COMPARISON OF COURSES AT UNIVERSITIES IN THE USA AND IN GERMANY - CONTENT, TEACHING AND LEARNING METHODS, PERFORMANCE ASSESSMENT AND GRADING

J. Günther[1], J. Widmann[2]

[1]Hochschule München, University of Applied Sciences (GERMANY)
[2]California Polytechnic State University (UNITED STATES)

Abstract

This study compares lectures in the USA and Germany using the example of a course in Engineering Statics at Cal Poly (California Polytechnic State University) and at HM (Hochschule München, University of Applied Sciences).

Courses in Statics are part of all Engineering study programs and the content has been very stable over decades. Application knowledge in statics is an important prerequisite for subsequent engineering courses and a foundation for the engineering profession. The subject of statics is very demanding for many students because, in addition to understanding the theory, you have to practise intensively to develop the skills to imagine the effect of forces and moments on rigid bodies and to sketch free body diagrams.

The way in which material is taught at universities of applied sciences has developed over the last decade from traditional "Sage on the Stage" instructor focused lectures to seminar-style teaching with active interaction between the students and the lecturer. For example, there are sections in the course where students work on problems individually or in small groups (see Section 3.7 below).

The courses "Engineering Statics" (ES) at Cal Poly in the Mechanical Engineering degree program and the contents in the module "Technische Mechanik" (TM) at the Munich University of Applied Sciences in the Industrial Engineering degree program are compared. The TM course in Munich is taught in English and German and the reference for the comparison is the English version of the course.

The ES course duration is one term of 10 weeks, the TM course duration is one semester of 15 weeks. Therefore, the TM course includes more content than the ES course. In addition to the statics of rigid bodies, the basics of elasticity theory and strength of materials theory are covered in the second half of the semester: Deformation, normal and tangential stresses and structural damage. This material is taught at Cal Poly in a follow-up course "Mechanics of Materials", for which ES is a prerequisite.

Who is the study interesting for?

- For lecturers and researchers who are interested in teaching and learning methods and their effectiveness across cultures.
- For lecturers who are currently working in another country and will be working in the USA or in Germany, e.g. in the context of a visiting professorship.
- This study may also be of interest to American students who will be studying in Germany or German students who will be studying in the USA.

The objectives of the study are to describe the courses and the condition of studying in several steps. In each step, commonalities and differences are shortly discussed. The parts of the study are the:

- Comparison of the contents of the lectures
- Pedagogical approach of the classes and the use of in class exercises and out of class assignments
- Use of formative and summative performance assessments

The goals of the paper are to highlight similarities and differences, thus creating a platform for discussion and pointing out possible directions for the development of teaching-learning systems.

Keywords: Higher education, descriptive study, course, intercultural, teaching and learning methods.

1 METHODOLOGY

The research method used for this study is a participatory observation as a lecturer in both courses ES and TM and a comparison of the main characteristics of both courses.

2 LIMITATIONS

This participatory study cannot be representative for Universities of Applied Sciences in the USA or Germany, which may have less focus on strong interaction with students and support for the learning process and are more research-oriented. However, learner-centered and interactive teaching has become an important topic at many universities in the US and Germany in the last decades. For example, the development of interactive teaching is addressed by the following authors [1, 2, 3]. We also compare two specific courses that undergraduate students take. These cannot give a picture of all courses from the beginning to the end of the study program. Moreover, the article is based on the authors' personal experiences as lecturers and therefore should not be generalized.

3 SURVEY

In the following sections, the characteristics of the ES and TM courses are discussed step by step. In Section 4, these are presented and discussed in an overview, and questions for further research are suggested.

3.1 Time frame of the courses

The quarter at Cal Poly consists of 10 weeks of lectures, in the 11th week of the term there is a uniform final exam. In the ES course there is a session of 50 min on Mon, Wed and Friday at the same time each day. In addition, the lecturers offer office hours for the students of the ES course - 2 approx. hours - in which they are available for questions about the lecture. The office hours also focus on assistance with the homework, which is graded (see below). Thus, for the instructor, the course includes about 3 hours of lecture and 2 hours of tutorial per week. The office hours are actively used by about one third of the students from the second week of the term based on the author´s experiences.

