

Improving the structure and content of the Mexican engineering design education on university level

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Das Studium des Maschinenbaus ist weltweit in den Grundzügen gleich, jedoch ist es das Spezielle, das eine Universität von den Anderen unterscheidet. Aufgrund der Spezialstellung, die das IMW in Bezug auf Konstruktion und Entwicklung einnimmt, wurde ein DAAD-Projekt mit mexikanischen Universitäten ins Leben gerufen, um diesen die Möglichkeit zu geben, selbst eine solche Fachrichtung zu entwickeln.

Mexican universities got a lack of methodical and integrative basics of a comprehensive engineering design understanding, which is mainly caused by university education. To eliminate this, a co-operation DAAD-project between the IMW and Mexican universities was established.

1 Introduction

The Institut für Maschinenwesen of Technische Universität Clausthal is conducting intensive relationships with the Mexican university CUCEI (Centro Universitario de Ciencias exactas e Ingenierías) in Guadalajara. Within this project, the basics of the German educational system shall be evaluated with respect to applicability in Mexican universities and transferred to Mexico. By introducing and evaluating this in a pilot project in Guadalajara it is possible to extend these structures to other Mexican universities.

In Mexico is a lack of methodical and integrative basics of a comprehensive engineering design understanding, which is mainly caused by university education. As representatives of science and industry in a discussion in December 2002 confirmed, the „German educational system for engineers is much more practical-oriented and efficient than the Mexican one“. The main points stated in this discussions were the German basic education with the integration of science of material, production and design, leading to basic projects like „Maschinelemente-Entwürfe“, where the students applies his theoretical knowledge to design products under the conditions of material properties and manufacturing abilities.

Also the process, the offers and the application of lifelong learning in Mexico is a very important factor in the education of engineers. This type of education plays an enormous role in Mexico (much more than in Europe) and at least one part of the here presented project must be directed to students of this type of courses.

The project oriented application of basic sciences including the challenge of a time-management in teaching mathematics, mechanics, material sciences, manufacturing and design like it is part of the curricula in Europe is up to now not known in Mexico.

2 Report of stay

Prof. Dr. Peter Dietz and Dipl.-Math. Bianca Sambale stayed about two weeks in Mexico. At Friday 10th of March, 2006 they arrived at Guadalajara Airport and they flew back from Mexico City Airport on Thursday 23rd of March.

In this time several meetings with the University of Guadalajara, Instituto Tecnológico of Irapuato and the Instituto Tecnológico of Queretaro were held, also the lecture „Konstruktionslehre“ (Methodology of Design) had taken place in Guadalajara in the first week. Several students and members of the industry participated this lecture.

Within the first meetings Prof. Dr. Dietz and Dipl.-Math. Sambale explained the art of study and the curriculum in Germany and they discussed with Dr. Villavazo Naranjo and his assistant Mr. Rangel from the University of Guadalajara how to involve this in the career of a mechanical engineer in Guadalajara. An analysis of the Mexican curriculum of mechanical engineering, extensions and shortenings on it were made during the first week. Also a PowerPoint presentation about this work was made and presented to participants of the university, industry and state institutions of Guadalajara.

The discussions with the two Institutos Tecnológicos in the second week, where the presentation was also presented, showed that in this case another strategy is needed.

