Paper ID #22281

# Teaching Mechanics in Another Country – Reflections on a Professorenaustausch

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# Teaching Mechanics in Another Country – Reflections on a Professorenaustausch


## Abstract

In an ever-expanding global economy, it has been increasingly important for engineering students to pursue some type of international experience. There has been a great deal of research on the benefits of having students participate in a study-abroad program. Much less has been reported, however, on the benefits of having faculty participate in an international exchange. We will discuss a professor exchange, or Professorenaustausch, between two polytechnic universities, one in California and one in Karlsruhe, Germany, between two mechanics professors.

To understand the challenges of setting up such an exchange, we will first provide some institutional and cultural context on the two university settings. Typical teaching philosophies and overall curricula will be discussed, and then we will focus on our primary course topic: dynamics. One major difference is the German institution's use of d'Alembert's Principle in solving kinetics problems, and another involves their use of professor-written skriptums rather than textbooks. The German system places much more responsibility on the student to learn the material – in many courses there is one high-stakes ninety-minute exam that is used to assign the entire grade. Students are provided with a number of example problems and old exams, and are expected to learn the material how they see fit. This is in stark contrast to the California system that assigns multiple homeworks, quizzes, projects, and tests each term.

We will share instructor perspectives on differences and similarities teaching mechanics at the two universities, as well as our perceptions of the student populations. Additionally, we will collect student survey data to examine their thoughts on professor exchanges and the differences between instructors from the two institutions.

Finally, we will share some of the logistical issues of an exchange program. Performing a house exchange is one of the easiest ways to organize the swap, and we also agreed to swap automobiles and bicycles. Because it was an exchange agreement established at the highest levels of each institution, we were paid by our respective universities and the term did not count as a sabbatical. The exchange was a highly constructive experience each of us, both academically as well as culturally. Such programs can be used to enhance global awareness for students, to exchange interesting pedagogical practices, and to provide personal and professional growth for mechanics faculty members.

## Introduction

At Cal Poly, international professorial exchanges are quite common. Cal Poly has an excellent collaboration with the Munich University of Applied Sciences, including professor and student exchanges as well as the Munich Summer School (Self and Wolfsteiner 2012). The professorial exchange of the authors of this paper is the first one involving Cal Poly and the University of Applied Sciences in Karlsruhe ("HSKA"), Germany.

In our exchange, we not only took over the office and the courses of the exchange partner, but also switched houses, cars, and bicycles. By doing this, the exchange was much less complicated, and we did not have to spend time finding short term rental homes, automobiles, or bikes. It also gives each partner a glimpse into typical life in the partner community – we each met neighbors, learned about one another through pictures and furnishings, and "lived like a native."

Many have discussed the benefits of student exchanges, and today's students have multiple opportunities to go abroad to experience the way of studying and instruction in other countries (Dyer et al. 2015, Parkinson 2007). Basically, any student who is interested (and financially able) can find a way to have an international experience, especially students within the European Union. Today's generation of professors grew up in a period when going abroad was not as easy or available, therefore a professorial exchange can be very fruitful in widening our horizons and getting to know the habits and traditions of academic life and procedures in a foreign country.

We both taught mechanics during the exchange, and noticed interesting similarities and differences in teaching traditions. Although teaching styles and content certainly vary within each country, our experiences are representative of those at American engineering colleges as well as at German Universities of Applied Sciences. We will describe the curricula and provide context for each university, paying special attention to the HSKA because most readers will be less familiar with this system. Then, we will discuss educational differences, including office hours, grading, and the use of syllabi. Specific areas of teaching mechanics will be discussed, including the reflections of the American and German professors. Finally, we will provide advice to those who might be considering starting professorial exchange programs of their own.

### Background of Incoming Students at HSKA

Students at Cal Poly are typical of many US institutions – most come directly out of high school and are around 18 years of age. Qualifications are quite high, with average incoming SAT scores above 1450 for Mechanical Engineering. During the first year, students are required to live in the dorms, and many continue to do so during their second year.

In Germany this is quite different since there are multiple ways to get admitted to a University of Applied Sciences; this makes the students as a group more inhomogeneous. The most common way to enter the HSKA is by earning the so-called "Abitur", which denotes graduation for university-preparatory high schools (this is the highest level of secondary education in Germany and typically takes 12 years of school). The percentage of students graduating with an Abitur has been growing over the past decade, as shown in Figure 1. Other school students may decide to leave school after finishing 10th grade of secondary school and do a professional apprenticeship in industry, which usually lasts 3 years. After successfully completing an apprentice program, these students can go another year to a secondary technical school and then also qualify for study at a university of applied sciences.