The semester at Munich University of Applied Sciences comprises 15 weeks of lectures with four sessions per week of 45 minutes each. These four sessions are scheduled in a block, i.e. 4 hours in one day with a break of 15 min after 90 min. The uniform final exam takes place in a two-week period following the lecture period. The lecturer at HM offers one hour office hours per week for all his courses. In the author's experience, this is used little during the semester and more frequently by students at the end of the semester.

3.2 Final Common Exam

The final common exam is used at both Cal Poly in ES and HM in TM, this means that each ES or TM instructor has the students in their course work the same problems in the exam. Likewise, a uniform correction and grading key is used for all ES and TM courses, respectively. The problems for the exam, as well as the correction and grading key, are developed collaboratively by the group of instructors. The duration of the exam at Cal Poly is 170 min, at HM it is 90 min. Based on the comparison of exams from several semesters, the exams in ES and TM are estimated to be of about the same difficulty, the problems at Cal Poly require longer calculations.

3.3 Number of Course sections and participants

Depending on student enrolment, between 6 and 14 ES course sections are offered at Cal Poly in each of the three quarters that make an academic year. In a typical year, 28 sections are offered by 8 to 10 different instructors. Courses are limited by lecture room size to 35 participating students. During the first week of the term, it is possible for a student to still change courses. Students firmly enrol in a course and with an instructor during the second week who then also assesses and grades them throughout the quarter.

At HM, three TM course sections are offered in the summer semester and 4 in the winter semester, defined by 150 and 200 first-year-students respectively, enrolled in the study program Engineering and Management. Each section is scheduled with 50 first semester students in a study group. It is possible at any time, even during the semester, for a student to change section. There is a free choice of section and examiner. So a student can listen to the lecture given by lecturer A and write the exam given by

lecturer B. Two other effects, the participation of repeaters and the optimization of the timetable lead to the fact that up to more than 100 students can appear in one lecture. A large number of repeaters who have failed the TM exam once or twice (see Section 3.8 for reference values of failure rates) attend the lectures at HM and the students try to optimize their schedule, e.g. to have a lecture-free day in the week. The time of day also has an impact on attendance. TM course sections that start at 8:15 hours in the morning usually have few participants.

If we add the number of repeaters to the first semester students and divide by the number of sections, the average section size in TM at HM is about 70 to 80 students.

3.4 Attendance

In the ES course at Cal Poly, attendance is compulsory for the students. If students cannot attend class for a valid reason, they excuse themselves beforehand.

At HM, there is no attendance requirement in the TM course. This means that students may not hear all of the lectures and then have to make up the content on their own. In rare cases, students who have never attended the TM lecture may take the exam.

3.5 Instructional materials

The ES course at Cal Poly is based on the textbook Vector Mechanics for Engineers – Statics/Dynamics [4]. This 1400+ page work contains both statics and dynamics content and features a very comprehensive collection of exercise problems for each chapter. Students typically purchase an electronic version of the book to use during the term.

The first 500 pages of the book (chapters 1 through 9) contain the theory of the ES course and the related problems for the course and for the assignments. The theory sections of the book are comprehensive and suitable for self-study. Not all of the content of the structural analysis section of the book is taught in the ES course. Therefore, ES instructors individually prepare a handout for their course that includes theory and exercises. The handout is provided to students both online as a pdf document via the Canvas Learning Management System and as a hard copy upon request.

At HM, the TM course is held with a lecture script [5] which one of the TM lecturers has prepared. All instructors use the same script and lectures are also timed so that the same content is taught in the same week in all courses. The script comprises the theory of the lecture on 144 pages in 24 chapters. For each chapter there are two to five application examples, which are worked on interactively in the lectures. In addition, the script contains a four-page collection of formulas that students may use in the final exam and a collection of homework assignments that students can work on in self-study until the next lecture. Students may ask questions about the homework assignments during office hours or at the beginning of the next lecture. The script will be provided to students online as a pdf document and as a hard copy upon request. As part of the course, students are also recommended other textbooks and assignment collections [6, 7] for independent study. These books can also be borrowed at no cost by the students from the HM library as an eBook or in hardcover format.