	1 semestre	2 semestre	3 semestre	4 semestre	5 semestre	6 semestre	7 semestre	8 semestre	9 semestre	10 semestre					
1	Dibujo industrial	Algebra lineal 1	Analisis numerico	Adminis-tracion	Cinematica y dinamica de maquinas	Analisis contable	Electronica analogica	calidad	Electronica digital	optativa II					
2											3	4			
5						Introduccion computacion	Diferencial y integral	Calculo avanzado	Materiales	Circuitos electricos 1	Circuitos electricos 2	Etica profesional	Diseno elementos maquinas	Diseno de maquinas	optativa II
6															
9	10	11													
12	Introduccion ingenieria	Estadistica	Comportamiento humano	Equaciones diferencial	Fluidos	Lab. Fluidos Lab	neumaticos y hidraulicos	Instalaciones mecanicas	Control	Lab maq electricas II Lab. Maq. hidraulicas Lab. maq. Termicas	Diseño equipo de procesos				
13												14	15		
16	Precalculo	Socio-economia	Dibujo CAD	Electro-magnetismo	Mecanica de materiales I	Mecanica de materiales	Instalaciones electricas	Maquinas electricas I	Sistemas control sq.	Metodologia proy. Electro-mecanicos					
17											18	19			
20	Quimica basica	Programacion	Dinamica	Elementos de ingenieria industrial	Labor fisica	Trans-ferencia de calor	Procesos de manufact.	Maquinas hidraulicas	Manufactura II	tratamiento de superficies					
21											22	23			
24	Comunica-cion	Programacion	Dinamica	Elementos de ingenieria industrial	Labor fisica	Trans-ferencia de calor	Maquinas termicas	Maquinas hidraulicas	Refrigeracion y aire						
25										26	27				
28	Comunica-cion	Programacion	Dinamica	Elementos de ingenieria industrial	Labor fisica	Trans-ferencia de calor	Maquinas electricas II	Maquinas termicas II	Refrigeracion y aire						
29										30	31				
32	Comunica-cion	Programacion	Dinamica	Elementos de ingenieria industrial	Labor fisica	Trans-ferencia de calor	Maquinas electricas II	Maquinas termicas II	Refrigeracion y aire						
33										34	35				
36	23 SWS	24 SWS	32 SWS	33 SWS	23 SWS	18 SWS	34 SWS	29 SWS	27 SWS	20 SWS					
37	Basis Catalogo de Carreras U. d. G. Pag. 366-373; Orientacion en disenio mecanico														

Figure 1 Curriculum split in choice and have to (SWS = hours/week)

2.1 Strategy Guadalajara

As one can see in Figure 1, more than 25 % of the lectures of the mechanical engineering career as existing in Guadalajara are basics in mathematics, informatics and natural science.

mathematics, informatics	47	17,87%
natural sciences	22	8,37%
basic ingen. sciences	38	14,45%
electronics	66	25,10%
economics, non-technicals	22	8,37%
basic machine design	17	6,46%
special machine design	51	19,39%
sum	263	100,00%

Table 1 Curriculum in %

The distributions of the other competences were shown in the table above (Table 1). Also Mexican Curriculum doesn't allow the students to choose much of their lectures (Table 2).The possibility to choose and organize their study for themselves is a good exercise for German students to learn "social competences", as autonomy, flexibility, ability to communicate and so on. They are also able to spe-

cialise themselves in things which belong to their interests. Mexican students haven't got this possibility until now.

		hours/week	%
	optional	8	3,04
	specials	12	4,56
	compulsory:		
	common basics	76	28,90
	peculiar basics	120	45,63
	specials	47	17,87
		263	
	sum		
	compulsory	243	92,40
	selective	12	4,56
	optional	8	3,04

Table 2 Table of choice in %

German industry questionnaires have shown that German universities serve the condition more than just well, looking on the basics of science and the specialisation. The next graphic shows the difference between the wanted condition from German

industry and the served one from German universities:

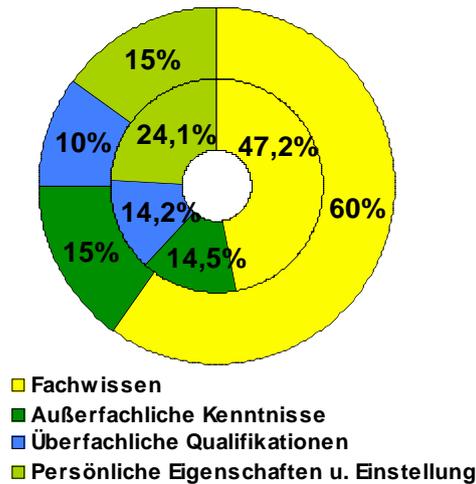


Figure 2 Outside: Supply of German University
Inside: Wishes of German Industry

As one can see, German universities are already teaching to much special competences (60% > 47,2%), which involved the basics of science and they serve more or less the need of methodical competences (14,5% > 15%). Mexican universities haven't any lectures of methodical competences at all, like "Konstruktionslehre" (Methodology of Design) and much more lectures, which belong to the basics of science and specialisation.

