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Reflections on international exchange of students and professors in mechanical engineering

As described in our companion paper, California Polytechnic State University in San Luis Obispo (CP) and the Munich University of Applied Sciences, or the Hochschule München, (HM) have developed a strong partnership to increase the global competitiveness of their students. As part of this relationship, faculty are encouraged to participate in a teaching exchange, typically for an entire year. Students also participate in the exchange – this year there are ten HM students taking courses at CP and ten spending at least one semester at HM.

Although very rewarding, this exchange also presents a variety of challenges for the faculty, students and for the department. The HM offers some classes in English, but students often do not received as many credits as they would if they had remained at CP. Students from HM have to contend with taking courses in their non-native language, and are not used to the continuous graded assignments that are more typical of a US university.

The paper will help other mechanics educators who are thinking of increasing their international activities to understand the cultural and educational differences they may encounter. An exchange is an extremely valuable experience for both students and professors, particularly in the ever-increasing global engineering workplace.

Workload and Teaching Demands

Faculty at CP typically have 15 units each week, with three of those devoted to committee work, advising, and other service activities. This translates to between 12 and 15 hours (1 unit ~50 minutes) of teaching, depending on how many laboratory courses the CP faculty member is teaching. There is also a requirement for five office hours each week. The load is even higher at the HM, where instructors are expected to teach 19 units (1 unit ~45 minutes) each week. There is one scheduled office hour per week. Fortunately, each of the respective institutions typically decides not to require the faculty member to teach a full load, and allows them to adjust to the different culture, teaching methods, and language in their host countries. However, both of us still had to meet challenges of dealing with different workload issues at our host universities. In each of the following sections, the Cal Poly professor (BPS) will reflect on his experiences at the HM, followed by the Hochschule München professor (PW) discussing his experiences at CP.

BPS at HM

The HM is making a strong commitment to its international programs, and offers many courses in English each semester. Because of this, I was able to teach courses in my native language (unlike the experience of my colleague at CP). The primary language difficulty came in having to translate course material (~300 slides and some problem sets).

At CP, there are multiple sections of almost every course, and instructors usually teach only two different courses (and sometimes one). This is not the case at HM, where instructors often must prepare 3-5 different courses each semester. I was fortunate to only have to prepare three different lectures, all in the area of mechanics. Although I typically teach undergraduate dynamics, my assignments at HM included a graduate level multi-body systems (MBS) course and two undergraduate courses with considerable content in vibrations. I would have to say that my primary workload issues revolved around trying to re-learn the MBS and vibrations material, and trying to develop good example problems for each class. Although I have numerous problems and real-world examples for sophomore level dynamics, the same cannot be said for MBS and vibrations.

It was also challenging to plan a 90 minute lecture, when I am used to 50 minute classes. One of the courses only met once a week, and the other two had a 90 minute lecture and a 90 minute computer lab each week. Therefore all of the topics that were required to be covered in a week had to fit into a single lecture, and then I had to hope the students would retain the material for a week until we met again. As will be discussed in a later section, there are no homework assignments or midterm examinations, so it was also quite difficult to know if the students understood the material or not. On the other hand, this did dramatically reduce my workload – and we know that every professor's favorite part of the job is grading.

PW at CP

In my first term I had to give two different lectures: a basic lecture in dynamics (three times a week for 50 minutes) and a follow-on intermediate dynamics lecture (3 sections) in combination with a computer lab (2 sections). Fortunately these lectures were also given in parallel by other colleagues, which was very helpful for me. The basic dynamics lecture seemed to be very easy for me, because I did the same material in Munich before. I had to change my lecture style totally, because firstly the total lecturing time to cover the material is half compared to the style I did in Munich; and secondly I learned that my personal teaching style is not suitable for the 50 minutes usually done at CP. I often struggled to combine theoretical material with a visual example, because it did not fit to the 50 minute lecture. I learned that students really do the reading assignment, and it is not my job to explain the entire material. In addition I learned that some core elements of the theory are taught completely different here (e.g.: writing of vectors, use of mass acceleration diagrams, US customary units). When teaching in German, I can provide a much wider spectrum of different explanations of material; this is much more difficult for me to do in a second language. This did not seem to bother the students – but it did bother me! It seems that persons with limited language abilities are more common in the US compared to Germany.