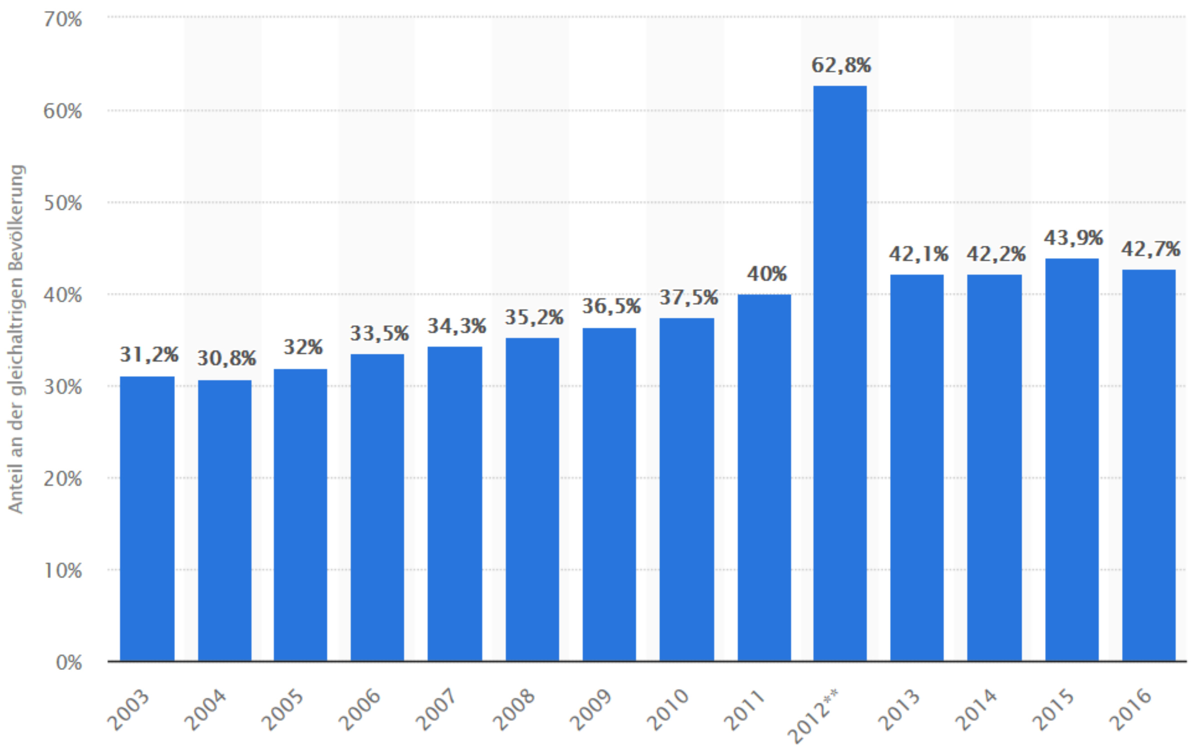


**Figure 1**. Percentage of students in Germany graduating with an Abitur (*Baden Württemberg Statistics*)

Students who have done an apprenticeship have lots of practical knowledge from their time in industry, but they are usually a little bit behind in basic mathematics and physics knowledge compared to students with an Abitur. But the different kinds of curricular background turn out to be quite fruitful, and the different backgrounds of students can be very beneficial when students are working together on a project.

Recently, the average age of entering college students has dropped in Germany. The Abitur used to require 13 years of schooling, and males were required to do military or civil service (a Wehrpflicht) for 15 months. In 2011, the mandatory service was discontinued, and most German provinces decreased the required years of schooling from 13 to 12. Additionally, the German government made a push to get young people into skilled jobs at an earlier age.

**Institutional Context**

The general instructional philosophy of the California State Universities and the Universities of Applied Sciences in Germany is quite similar. Class sizes are generally kept small; at Cal Poly courses usually don't contain more than 35 students. At the HSKA group size tends to be a little larger; a section size of less than 50 is desired, but it sometimes can go up to 70 students. The approach focuses on practical engineering skills at both universities, containing many hands-on laboratories and projects. At HSKA (as at most Universities of Applied Sciences) an industrial internship is mandatory and usually done by the students in their fifth semester.

Neither university offers a doctoral degree, but both can partner with other PhD-granting institutions if professors wish to mentor doctoral students. This is much more common at the HSKA, because the Technical University of Karlsruhe is less than 2 km from the HSKA campus. In Germany, the TUs focus more on research, typically have larger class sizes, and the educational approach tends to be more theoretical. This is analogous to the differences between the University of California (e.g., UC Berkeley, UC Santa Barbara) and the California State University systems.