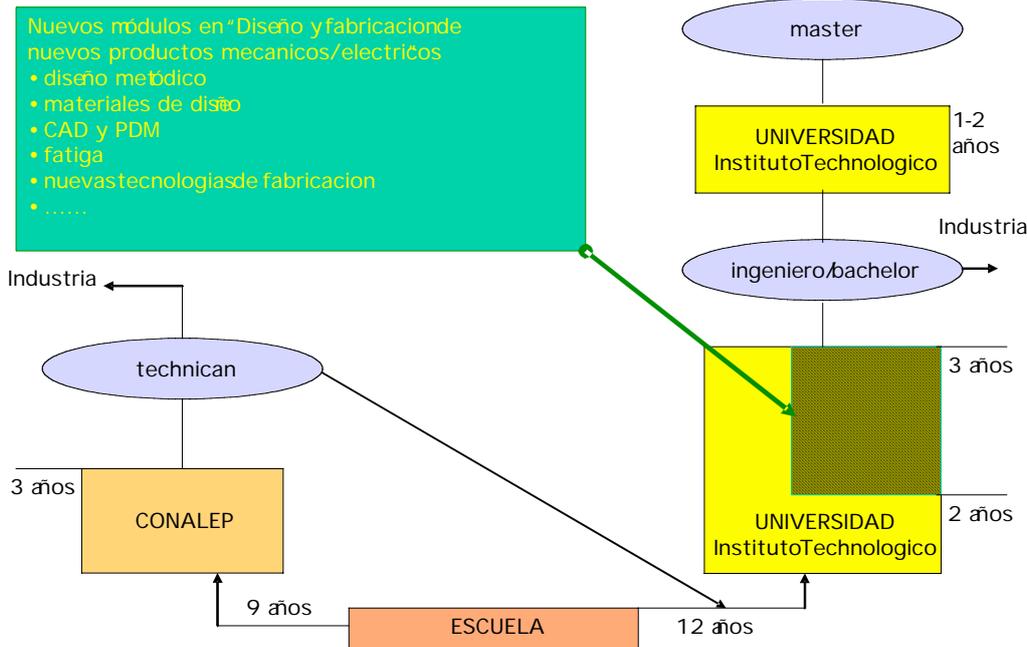


Figure 3 Where to change

A percentage comparison of the two curricula of the University of Guadalajara, Mexico and TU Clausthal, Germany shows clearly the differences:

	Guadalajara		Clausthal
mathematics, informatics	17,87%	>	13,66%
natural sciences	8,37%	>	6,83%
basic engineer sciences	14,45%	<	26,09%
electronics	25,10%	>	8,70%
economics, non-technical	8,37%	<	9,32%
basic machine design	6,46%	<	22,36%
special machine design	19,39%	>	7,45%
social competence etc.	0,00%	<	5,59%
	100,00%		100,00%

Table 3 Comparison of Curricula

But what Mexican industry needs, are not just only bachelors, who know how machines are working and how to read a construction plan. Mexican industry needs bachelors with a view for methodical and integrative basics of a comprehensive engineering design understanding. Mexican industry needs more designers.

So a proposal for changes in the Curriculum was made, as one can see in **Figure 3** (left).

Most of the changes appear in the second half of the time spent in the university respectively Instituto Tecnológico. A curriculum related to more intensive education in design could now be designed as following (some old lectures were erased):