The way the students use the office hours was quite new for me: they come to my office in groups without showing much respect; it is as if they own my office for this hour and feel very comfortable with me. Although having this type of office hours was quite new to me, I enjoyed coming in close contact with the students. Some of them seem to develop a deep interest in my German background.

Perhaps the greatest workload was as a result of the large amount of grading and preparation of quizzes, labs, and homework that is done at CP. I would estimate that I spend about 15 hours per week grading student papers and preparing solutions for my student assistant (who graded homeworks). As discussed below, this heavy grading load does not exist at the HM.

Discussion on Workload

As with teaching any new class, the first term is the most difficult. We both feel that the workload should decrease in the following terms, since we will be more familiar with the material (only BPS will be doing a new prep). It may be helpful for exchange professors to try to plan their course assignments a bit more in advance, so that initial translating and preparation can be done earlier. In some cases, arranging a graduate course or technical elective may also be helpful since the instructor may already have course material available.

Educational Philosophies

The approach to teaching is quite different between the HM and CP. The HM believes very strongly that learning is the responsibility of the student, and that the instructor's role is to explain the material to the students. To help with this, instructors write (or use) a *script*; students basically obtain class notes from the instructors, make copies of them, and sell them inexpensively to future students. Textbooks are therefore rarely required, although often instructors place textbooks as additional resources in the library. In most classes, there is a single 90 minute exam at the end of the semester, making up the entire grade for the student. Students actually only sign up for this exam, not for the course (they sign up halfway through the semester).

There are very close ties to industry; in fact, HM students are required to complete a 4-month industry internship during both their 3rd and 6th semesters. Additionally, almost all of the coursework done by HM students relates to engineering; there are only three required elective courses to be taken in the humanities. Many courses have a lab section integrated in the lecture. Additionally the HM has a one semester course concentrating on different laboratory techniques where students do real experiments in different labs and write reports about their work.

CP follows a fairly traditional US engineering curriculum. There are many different graded assignments, particularly homework and midterms, in addition to the final exam (which is usually three hours long). Many courses at CP have an associated laboratory, and often instructors will assign additional projects in the class. There is no requirement to do an internship, although most students seek to do these during the summer break. There is a substantial general education requirement, including 72 quarter credits.

BPS at HM

Teaching at the HM certainly took some adjustment, as I am a firm believer in active learning, formative feedback, and promoting conceptual understanding. Students here are used to lecture-

style courses, and have indicated that professors rarely get to know all of the names of their students. Although I did still learn student names in one of my classes, and tried active learning all of them, it was difficult to teach the course in the manner in which I am accustomed. I struggled to gage how well my students understood the material, since they did not complete homework or take midterms or quizzes. The only chance to really determine if they understand the course is on the final exam.

One of my classes had a well-established script – in German of course. I spent considerable time translating the notes, and trying to understand the author's intent. Another course had a script in English, which I provided online to the students. The scripts I used contain the material that the instructor thinks is important, but the majority of the script contains equations with limited text (and explanations). Luckily the script authors were available to help me interpret (and in some cases translate) the content. Although I am also concerned about the high cost of textbooks, I think learning from a textbook or primary reference is a very important part of becoming a professional. Although textbooks were provided as references in the library, it is doubtful that many of my students took advantage of them. When these students graduate and need to learn a new topic, it is doubtful that they will find a script to help them.

The major difference in my teaching philosophy and that of the HM is in the area of formative feedback. Most of the HM faculty provide exercises (and solutions) in their scripts, although from speaking to the students most of them work through the problems just before the final exam. In an informal poll of my students, one student stated he had worked "about half" of the problems from the first chapter (out of four chapters), while the remainder had worked "only a few". The previous lesson, I had asked them to look at two different problems and work them on their own. There were eight responses that they hadn't looked at them at all, six had glanced at it, and two had studied the problems (there were solutions posted for one of them). In one instance I posted a video of a solution to a problem we did not get to in class – by the next week, none of the 15 students had bothered to watch it. Unfortunately, with no grade associated with the work, students typically will not do it. It seems like the primary study method is to go over previous final exams, which are also usually posted.

One thing that I will work to improve upon in the second semester is getting to know my students better. As mentioned before, there is only one office hour per week at the HM (attendance is minimal), and I did not work to get to know the names of all of my students. This is partly because there are no official student rosters and I wasn't sure who would continue attending the classes, but was also due to being overwhelmed by the first semester in at a new university.