3.6 Lecture contents

In the following, the contents of the two compared courses are extracted in order to find congruent and different topics. Table 1 presents an overview of the contents of the ES and TM lecture structured according to the weeks of the term and semester.

When comparing the two courses, the following picture emerges: the contents of more than 8 weeks of the ES course are included in the 15-week TM course with high agreement. So, the TM course can be said to contain more than 80% of the ES content.

Due to the four session scope (4x45 = 180 min), more material can be taught per week in TM than in ES (3x50 = 150 min). In addition, the quizzes (see below) that occur each week reduce lecture time by about 15 min because they are done in the classroom. Other significant differences are notable. The matching topics are not taught in the same order in both courses, for example "Static and kinetic friction" is taught in ES in week 7 and in TM in week 4. Also in the TM course, only two-dimensional problems are covered in statics, but in doing so, unlike ES, graphical solution methods are covered, e.g., Culmann's method [5, p.32-33]. Some topics for example “Trusses” and “Frames and Machines” are taught to a much lesser scope in TM than in ES.

Table 1. Cutout of the comparison of the ES and TM contents in each week of the term and semester respectively. For a full version of this table, contact the first author.

Week	*Contents Cal Poly*	*Contents HM*	*Remarks*
1	Introduction Repetition of the vector concept Addition and subtraction of vectors Axioms of Statics	Introduction Repetition of the vector concept Addition and subtraction of vectors Axioms of Statics, Moments in the plane The couple of forces, Equivalent forces and moment systems Free body diagrams	
2	Equilibrium for central force systems Equilibrium in general force systems of rigid bodies Free body diagrams	Equilibrium for central force systems Equilibrium in general force systems of rigid bodies Resulting force from parallel forces Graphical and analytic solutions	*Graphical solutions are not presented in ES at Cal Poly*
3	Support types of planar bodies and reactions Moments in the plane The couple of forces Equivalent forces and moment systems	Support types of planar bodies and reactions Equilibrium of forces and moments of rigid bodies in 2D Truss Systems Frictionless pulley in rigid body systems	
4	…	…	…

3.7 Style of the courses

Both ES and TM courses are seminar style with high interaction between students and instructor. There are alternating theory sections with application sections where theory is applied to problems. There are also sections in the course where students work independently in pairs or small groups on problems (so-called in class exercises), the solutions and results are then discussed in the whole course.

In addition, homework is given out in ES and TM, these are problems that students are expected to work on in independent study until the following week. The homework assignments at HM are not graded, at Cal Poly they are handed in, graded and contribute to the overall course grade

3.8 Performance Assessment and Grading

At Cal Poly, students in the ES course participate continuously in performance assessments. Each week there are **homework** assignments to be handed in, which are corrected and graded. Each week there is a **quiz** (a short exam of about 15 min), which is corrected and graded. There is also a **midterm exam** that is corrected and graded. At the end of the semester there is the **final common exam**, which is of course also corrected and graded.

At both universities Cal Poly and HM a student must score at least 50% on the final exam to receive a passing mark for the entire course. All assessments of individual performance at Cal Poly are calculated as a percentage, For example, a homework assignment in which a student has worked out 35 points out of a possible 50 is assessed as 70%. All single and average scores (e.g., for all quiz assignments) are available for students to view at any time in the Canvas Learning Management System.

This is important for students. As it allows them to monitor their performance during the term The performance from homework, quizzes, midterm, and final common exam are converted into a total percentage at the end of the course with a weighting and then converted into a final course grade using a system of letter grades common in the U.S. (i.e. A, B, C, etc). A conversion table used at Cal Poly in Mechanical Engineering is shown below. This then gives the student a grade on the ABC grading system for the ES course.

Table 2: Grading Scale used at Cal Poly

Grade	*Total performance in %*
A	93.1 to 100
A–	89.5 to 93.0
B+	86.6 to 89.4
B	83.1 to 86.5
B–	79.5 to 83.0
C+	76.6 to 79.4
C	73.1 to 76.5
C–	69.5 to 73.0
D+	66.6 to 69.4
D	63.1 to 66.5
F	63.0 and below

Through the continuous processing of homework, quizzes and midterm, students receive ongoing feedback on their performance in the term and know whether they are working and learning sufficiently. As a result, the majority of students are very well prepared for the final common exam. Failure rates in ES average less than 10%. The overall grade for the module is made up of the grades from the final exam (if passed), homework, quizzes, and midterm exam, using weighting.