	1. semestre	2. semestre	3. semestre	4. semestre	5. semestre	6. semestre	7. semestre	8. semestre	9. semestre	10. semestre
1						Circuitos electricos 1				
2	Dibujo industrial	Matematica Ing. 2	Matematica Ing. 3	Administracion	Circuitos electricos 1		Electronica analogica	calidad	Electronica digital	Dispositivos medicion
3										
4						Circuitos electricos 2				
5										
6	Introduccion computacion	Socioeconomia	Comportamiento humano	Materiales	Fluidos		Ética profesional	Control	Electronica industrial	Instru-mentacion
7										
8						Lab. Fluidos	Ingenieria economica			
9						Lab. Neumaticos y hidraulicos				
10		Estatica						Maquinas electricas	Lab maq electricas	Robotica
11				Equaciones diferencial					Lab. Maq. hidraulicas	
12	Matematica Ing. 1		Dibujo CAD		Mecanica de materiales (para el diseno)	Mecanica de materiales (para el diseno)		Instalaciones mecanicas	Lab. Maq. Termicas	
13		Programacion		Electo-magnetismo					Lab. Medicion	
14				Temas selectados de fisicas	Transferencia de calor			Instalaciones electricas	Sistemas control sq.	Proyecto mecatronico
15				Labor fisica		Elementos del diseno 3		Maquinas hidraulicas		
16	Quimica basica		Dinamica				Procesos de manufact. Nuevos			
17		Procesos de manufactura 2		Labor fisica		Proyectos diseno		Metologia del Dis. 1		
18			Elementos de ingenieria industrial	Matematicas para ingenieros	Elementos del diseno 2	Elementos mecatronico	Maquinas termicas	Resistencia, fatiga 2	Mikro-Manufactura	Product Data Management
19	Comunicacion	Lab manufactura								
20	Procesos de manufactura 1		Termodinamica	Elementos del diseno 1	Proyectos diseno	Calculo con elementos finitos	Maquinas electricas	Maq. De transferencia	Refrigeracion y aire	
21										
22							Lab. Fluidos		Metodologia del Dis. 2	
23										
24							Mediciones en ing.		Lab. Resistencia	
25									Maq. De transferencia hdraulico y	
26							Reststencia,			
27										
28										
29										
30										
31										
32										
33										
34										
35										
36										

Figure 4 Modification proposal

This Figure 4 is just an example, how a new career of a Mexican engineer, who will be able to design a new product, can look like. But just with add-ons and a small shortening of lectures, in a semester the hours per week would grow extremely high.

Another possibility is a total change of the curriculum (Figure 5).

In this proposed total modified curriculum students have more possibilities to choose their lectures (shown in Table 4).

	1. semestre	2. semestre	3. semestre	4. semestre	5. semestre	6. semestre	7. semestre	8. semestre	9. semestre	10. semestre
1	Dibujo industrial	Matematica Ing. 2	Matematica Ing. 3	Administracion	Circuitos electricos 1	Circuitos electricos 1				
2				economia para ingenieros			Electronica analogica	calidad	Electronica digital	SELECTIVA 6
3						Circuitos electricos 2		Control		
4									Lab. Medicion	ABIERTA 3
5	Introduccion computacion	Socio-economia	Comportamiento humano economia para	Materiales	Fluidos	Lab. Fluidos	Instalaciones mecanicas		Sistemas control sq.	
6										
7		Estatica			Mecanica de materiales (para el diseno)	Lab. Neumaticos y hidraulicos	Instalaciones electricas	Metologia del Dis. 1		ABIERTA 4
8										
9	Matematica Ing. 1		Dibujo CAD	Temas selectados de fisicas	Elementos del diseno 2	Mecanica de materiales (para el diseno)	Mediciones en ing.	Lab maq electricas	Mikro-Manufactura	
10		Programacion		Labor fisica						
11			Dinamica	Matematicas para ingenieros (Estadística)	Proyectos diseno	Elementos del diseno 3		SELECTIVA 2	SELECTIVA 5	Proyecto mecatronico
12	Quimica basica					Proyectos diseno		SELECTIVA A 3		
13		Procesos de manufactura 2		Elementos del diseno 1	SELECTIVA 1	Elementos mecatronico	Maquinas electricas 1	SELECTIVA A 4	ABIERTAS 1 y 2	Product data management
14	Comunicacion 1	Lab manufactura								
15	Procesos de manufactura 1						Lab. Fluidos	Maq. de transferencia a maicanica	LAB. SELECTIVAS	ABIERTA 5
16							Comunicacion 2			
17										
18										
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35										
36										
37	25 SWS	23 SWS	24 SWS	24 SWS	24 SWS	24 SWS	26 SWS	25 SWS	26 SWS	26 SWS