<u>PW at CP</u>

From my perspective, it seems US students are used to learning on a short term reward-based system; credits make them work and it seems that this is a major source of student motivation. The students are used to this system and assume that following this short-term strategy produces learning success. The professors have a high responsibility to use this reward system in such a way that fits this student model. Students are used to following the detailed learning path they are shown by their professors, even if it does not fit their personal learning style. I was surprised

how easily I could force students to write nice looking lab reports, even if the technical content of the reports was somewhat poor. The German philosophy is totally different. It gives freedom and responsibility to students; it assumes that students have the ability and motivation to learn on their own and that their tolerance towards frustration is high enough to do so. To give an example here: the textbooks and scripts used in Germany usually show the full solutions for the problems covered in the books; the intention is to give the student all the material he needs to be able to work on his own. The situation in the US is different; here the problems in the textbooks seem mostly not to have solutions, with the reason that students would not practice if they already see the solution. It seems that the learning system is focused on students not having the ability to motivate themselves. When German students fail on exams they usually search for mistakes in their own behavior. However, this learning model has drawbacks: it is often very difficult for German students, especially if they are just in the first semesters and do not have the necessary maturity, to follow this model. For these early students, there can be failure rates on final exams of over 50%.

The deep involvement of CP professors in the students' learning produces a high workload compared to the German system. In addition the way of using textbooks seems to shorten the freedom of professors. The very close integration of textbooks in the lectures seems to produce a certain dependency on textbooks, and also the publishers of these books. The publishers seem to be intelligent enough to use this dependency by producing newer and better textbooks having more problems, with better colorful pictures and also more text, more pages and higher prices.

In addition I wonder about the expectations of US students to get good learning support from professors for the high prices they pay for the higher education at a US-University. Perhaps the expectations that German students have on their German professors is very low, because they pay very small (or no) fees to the universities.

Discussion on Educational Philosophies

Perhaps the optimal system would combine the advantages of the two different philosophies. Certainly we all want students to possess strong metacognitive skills, and to take responsibility for their own learning. The HM system has encouraged students to form collaborative study groups, to organize the publication of different course scripts, and to teach themselves the material on their own. Without the typical onslaught of homework, quizzes, tests, and projects, the students actually have time to process what they have learned, and perhaps assimilate material from different courses. Additionally, the HM instructors and students have much closer ties to industry, and which can help provide context to the material they are learning in their courses.

It would be extremely beneficial if these advantages could be combined with some of the strengths of the CP system. Although there are other ways of providing feedback than homework and midterm exams, these types of assignments can definitely serve to "force" students to engage with the material. This seems to be lacking at the HM, where most of the learning appears to come at the end of the 15 week semester. In the US, it was reported long ago that faculty-student interaction is a key component to student success[1]. If the HM had more resources, it would certainly help to have additional office hours and smaller classes.

Student Experience

The HM and CP have an agreement that allows the students to pay tuition at their respective home institutions. The students can choose to come for part or all of a year, although it is sometimes difficult to match up the academic terms. The HM is on the semester system, where their "Winter" semester starts in early October and ends in early February and "Summer" semester starts in mid-March and ends in early July (for a more complete description of the HM system and curriculum, please see [2]). CP is on the quarter system: Fall runs from late September to mid-December, Winter quarter from early January to late-March, and Spring quarter from early April to early June. The HM offers several courses in English, although it is sometimes difficult for the students to find courses that will directly transfer to CP.

The HM students typically attend Cal Poly for two quarters, which allows then to return to Germany for the Summer semester. They can also struggle to get enough courses to count towards graduation, and most of the CP senior level technical electives are only offered once during the year. Cal Poly also puts a limit on the number of students who can enroll in a class (unlike at HM), so it can be difficult for the students to get into a course.

A survey was given to the exchange students at both universities. They were asked about differences between the two schools, the time spend studying and doing homework, the number of transfer credits they would get, the top three things about each university, and ideas for improving the exchange program. The results are summarized in Table 1.

Overall Experience

In the current exchange, the professors swapped homes, offices, and automobiles (but brought their lovely wives along with them). An agreement was written up and signed by both parties, but in the end things were really more about trust and verbal agreements than legal contracts. Each host institution established an official liaison to help the visiting professors get situated, and each of us found others to help us with the transition.