<u>Curriculum at the HSKA</u>

German Universities of Applied Sciences are 7 semesters long (which includes a one-semester internship). There is not a General Education requirement, and students only take 4 units of humanities classes while attending university. Additionally, students often take 5-6 topics each semester, the majority of which are highly technical. The class list for Mechanical Engineering students at the HSKA is shown in Table 1. More than 90% of Mechanical Engineering students also do their bachelor's thesis with an industrial sponsor. It is estimated that over half of the students obtain job offers from their internship or thesis sponsor (which are often the same company) after graduation.

***Table 1.*** Curriculum at HSKA in Germany.

<table>
<tr><th>Semester 1</th><th>Semester 2</th><th>Semester 3</th><th>Semester 4</th><th>Semester 5</th><th>Semester 6</th><th>Semester 7</th></tr>
<tr><td>Mathematics 1</td><td>Mathematics 2</td><td>Thermo-dynamics</td><td>Fluid-dynamics</td><td rowspan="5">Internship</td><td>Project Study</td><td>Basics of Business Admin.</td></tr>
<tr><td>Statics</td><td>Mechanics of Materials</td><td>Dynamics</td><td>Production Technology</td><td>Energy Conversion</td><td>Plastics Engineering</td></tr>
<tr><td>Materials Science</td><td>Informatics</td><td>Design Exercise 1</td><td>Design Exercise 2</td><td>Automation Technique</td><td rowspan="3">BACHELOR-THESIS</td></tr>
<tr><td>Manufacturing Technology</td><td>ME-Design 1</td><td>ME-Design 2</td><td>Technical Elective</td><td>Technical Elective</td></tr>
<tr><td>CAD/CAM Technical Drawing</td><td>Electrotechnics</td><td>Machines + Laboratory</td><td>Electives</td><td>Electives</td></tr>
</table>

<u>Curriculum at Cal Poly</u>

The curriculum at Cal Poly is similar to many engineering schools, and is a four year program with 72 units of general education (many of which are science and math and also offered at HSKA). Cal Poly does have a few more laboratories than most universities, and is known for its *Learn By Doing* philosophy. A list of classes is shown in Table 2.

*Table 2. Curriculum at Cal Poly. Italics indicate classes with a laboratory.*

| Year 1 | Year 2 | Year 3 | Year 4 |
|---|---|---|---|
| Intro to ME (1) | *Intro to Solid Modeling (2)* | Intermediate Dynamics (4) | *Controls (4)* |
| *Manufacturing (2)* | Statics (3) | Thermodynamics I (3) | *Senior Design I (2)* |
| Calculus I (4) | Calculus IV (4) | Fluids I (3) | *Tech Elective (4)* |
| Expository Writing (4) | *General Physics III (4)* | *Circuits (4)* | GE - Literature |
| Oral Communications (4) | *Chemistry II (4)* | Economics (4) | Life Sciences and Bioeng (4) |
| GE (4) | Dynamics (3) | *Design for Strength/Stiffness (4)* | *Senior Design II (2)* |
| *Intro to ME II (1)* | *Measurement and Data Analysis (3)* | Thermodynamics II (3) | *Tech Elective (4)* |
| Orientation to ME (1) | Linear Analysis I (4) | *Fluids II (4)* | GE -Fine Arts |
| *Material Removal (2)* | Mechanics of Materials I (3) | *Electronics (4)* | GE - American History |
| *Manufacturing Processes (1)* | GE (Philosophy) | *Mechanical Systems Design (4)* | *Thermal Systems Design (4)* |
| Calculus II (4) | Philosophy of Design (3) | *Heat Transfer (4)* | *Senior Design III (2)* |
| Physics I (4) | *Materials Science (4)* | *Vibrations (4)* | *Tech Elective (4)* |
| *Intoduction to ME III (1)* | Linear Analysis II (4) | *Energy Conversion (4)* | GE - Political economy |
| *General Physics II (4)* | Mechanics of Materials II (2) | | GE - Social Institutions |
| *Chemistry I (4)* | Computer Programming (2) | | |
| Technical Writing (4) | | | |

Tuition and Student Costs

At German Universities, citizens from all European Union (EU) countries may attend college for free. Students coming from non-EU countries still pay much less than at most American universities. The European philosophy is that higher education should be accessible for everyone, and not depend on the income of the students' family. A low tuition of 1000 € per year was in fact introduced in most of German states in 2006. Since this was very unpopular in many parts of Germany, and many politicians feared re-election it was discontinued in 2014. In 2017 the German state of Baden-Württemberg (Karlsruhe is located here) instituted a tuition of 3000 € per year for all foreign students coming from non-European-Union-countries, which is still much less than at most American universities

The high tuition charged at US universities can have major consequences on the educational system. Some students can feel tremendous financial pressure to finish their degrees in a timely fashion, and this may be a bit of an external motivator to perform well and not have to repeat courses. American students may think of themselves more as paying customers than their German counterparts, and occasionally parents also feel this way.