Figure 5 Total modification proposal (SWS = hours per week)

	new			old	
	week/hour	%		week/hour	%
compulsory	203	82,19	<	243	92,40
selective	47	17,81		21	7,60

Table 4 Total modification proposal in %

	hours/week	semester
compulsory	340	1-8
specialities	40	9
practicum	20	9

Also in the original Curriculum, as seen in Figure 1, the hours per week vary from 18 hours in the sixth semester to 34 hours in the seventh. In the new proposal the hours per week were uniformly distributed, so that Mexican students have constant amount of work during their whole study.

Table 5 Disposition at the IT Queretaro

How to solve this problem has to be discussed in further meetings.

2.2 Strategy Institutos Tecnológicos

As said before the strategy for the Institutos Tecnológicos should be a different one. The problem in this case is, if they are not a private institute, the Institutos are not allowed to design their own career unlike the universities. The DGEST (General Directorate of technological education) creates a career plan and every state-run Instituto Tecnológico has to adhere to it.

3 Resume of Meetings

The meeting partners of SEPROE (Secretary Promocion Economía) Ms. Laura Guevara, Directora Sectorial, Minister of Economy of State and of CAREINTRA (Cámara Regional de la Industria de Transformación del Estado de Jalisco) Mr. Jose Flores and Ms. Mariciela Ramos Saenz Pardo agree with the necessity of change in the career of the Mexican mechanical engineer. They also agree