At HM, the final course grade is determined only by the final exam. Students do not receive feedback from the instructor during the semester in the form of mid-term grades. The homework problems are the tool with which the student can self-assess their knowledge in TM. Because the homework problems are voluntary and not handed in, many first-year students do not begin to engage with the homework until late in the semester. Failure rates on TM exams have averaged over 50% in recent semesters. There are certainly many other factors contributing to these high failure rates (e.g., lack of basic skills in mathematics from school), so the complex issue of failure rates will not be discussed in detail here.

A major difference between ES and TM is found in the grading of intermediate performance. The final grade for the TM course at HM comes only from the student's performance on the 90-minute end-of-semester exam. Students at Cal Poly receive approximately 20 individual assessments which are then incorporated into the overall ES course grade. As a result, the student's daily form on the day of the final exam determines the overall grade to a much greater extent at HM than at Cal Poly.

3.9 Student-instructor relationship

Through the continuous performance assessments during the terms (homework, quizzes, midterm), the instructor at Cal Poly gets a picture of his students' strengths and weaknesses in ES very quickly. Also, by handing out the corrected assessments in class within the first few weeks, the lecturer learns the names of his students and can address them by name. This is further supported by the small number of students (max. 35) per course and when students attend office hours. The students also get individual coaching from the instructor through the corrected assessments to improve their performance: e.g. "Make sure to document the solution approaches completely" or "Sketch the Free Body Diagrams more precisely with all forces and moments”.

At HM, the relationship between professor and student is not as close. The instructor does not know the names of the students in his course which averages about 70 to 80 students. With the exception of a few students who ask questions to the instructor after class or during office hours, students are anonymous participants in the lecture for the instructor. Students do not receive continous individual feedback on their TM application knowledge.

3.10 Overall grade of the study program

Another important value for students at Cal Poly is the Grade Point Average (GPA).The GPA is a number in the American education system that indicates how high a student scored in his courses on average. Using a scale from 1.0 to 4.0, the GPA tracks progress during the studies. It is used to assess the meeting of standards and expectations set by the degree programme or university. At many universities the GPA determines the students eligibility for financial aid programs and scholarships [8]. Additionally a minimum GPA of 2.0 for all major courses is required to receive the Bachelor's degree.

Dividing the overall percentage off assessment by 100 and multiplying it by 4 will deliver the GPA score. For example an average score of 70% delivers an GPA of 2.8 (=70/100 x 4). There are also more complex procedures for calculating GPA at various colleges that involve weighting based on the number of hours in the course or the difficulty of the course. The GPA can be important when applying for jobs at companies. Many employers use the GPA as one way to measure a candidate's academic performance and potential for success. Some employers may require a minimum GPA for certain positions. However, it is important to mention that grades and GPA are not the only factors employers consider when evaluating job applicants. Employers also look at a candidate's experience, skills, and other qualifications [9].

The university examination regulations of the HM provide that the final grades of individual modules as well as the grade of the bachelor thesis can be weighted differently. For the calculation of the overall examination result at the HM in the study program Industrial Engineering and Management, the final grades of all modules in the study program are weighted with the factor one. Exceptions are the final grades of the modules of the first two semesters, which are weighted with a factor of 0.25 only. The grade of the bachelor thesis is weighted three times [10]. This calculation method is also used in other engineering programs at HM. Here is a very simple calculation example to explain it: a student has passed 10 exams in his first year each with a grade of 3.7 and 20 exams in graduate studies each with a grade of 2.3. The bachelor thesis on his final project was graded with 1.7. He has thus achieved 31 individual grades. The overall final grade for the program is 1.95 (=10*3.7***0.25**+20*2.3***1**+1.7***3**)/31). The weighting factors are printed in bold. With this regulation, the grades in the basic studies, i.e. in the first year of study, are less important for the students; the priority is to pass the examinations in order to enter the main studies.