Students

The percentage of female students in engineering is clearly higher at Cal Poly, presently about 18%. Although in Germany big efforts have been done lately on motivating girls into MINT (Mathematics, Informatics, Natural Sciences, Technics), the female student percentage is only about 7% in the Faculty of Mechanical Engineering and Mechatronic at HSKA. Part of this push is because German birth rates remain somewhat low and German industry is continuing asking for more young engineering academics.

Prof Deutsch Reflections on the Students

My impression is that the American students tend to be quieter and more focused during the lectures, so that instructing is not so exhausting for the professor. The reason for that might be the longer periods at Karlsruhe, which last 90 minutes compared to the 50-minute-lectures at Cal Poly. This longer duration makes it more difficult for the German students to keep up their concentration. At both universities it is quite common for the students to ask questions during the lectures and to provoke a lively communication between student and instructor.

Prof America Reflections on the Students

I occasionally noticed the German students talking in class a bit more than the Cal Poly ones, but this was not excessive. I generally use active learning methods, and during group work or think-pair-share activities, I encouraged them to explain concepts to one another in German if needed. As discussed below, the German students rarely come to office hours, so I did not get to know them as well as my students at Cal Poly.

**General Class Structure**

Courses at the HSKA generally run for 90 minutes; the course taught by Prof America in Germany was 5 units, so met five times every two weeks. This is longer than the typical courses taught at Cal Poly, so some adjustments had to be made. Prof America typically teaches using active learning and interactive methods, so he gave plenty of time for the students to talk to one another while they were working problems in groups or answering concept questions.

A major difference in the educational systems is the assessment methods. In Germany, course grades are typically assigned solely on the basis of a 120 minute exam (in some cases this is just 90 minutes long) at the end of the semester. Students really only sign up for this test – they can choose to come to class, or to just show up for this exam. In the Technical Mechanics 3 (dynamics) course taught in Karlsruhe, the students were required to take four 30-minute tests and score a cumulative 50% on these tests in order to take the final exam – but these test scores did not factor into the final grade.

The way courses are taught has started to change in Germany recently. Some have contended that many beginning students lack the maturity and self-regulation (possibly due to the average age decreasing) to only have a single test at the end of the semester. In 2016 the HSKA changed its grading regulations so that up to 10% of scores during the semester (i.e. homeworks, tests, quizzes) may be incorporated into the final grade. It is hoped that this will make students work more continuously and study harder during the semester. In 2018 this portion will be raised to 20%. Still, it is completely up to the professor to adopt this policy, and almost all professors keep it the way it was when they were studying: the Final Exam is all that counts.

In Germany it is an old academic tradition that the professor gets applause, which is done by knocking the knuckles on the table at the end of a session. It gives the students the possibility to express some feedback to the professor about his performance, because sometimes the applause can really be striking and pronounced, sometimes only slight and unmotivated after a poor lecture. In America this tradition is not common – so after the first class at Cal Poly Prof Deutsch wondered if he had done something wrong! Instead of applauding many student thank the professor for the lecture while leaving the classroom.

Textbooks and Skriptums

American professors usually ask their students to get a specific textbook and require them to read chapters in advance of the lecture. The books have large numbers of both sample and homework problems. German professors think that it is more efficient if a professor introduces and explains things, and the student can review material in a book if something has not been understood. In Germany, professors often prepare skriptums for their students (this was the case for the dynamics class at HSKA). These skriptums tend to be much shorter than textbooks, and concentrate on the really important things.

Prof Deutsch Reflections on Class Structure

In the US all instructors have to set up a syllabus, which not only displays the course of instruction but also defines how the final grade is determined. A typical grading scheme might have Homeworks at 20%, Quizzes at 10%, Midterms at 30%, and the Final Exam at 40%. In Germany this does not exist, since it's entirely the final exam which determines the grade. Sometimes the German professors let the students do homework or have tests to make the students reflect on the content and work on problems, but these assignments don't influence the final grades. They are only a prerequisite to sit for the final exam. In many courses there aren't any prerequisites like homework or tests, so it's entirely up to the students if they do anything during the semester or not. This leads to more self-reliant behavior of the students. But there are certainly downsides of this system, since many student don't do enough work during the semester to learn the material. They try to make up for it by studying hard two weeks before the exams, but most of the time this is too late. Failure rates of up to 70% is therefore not uncomon on final exams in Germany.