BPS at HM

My wife and I have truly enjoyed the experience of living in another culture. Although our German is coming along much more slowly than we had hoped, we can generally get by in restaurants and stores. Of course the majority of Germans (and most Europeans) speak English, so it has been quite easy to communicate with most of the people here. We do not have children, so we did not have to worry about the primary or secondary schools here in Germany.

Munich is a lovely city, with bike lanes throughout. It has one of the largest city parks in the world, the Englisher Garden, and of course beer gardens sprinkled all over the city. There are amazing locations to visit within a few hours drive (watch out for speeders on the autobahn), including Prague, the Bavarian Alps, Süd Tirol in Italy, Switzerland, Salzburg, and Innsbruck. The train system is excellent, and the subway and bus system are also easy to navigate.

Table 1. Student survey responses.

Responses from CP students at HM	Responses from HM Students at CP
Differences between HM and CP	
Homework, tests, midterms vs one final exam (4/5); No organized sports at HM, clubs not advertised as much at HM. Students can drink beer in class at HM	Homework, tests, midterms vs one final exam (4/5); Quarter system; Lots off labs, group projects, presentations at CP. Contact to professors at CP is much more personal.
Transfer credits and delaying time	
Hope to transfer 12 units- delay of one year because of 1 yr senior project; Might get elective credits, will delay 1 year; 12-16 units, delay by 1 quarter; hopefully 7-12 units, delay by 1 quarter; delayed graduation by one year.	~35 credits because of English courses; 14 units, increase graduation time; 12 units, maybe 1 semester delay; 8 units, may delay because can't find good internship because times do not match up.
Best three things about HM	
No costly books to purchase (2); Lab time for Matlab, registration process; internship is required for a bachelors degree; Since all teachers are required to have a minimum of 5 years' experience in industry, most instructors implement real-world aspects of the engineering fields into their lecture material. Classes are taught in multiple languages; Easier Classes, Less homework, More time to enjoy life	Some classes have higher academic value than at CP especially technical classes, you have to study on your own - it is important to learn how to do that; you have more time - a semester is 2 quarters (2); no books needed, no midterms/homework (2); easier to get into classes, autonomous working, relaxed rules (no attendance) (2); time of working is up to students; grading system more fixed and not up to mood of professor
Best three things about CP	
Homework, tests, and midterms (3) means I will retain it for the rest of my career. Projects prepare your for real work-environment scenarios experienced after university. The library holds plentiful academic resources and study space to help facilitate learning throughout the quarter; having a lab with classes. 24 hour computer labs; More interactions with Professors, Step by step learning, Less room to fall behind; I learn more in my classes, It is warm	more presentations - it is just so important for the career, teachers/profs take care of you and are more interested in your grades (3), people in California are much more friendlier - it is easier to meet people and hang out with them; the whole campus and it's facilities. - bigger staff and better organisation. - larger office hours; less people in classes (2) , huge campus, extensive use of internet for example blackboard; more labs (2) and practical examples; high availability of the Professors; More hands on tasks, greater variety of classes (piano)

Anyone considering an exchange will have to be open to new experiences and to adapting to a new culture. Don't expect stores to be open on Sunday, or for any of them to sell ice trays. You won't be able to find all of the foods or drinks that you typically get, but you will be able to replace these with new culinary experiences. We were fortunate that Peter "introduced" us to several of his friends, who have subsequently become our friends as well.

PW at CP

From the beginning I felt very welcome and found lots of open and warm-hearted colleagues who cared about my personal well-being and that of my family. I felt immediately integrated in my temporary environment and was surprised about all of the helping hands making me a part of the ME department at CP. From my German point of view I am still amazed how much friendliness, openness and curiosity I find not just in my academic environment but also among the usual American! It seems to me that the US society is much more used to accepting and integrating people with a foreign background compared to German society. Also my wife and children seem to enjoy their temporary environment in and out of school. California offers an extremely comfortable climate compared to Germany, and the places to discover between mountains and ocean are endless. It seems that even a year of living here is not sufficient to be able to see the large number of interesting places here. The usual picture of the USA in Europe is built on Hollywood movies and political news, the reality seems to not quite fit these preconceptions.

References

1. Astin, A. W. (1993b). What Matters in College? Four Critical Years Revisited (1st Ed.). San Francisco: Jossey-Bass.
2. Wolfsteiner, P. and Self, B.P. (2012) A Detailed Look at the German Universities of Applied Sciences. Proceedings of the American Society for Engineering Education, San Antonio, Texas.