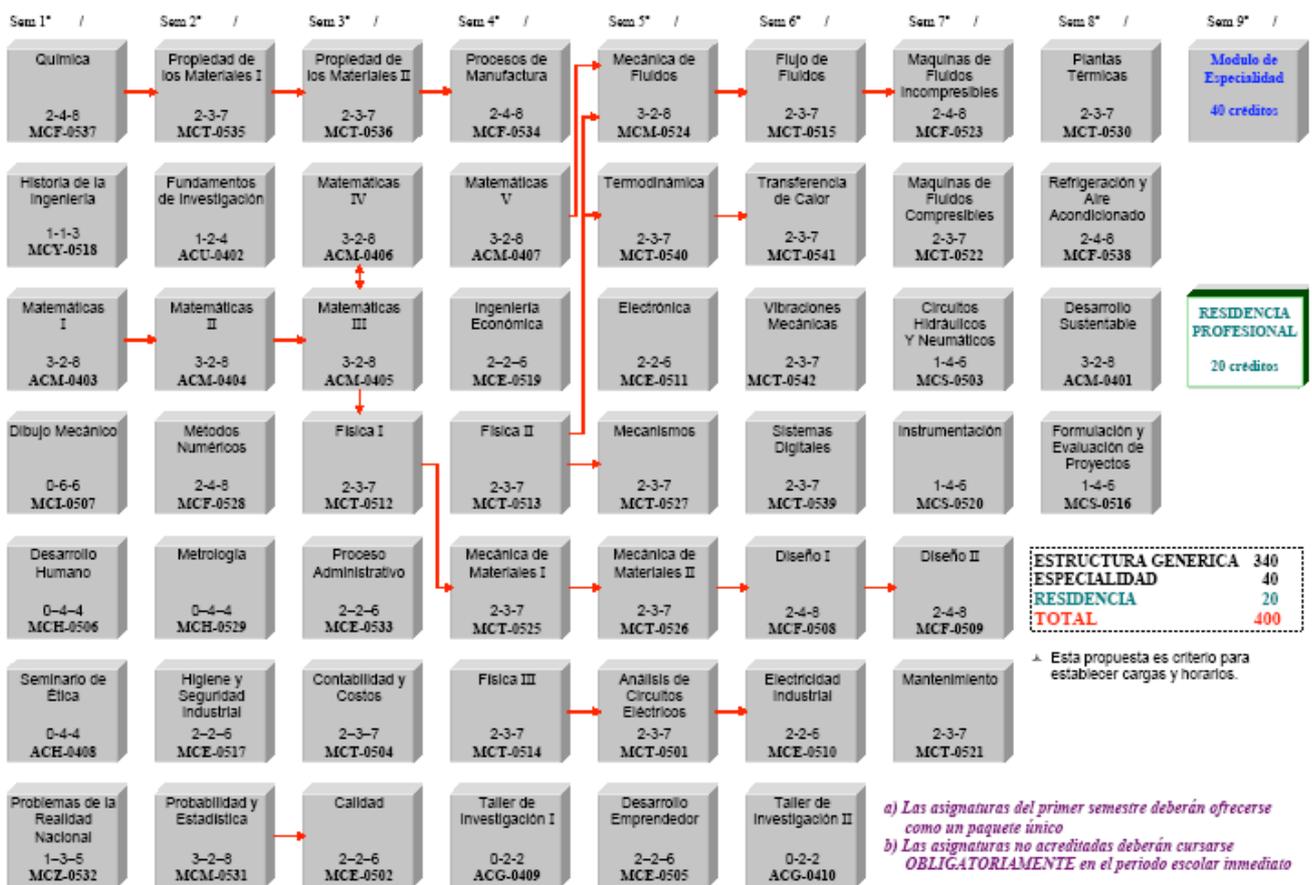


Figure 6 Curriculum Mechanical Engineer IT Queretaro

The below shown **Figure 6** describes the career of mechanical engineer at the IT Queretaro. The Institutos Tecnológicos have got a strict plan to hold on. They are only free in the choice of offer some specialities in the 9th semester (**Table 5**).

in the opinion that the period of education has to be shortened and the content has to change in much more applied and comprehensive lectures. The Institutos Tecnológicos are very interested in this project.



Figure 7 Meeting with an Instituto Tecnológico

4 Further Steps

The first meeting to fix the first steps of the program (namely the offers of contents, time, place and target group of the intensive courses) for the next two years was already held. The next step, as shown in the table below (**Table 6**), should have been a sort of summer school in September / October, but special circumstances displaced this step into the next year. These courses will be given first by professors and teachers from Clausthal university and if needed, experts from German industry.

In doing so, a fluxionary handing over to Mexican professors is planned during the project. The courses will have duration of three to four weeks, depending from the Mexican situation.

to evaluate and decide about lectures and the respective contents.

During their stay, the professors from Clausthal will also meet with other professors and university management responsible people to conduct extended conversations about the framework and the major requirements for changing and improving the Mexican teaching system. There will be special talks about the specific requirements of Guadalajara university, for which the program will have to be adopted to.

Another point, which started in 2006, is the clarification and planning of a curriculum for a new engineering career. During this phase the integration of the modules will be prepared and the curriculum for Mexico will be fixed. This phase take place since July 2006, the results of this step should enable the University of Guadalajara to offer the new course in the middle of 2007.

The different modules are based on lectures given at different institutes of the university. This task will be lead by the IMW (Institut für Maschinenwesen). The respective courses will have to be adapted to the local situation. In addition, the overall engineering curriculum at the University of Guadalajara needs to be analysed regarding the knowledge of students in mathematics, physics and engineering mechanics. On one hand, this enables a better understanding for the new classes in terms of what is known and what needs to be introduced. On the other hand, basis lectures may be adapted to cover the basics required for the new design classes.

id	Task	Begin	End	2006				2007				2008				2009			
				Q1	Q2	Q3	Q4												
1	Determination of requirements, Programm conception	01.01.2006	30.06.2006	■	■														
2	Add on arrangements alongside the course	01.07.2006	31.12.2009			■			■			■						■	
3	Clarification of Curriculum	01.07.2006	31.12.2006			■	■												
4	Participation of mexican Professors in german University	01.01.2007	30.06.2008					■	■	■	■								
5	Introduction of new engineering career	01.07.2007	30.06.2009						■	■	■	■						■	
6	Evaluation and Improvement, Adoption in mexican Curriculum	01.07.2008	31.12.2009										■	■	■	■	■	■	

Table 6 Timetable of the project IMPROVENG

Contemporaneous it is planned to have meetings in Guadalajara with these professors and teachers in order to give the Mexican participants the possibility