Textbooks used in the US are quite extensive, which makes it difficult for students to distinguish between the really important and the not-so-important topics. For my Cal Poly lectures I prepared a skriptum with gaps, which were filled during the lecture. The gaps were for formulas, some drawings, and derivations and were supposed to motivate the students not to miss a lecture. The course evaluation results indicated that the American students very much appreciated this shorter version of a textbook.

Prof America Reflections on Class Structure

In the US, we have become reliant on constant testing and feedback. Although formative feedback is certainly an important part of learning, we may sometimes overload the students with so many graded events that they don't have any time for proper reflection. German professors provide a skriptum to the students, which consists of content notes and a number of solved problems. Students can use this to study and to work problems along the way, but many do not take advantage of this opportunity. Additionally, many simply look at the worked out solutions rather than attempting to solve the problems on their own. The skriptum may also allow students to skip a very important skill – determining important material from books that may have a lot of very dense, technical information. The TM3 course that I taught required the 50% on the four tests, so this did motivate the students to keep up with the material to some extent. I certainly appreciated the lower grading requirements during my time in Germany (plus they had teaching assistants grade the tests, so I basically didn't have to grade anything!)

Office Hours

At Cal Poly students come much more often to office hours. In Germany professors only have to offer one office hour (or Sprechstunde) per week, and many times no students come. At Cal Poly every professor has to offer five office hours distributed over at least four different days, and no office hour goes by without students coming. The reason for this is most likely due to the class structure describe above: American students are constantly assigned homework and projects that affect their grades, so if they have questions on homework problems they are much more motivated to come and ask the professor.

**Mechanics-Specific Experiences**

At the HSKA, there is only one mandatory dynamics course with approximately 75 45-minutes instructional periods covering the subject matters of three courses ("Dynamics", "Intermediate Dynamics", "Vibrations") at Cal Poly. These three Cal Poly courses amount to 90 instructional periods of 50 minutes each, with an additional Matlab Activity in Intermediate Dynamics and a laboratory in Vibrations. Due to the larger amount of time, the Cal Poly courses on dynamics and vibrations are more extensive. Additional content is mainly 3D-dynamics and vibrations of multiple degree-of-freedom systems, while HSKA sticks to the basics dealing with 2D-systems. This allows HSKA to cover most dynamic problems and one-degree-of-freedom vibrational systems, which enables students to know the essential phenomena of mechanical vibrations. At the HSKA, Prof America taught 80% of this dynamics course (12/15 weeks of the Winter semester) and a technical elective.

Prof Deutsch taught three sections of the intermediate dynamics class at Cal Poly. This intermediate course does not cover much particle dynamics, but does review planar rigid body kinematics and kinetics. Because the introductory dynamics course at Cal Poly is only 10 weeks long, it does not include rotating coordinate systems (e.g., sliders, slots, Geneva mechanisms). Intermediate dynamics goes on to cover three-dimensional kinematics and kinetics, as well as gyroscopic motion. Additionally, a two-hour Matlab programming lab, taught by a graduate student, accompanies the intermediate class.

## Vectors vs Graphical Techniques

At Cal Poly, and at most U.S. engineering schools, rigid body kinematics and kinetics are typically taught using cross products. At the HSKA, the student determines the magnitude of a component of velocity or acceleration, and also the direction of the normal or tangential component by looking at the geometry of the problem. To help facilitate this, HSKA students are required to draw scaled vectors using a ruler and protractor. An example of this is shown in Figure 2.

