in order to continue their education. Furthermore, compared to their German counterparts, the U.S. first year students (freshman) are younger (17 to 18 years old) and do not have an apprenticeship or similar engineering-related work experience.

2.2. **Financing Engineering Education –** With very few exceptions, most American students must pay tuition and fee for higher education. As a result many must work to earn money and/or have debts to finance their education. This is one of the reasons why relatively few American students go to graduate school to work towards an MS or a PhD degree. They are either exhausted from working and studying simultaneously and are in considerable debt or they are not able to make the grades necessary to enter the Graduate School.

2.3. **Practical training –** In some U. S. engineering colleges "cooperative work" is encouraged (i.e., work one quarter (or semester) and go to college the next). This is similar to German Praktikum (26 weeks) but it is not as well structured as the Praktikum where a student is exposed to various manufacturing processes and equipment. Nevertheless, American graduates who have coop experience are preferred by industry.

2.4. **University Employment** – An extremely positive aspect of the German University system in engineering is the number of students working part time as student assistants or "Hilfswissenschaftler" or "Hi-Wi" during their studies. The advantages of this arrangement are:

- The student can work in an institute and advised by a PhD candidate and gain exposure to engineering research.
- The job may be steady, on Campus, and related to engineering.
- The job may lead to one of the student's projects and possibly motivate the student to continue his education.

This arrangement is possible only in exceptional cases in the U.S. engineering colleges.

2.5. **International students –** In undergraduate school (before BS) about 10 to 15% of the students may be from foreign countries. In graduate school (MS and PhD), however, more than 50% of the students are from foreign countries. Nearly 75% of all new PhD

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degrees are granted to international students. Fortunately, a large percentage (may be 50% or more) of foreign students remain in the U.S due to flexible immigration and visa policies. Foreign nationals who graduate from U.S. universities are automatically granted an 18-month "training visa" if they could find employment. Usually, the "valuable" graduates (with M.S. and Ph.D. degrees) are offered permanent employment, and temporary visas with help from their employers.

## 3. Educational Structure

3.1. **The university system** – In the U.S., as in many other countries we have the British educational system, i.e. BS, MS and PhD. Many engineering colleges have, in addition to engineering, an engineering technology education that is more practice oriented. In addition there is a system of community colleges that may be compared with the German "Fachhochschulen." Some U.S. colleges use the "semester" system while others use the "quarter" system.

3.2. **Position of engineering in the university system –** Most engineering colleges are part of a large university. The Institute of Technologies, i.e. RPI, MIT, IIT, Caltech are exceptions. As a result, the administration of a large university affects the organization in the engineering college. The situation is entirely different in Germany where engineering is the main portion of the Technical Universities (formerly Technische Hochschule). This situation has major implications regarding expenditures for laboratories, institutes, etc.

3.3. **Ranking of universities and colleges –** In the U.S. there are vast differences of quality (as measured by performance of graduates, expenditures per student, facilities, etc) and a generally accepted ranking system among engineering colleges. Most private universities and a few public universities are considered to be academically superior to the remaining group of "average" schools. Thus, in discussing the excellence of U.S. engineering schools it is necessary to consider this situation regarding which specific schools are considered.

3.4. **Science versus engineering –** The general perception is that in the U.S. the engineering schools are more science oriented than in Germany. While this is an asset in certain disciplines it is not necessarily an advantage in mechanical engineering education and research.

3.5. **Design and manufacturing** – These activities are very important in engineering, in particular in mechanical engineering. This activity starts in German universities during the first year by conducting a series of small projects in conjunction with the Machine Elements courses. In the U.S., in general there is only one "senior project" course where students are involved in design related work. In general this "senior project" is not sufficient to well prepare ME graduates with a BS degree for a position in industry. Thus, BS graduates need considerable, nearly two years, of on the job training before becoming a net contributor to their company.
Students need "projects" throughout their studies in order to learn how to work


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independently, how to communicate with others and to learn "how to learn." This aspect of engineering education appears to be more successful in Germany than in the U.S.

3.6. **Graduate School** – Entrance to most graduate schools requires good grades and obtaining a certain number of points on the "Graduate Record Examination." Thus, foreign students have a distinct advantage in entering graduate school in the U.S., as they are usually the "most successful" students from their countries and universities.

The MS program takes usually two years and requires a certain number of courses. Most MS programs also require a thesis although it is possible to obtain an MS degree without completing a thesis. This is a flaw in the system because without a thesis the graduate has no experience in self-study, self-learning and research.

The Ph.D. program takes about three to four years and requires also certain number of courses and a dissertation. In contrast, in Germany, PhD candidates are not required to take courses, they work full time as research engineers and usually they are older and more experienced than their counterparts in the U.S.

## 4. University Administration

In the U.S. the presidency of a university is a "permanent" job. The dean position is also a full time professional job. Many deans and presidents move from one university to another to obtain better pay, prestige or position. This situation may disrupt long-range plans and activities.

4.1. **Public and Private Universities** – The universities are public (state supported) or private. Private universities usually have large endowments and investments. They receive considerable income from their investments and donations of their alumni. State Universities depend on their budget determined by the state legislature. Both universities receive tuition and fees that may reach up to $20,000 per year or more. Public universities offer a fee discount to the residents of their own state.

4.2. **Federal and State Support** – Both public and private universities try very hard to obtain research funding from federal and state sources.

State funds (in addition to the allocated educational budget) for research may come from various departments of the state government. Most states encourage "matching funds", i.e. require that the university researchers should obtain federal funds in order to apply for state funds.

The major and most prestigious federal funding source for university research is the National Science Foundation (NSF). Other federal agencies, such as the Departments of Defense, Energy and Transportation also support university research. The U.S. does not have a separate Cabinet department, as does Germany, for research and development.

A major influence upon R&D funding is the identification of "popular" areas by NSF. Nowadays, for example, research support for nanotechnology, biotechnology, environmental technology and information technology are favored because the perception is that these are the areas of the future. As a result, "classical" mechanical


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engineering areas such as machine tools, transportation technology and manufacturing are not much in favor.

## 5. Summary

Mechanical Engineering education and research in US and Germany have different and unique features that affect the quality and performance of graduates. Thus, it may be useful for educators and policy makers, involved in the improvement of engineering education, to be aware of both the systems towards the possibility of utilizing the best features of both.

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