In addition to experience, skills, and other qualifications, the overall degree grade is also in Germany for employers a criterion when hiring graduates. Looking at the grading system in comparison to Cal Poly to HM, it is more complex at Cal Poly with the ABC system and GPA to determine an overall grade for all coursework taken during or at the end of the semester.

3.11 Tuition fees

One of the significant factors that differ between public universities in the US and Germany are tuition fees. A bachelor program at public universities of advanced sciences in Germany does not require any tuition fee. However, students have to pay a semester fee of 85 euros in the winter semester 2023/23 [11]. This fee covers administrative costs and the cost of student union membership, In contrast, undergraduate studies at Cal Poly amount per term to $4,000 for total base registration and tuition fees for California students. For students who do not live in California, the cost increases to approximately $11,000 [12] and even higher for international students. These tuition fees are one of the reasons why many students in the US take out loans to finance their studies.

4 SUMMARY AND CONCLUSIONS

The ES and TM courses have very similar content in the area of statics. About 80% of the 10-week ES course is also taught in the 15-week TM course. The teaching style in both courses is also very similar. It is characterized by strong interaction between students and lecturer and there are self-working periods for the students during the lectures. The following is a summary of the differences that were found.

The results of the comparison between the two lectures and study systems respectively can point to directions for research in the subject area of teaching and learning in Engineering.

One major difference is the high number of graded individual performances at Cal Poly The cost of studying is also an important factor, since repeating courses in the U.S. is directly associated with high additional costs.

Table 3: Overview of the differences between the courses

	ES ***Engineering Statics*** ***at Cal Poly***	***TM*** ***Technische Mechanik*** ***at HM***
Time frame of the course	Term of 10 weeks	Semester of 15 weeks
Weekly schedule	1 hour lecture on Mon, Wed and Fri, 2 hours tutorial	4 lecture hours in block on one day
Attendance	compulsory	not compulsory
Main instruction material	Text book	Lecture script
Class Size	Max. 35 students in a section, few exam repeaters	30 to 100 students in a lecture, many exam repeaters, 70 - 80 students in a section on average
Performance assessment	a) Homework, weekly b) Quizzes, weekly c) Midterm exam d) Final common exam	Final common exam
Overall grade of the course	Determined out of a) to d) with the help of a weighting	Determined by grade of the final common exam only
Duration of the final common exam	170 min	90 min
Fail rates	approx. 10% average	approx. 50% average
Basic differences between studying in the USA and in Germany		
	USA	***Germany***
Overall grade of the academic degree	Grade Point Average (GPA) on a scale from 1 to 4 (**4** corresponds to very good)	Grade mean of all course achievements on a scale from 1 to 4 (**1** corresponds to very good).
Tuition fees	Significant, although lower than many other Universities in the U.S.	Very low

Students at Cal Poly work in the following learning situation. They receive a continuous performance assessment. Students and instructors know well before the final exam how strong individual competencies are in ES. They can invest more time in ES, for example, starting with the midterm exam, if they want to improve. Students receive practice in working exams under time pressure already during the term, and they receive feedback on homework and midterm performance and details on whether they solved the problem correctly along with the correct procedure.

Students at HM will not receive credits for volunteering to complete homework assignments. They do not receive a grade for their performance during the semester. Judgement of learning progress and competencies is entirely the students responsibility.

Wolfsteiner and Self [13, 14] who compare the courses in the mechanical engineering programs also emphasize the continuous assessment at Cal Poly in comparison to "the freedom (for the students) to be responsible for their own learning" and the high failure rates at HM. And they describe the difference in relationship between students and professors at Cal Poly and at HM.

The differences noted in Table 3 above give rise to future research questions, especially concerning the use of continuous assessment. For example, it would be very interesting to investigate, in conjunction with learning psychologists, what influences the extrinsic motivation present at Cal Poly has on the student learning process and student success. This is in contrast to the students at HM who rely on intrinsic motivation for learning when intermediate performance is not assessed. An experimental design could include two courses teaching the same statics content: One course would use the Cal Poly performance assessment system, the other the HM system. Surveys and interviews with students on performance pressure, test anxiety, and studying satisfaction would need to supplement the experiments.

Other questions that could be asked, include the effectiveness of formative vs. summative assessment during the term, the relative impact on class sizes, required attendance and how the relationship between student and instructor impacts learning.

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