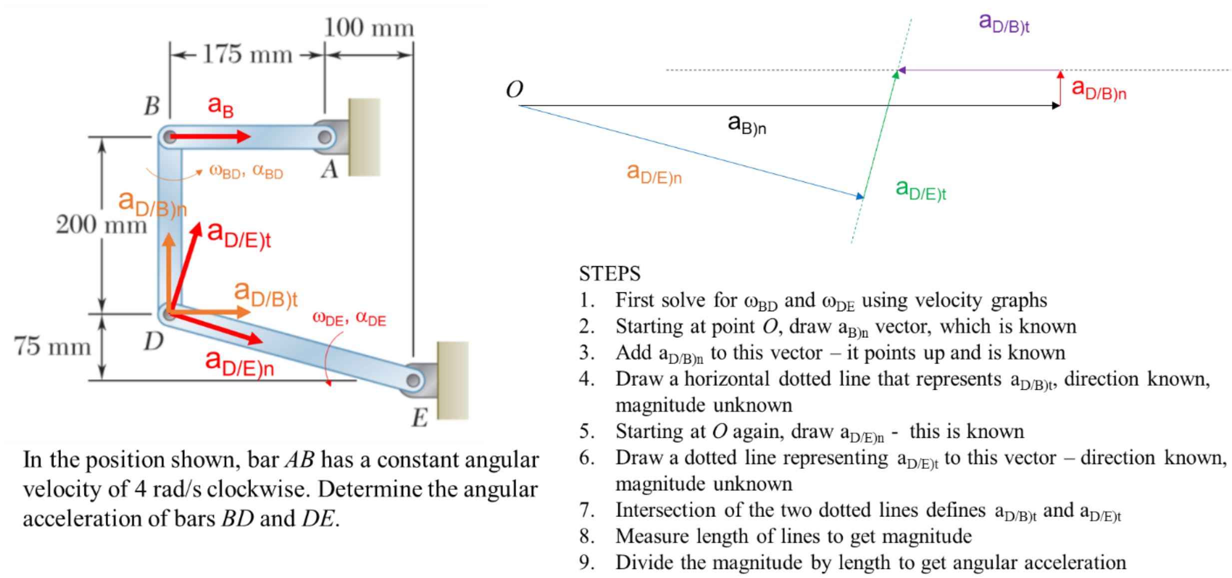


***Figure 2.*** Graphical method of solving a linkage problem (problem from Beer et al. 2015).

## Prof Deutsch Reflections on Kinematics

Working with cross products in formulating kinematic relationships is only really necessary when dealing with 3-dimesional problems. That might be the reason why Cal Poly students are more accustomed to work with vector products. When applying cross products, some of the students seem to lose the ability to critically question their result by checking if the direction found for the velocity/acceleration is plausible. The more geometrical approach, accompanied by the scaled representation of the vectors, makes the students understand the relationships better, but of course it leads to difficulties with 3-dimensional systems. A reason to make the Cal Poly students accustomed with the cross products is of course the parallel Matlab activity. It perfectly makes sense to work with cross products when solving dynamics problems with Matlab.

## Prof America Reflections on Kinematics

It was interesting using the graphical technique with ruler and protractor – I framed it to the students like solving a puzzle. The secondary method for solving the problems at HSKA was by breaking the vector into x and y components using trigonometry. In Fig 2, we would write

$$\mathbf{a}_{D/E)n} = \begin{bmatrix} 1.85\cos(15.63) \\ 1.85\sin(15.63) \end{bmatrix}$$

which is similar to how many US textbooks used to solve kinematics problems. As mentioned above, we do cover 3D problems in a follow-on course at Cal Poly, where we use cross products extensively. Additionally, vector algebra provides an elegant, consistent approach to solving problems involving linkages. I often ask students which direction the different velocity and acceleration vectors will point, and to check their cross product results with these directions. With modern computational tools, it just seems that the time spent using a protractor and ruler can be better spent working different variations of kinematics problems.

D'Alembert's Principle

Perhaps the largest different in teaching mechanics between the two universities is the use of d'Alembert's principle. Cal Poly, and indeed most US schools, utilize both a free-body diagram and a kinetic diagram (sometimes called a mass-acceleration diagram) that represents the inertial terms. This is a pictorial representation of the Newton-Euler formulation, and the equations:

$$\sum \mathbf{F} = m\mathbf{a} \qquad \sum M_G = I_G \alpha$$

follow directly. At the HSKA, it is thought that the students are already used to solving statics problems and will appreciate the use of the familiar statics formulation, where

$$\sum \mathbf{F} = 0 \qquad \sum M = 0$$

This force summation includes the so-called "inertial force", and is written as –m**a** on the left-hand side of the equation. In this technique, a single free-body diagram is drawn and the direction of the inertial term (i.e., the acceleration) is drawn in the opposite direction than its assumed direction. Typical diagrams for applying d'Alembert's (Fig. 3b) and the traditional Cal Poly approach (Fig. 3c) for a simple pendulum is shown in Fig. 3.

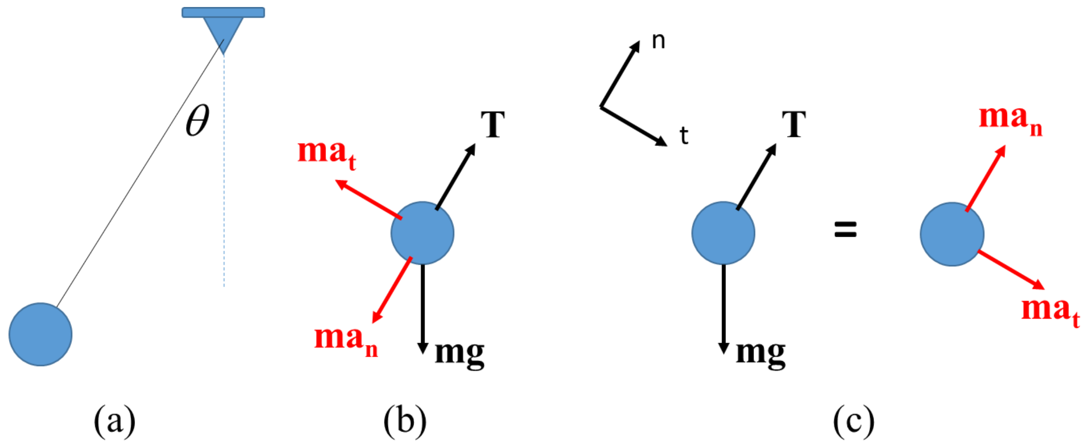


***Figure 3.*** (a) For the swinging pendulum shown, the free-body diagram for d'Alembert's principle and (c) solving with a free-body diagram and a kinetic diagram.

Prof Deutsch Reflections on d'Alembert's Principle

MAD-diagrams can't be found in any German textbook, and the necessity of them seems questionable. They always look like the same, containing the ma's drawn at the mass center into the possible directions of acceleration and the $I_G\alpha$ term about the mass center. In modern and very extensive textbooks this principle is barely covered. In (Beer et al. 2015) and (Hibbeler, Yap, and Fan 2013) it is only mentioned as a footnote, in (Meriam and Kraige 2012) there is a short essay about the principle, where it is "regarded as being mainly of historical interest". Probably most professors did not deal with this principle when they were students and therefore don't deal with it now. When I asked American students about this principle, they said they have never heard of d'Alembert.

In Germany it is a little different. German textbooks or skriptums, although usually much thinner than the extensive American ones, give d'Alemberts principle more space (Gross et al. 2015). Some even consequently work with it after introducing it to the reader (i.e. Dankert and Dankert 2011). Often the more theoretical technical universities in Germany don't work with it, but at the more practical oriented universities of applied sciences it's quite common. I've taught with it both ways, but have the impression that students are more comfortable with d'Alembert.

The clear disadvantage applying d'Alemberts principle is that it gives the students the impression that the m**a** term (the so-called inertia force) is a real force. Since this is certainly not the case, the instructor has to make sure to mention over and over that it is only a fictitious force. He can also emphasize this by choosing a different color for the inertia forces in the free-body diagram when doing example problems on the board.

I feel that the application of d'Alembert's principle has several advantages:

- By drawing the inertia forces (which of course show the reaction forces at bearings) into the FBD, the student get a better feel for what is happening in the system. In many systems they will be able to immediately determine the direction in which the bearing forces point.
- Multiple-body system are easier to solve with the principle of virtual work instead of the equations of motion since the method yields fewer equations with fewer unknowns. For the determination of virtual work, the inertia forces also have to be considered. If the students are used to working with d'Alembert's, it is easier for them to apply the principle of virtual work.
- Problems with relative kinematics are much easier to solve with the principle of d'Alembert. All accelerations, which sum up to the total acceleration, are considered by a fictitious force, which is considered in the free-body diagram in the opposite direction of the respective acceleration. We call these the "guidance force" and the Coriolis force.

So the comment of an American textbook (Meriam and Kraige 2012), that "no advantage results from this alternative formulation" seems at least questionable.

Prof America Reflections on d'Alembert's Principle

As mentioned above, use of d'Alembert's principle reinforces a major misconception of many students that the inertial term is a true force. Even after a course in physics or dynamics, students think that when they are traveling in a turn, some magical force throws them outward. Perhaps an instructor could try to take advantage of this when teaching d'Alembert's, but I think that it is more likely to encourage students in their incorrect understanding.

I also find it confusing for students to have to negate the sense of the inertial term. In teaching d'Alembert's, we ask them to first try to determine the direction of the acceleration, then put it in the opposite direction on the free-body diagram. Let us then imagine that we solve for an acceleration and get a negative number – in which direction does the acceleration now actually go?

Finally, the use of free-body and kinetic diagrams matches our schematic representations of other kinetic principles. For work and energy problems, we have students draw the energy states at position 1 and position 2, and a free-body diagram for forces that do work on the system. For impulse momentum problems, we have students draw the initial system momenta, add in the system impulse, and set that equal to the final system momenta.

Because we do not teach virtual work at Cal Poly, I do not see us ever teaching Newton's second law using d'Alembert's principle. This is somewhat analogous to why the HSKA does not choose to use vectors in their course – no follow-on dynamics classes use vector notation (for example to solve three dimensional problems).

Miscellaneous Differences

We each had to adjust to several other smaller differences, particularly in topics such as symbols and the use of the metric system. In Germany (and most of the rest of the world), a comma is used as the radix character (or decimal separator). So there, you write pi as 3,14. In the US and Great Britain, you write it as 3.14. Germans rarely have to deal with imperial units, but a few of Prof America's example problems were in these so they got a quick tutorial on the joys of US measurement units. Additionally, in the US we use k and c for the spring constant and damping coefficient, where in Germany they use c and d, respectively.

At Cal Poly, it is customary for the instructor to erase their own boards after finishing class. In Germany, you are responsible for erasing the board *before* your class. Fortunately, we both drive on the same side of the road!

## Student Comments on Foreign Professors

Based on course feedback, students in general benefited from the professorial exchange. It clearly widened their horizons by getting to know an instructor from another country, and to see how education is approached differently in the US and in Germany. It seemed that the students especially appreciated the aspects that they typically do not get from their native professors: the active learning approach in Germany and the skriptum in the US.

Student Comments from German Students about Professor America

Prof America gave a short survey just before he was leaving Germany. Responses to questions are shown below (n=31).

| **Which of the following reflects your thoughts on this class?** | **Responses** |
|---|---|
| There were major differences between how this class was taught and how most of my classes are taught | 45.16% |
| There were minor differences between how this class was taught and how most of my classes are taught | 35.48% |
| There was not much difference between how this class was taught and how most of my classes are taught | 19.35% |
| | |
| **Which of the following reflects your thoughts on how this class was taught?** | |
| I liked how this class was taught and wish most of my other classes were taught this way | 61.29% |
| I liked how this class was taught and wish some of my other classes were taught this way | 32.26% |
| I liked how this class was taught, but prefer a traditional lecture based approach | 6.45% |
| I did not like how this class was taught, but am glad that I experienced it once | 0% |
| I did not like how this class was taught, but am glad that I experienced it once | 0% |
| | |
| **How do you feel about courses in English?** | |
| I would like to take additional courses in English and would be very interested in some sort of certificate saying that I have passed these courses. | 83.87% |
| I would like to take additional courses in English but a certificate is not necessary. | 16.13% |
| I am slightly interested in additional courses in English. | 0% |
| I am not interested in additional courses in English. | 0% |

**Describe at least three differences between how this class was taught and how your other classes are taught**

> 1. Much more involved, more conversation and active thinking going on 2. Much more motivation in the entire class because of two-way conversation 3. Much more online files with skripts, background, exercises etc.
>
> More interactive, less traditional and frontal teaching, better atmosphere in general
>
> Quite often only figured out the approach and didn't solve the whole problem
>
> Much more interaction(!), therefore much more motivating. Also, the online-stuff was great - uploading all the examples, all notes, all the solutions! Absolutely great and very refreshing.

In general, students seemed quite happy with the active learning approach and appreciated that Prof America was able to learn student names. A few common complaints involved not having the entire skriptum from the beginning (he was translating and modifying it as he went along), issues this caused with organization, and the fact that we often only set up the problems and did not work all the way through the mathematics (solutions were placed on the learning management system). Student evaluations were excellent; it should be noted, however, that students who did not like Prof America had the option to sit in on the concurrent German section of the course, so these evaluations are somewhat skewed.

Student Comments from American Students about Professor Deutsch

> "Great professor. Was slightly concerned because I have not had an exchange professor before, but he came with a prepared scripture and did an excellent job teaching all the material. ..enjoyed the scripture …"
>
> " …his course skriptum was a nice touch…", "…however his grading methods were not clear..", "Becker used a skriptum, which was helpful..", "I liked the scriptum only format"
>
> "No partial credit on homeworks seems pretty harsh,…Midterm difficulty seemed inconsistent, …I really liked the printed course notes, though, these were really helpful"

Prof Deutsch Reflections on Student Comments

It seems like especially for homework assignments partial credit is given for good effort which was not clear to me at the beginning. I awarded credit for the correctness of solutions. Also many American colleagues use curved grading for the midterms and finals, which I was told by the students. I have never heard of something like that before since we always apply linear grading in Germany.

However the overall course results at the end of the quarter were not just about the usual average.

## Conclusions

Doing a professor exchange was a fantastic experience for both of us. We swapped homes, offices, cars, and bicycles. Teaching in another country helped us consider important aspects of *what* we teach, and to re-evaluate *how* we teach. Discussing teaching with colleagues at our exchange universities was also quite interesting, as was talking with different students in our classes.

The educational systems of the two universities could learn from one another. The self-reliance which is demanded in Germany might be a little too much, and greater learning gains might be achieved with additional formative and summative feedback. Students in the U.S. could benefit from more self-regulated learning, and rarely have time to reflect on what it is they have learned. Perhaps a system that is somewhere between the HSKA and Cal Poly model would be the best way to educate young people to be self-reliant and confident in their abilities and to provide meaningful learning through instructor feedback.

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