SEFI 2015

ANNUAL CONFERENCE

ORLEANS FRANCE

SEFI
European Society for Engineering Education
Europäische Gesellschaft für Ingenieur-Ausbildung
Société Européenne pour la Formation des Ingénieurs

POLYTECH
ORLÉANS
School of Engineering of the University of Orléans

UNIVERSITY OF ORLEANS

JUNE 29 - JULY 2

Proceedings of the 43rd SEFI Annual Conference 2014
Diversity in engineering education: an opportunity to face the new trends of engineering
Co-organised by SEFI and the Polytech Orléans

SEFI - Société Européenne pour la Formation des Ingénieurs
39 rue des deux églises, 1000 Brussels

Editors : Kamel Hawwash, President of SEFI
Christophe Léger, Conference chair

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European Society for Engineering Education
Europäische Gesellschaft für Ingenieur-Ausbildung
Société Européenne pour la Formation des Ingénieurs

SEFI is the largest network of higher engineering education institutions (HEIs) and educators in Europe. Created in 1973, SEFI is an international non-profit organisation aiming to support, promote and improve European higher engineering education, enhancing the status of both engineering education and engineering in society.

SEFI is an international forum composed of higher engineering education institutions, academic staff and teachers, students, related associations and companies present in 48 countries. Through its membership and network, SEFI reaches approximately 160000 academics and 1000000 students. SEFI represents 4 decades of passion, dedication and high expertise in engineering education through actions undertaken according to its values: engagement and responsibility, respect of diversity and different cultures, institutional inclusiveness, multidisciplinary and openness, transparency, sustainability, creativity and professionalism. SEFI formulates ideas and positions on engineering education issues, influences engineering education in Europe, acts as a link between its members and European and worldwide bodies, contributes to the recruitment of good students whilst always promoting an international dimension in engineering curricula.

Our activities: Annual Conferences, Ad hoc seminars/workshops organised by our working groups and task forces, specific events and actions for the deans in engineering such as the SEFI European Engineering deans Council (EEDC), scientific publications (incl. the European Journal of Engineering Education), European projects, Position papers, cooperation with other major European and international bodies such as the European Commission, the UNESCO, the Council of Europe or the OECD. The cooperation with partner and sister organizations in Europe and in the world is also one of our priorities.

For further information
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SEFI receives the support of its Corporate partners:

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GRANTA MATERIAL INSPIRATION

Welcome from the President of SEFI

I am delighted to welcome you to the SEFI 2015 Conference, which is being hosted by our colleagues at École d'ingénieurs Polytech Orléans. The conference provides an excellent opportunity for the engineering community to reflect on the important theme of Diversity and to share not only ideas but effective practice that we can take back to our own institutions.

The engineering community needs to continue to reach out to potentials engineers from traditional and non-traditional backgrounds to ensure we educate sufficient numbers to satisfy society's needs. As a community, we continue to investigate ways to attract more females to engineering and I know that this will be an issue that is widely discussed at this conference.

Across Europe, and beyond, there are tremendous examples of diversity in the way education is provided and institutions are organised, which merit sharing. This Conference provides a great opportunity for this to happen.

I wish to thank our hosts for their tireless work over the past year and to thank you for contributing to what I am sure will be a successful conference.

Kamel HAWWASH
University of Birmingham
President of SEFI

Welcome to Orléans



The city of Orléans is one of the most dynamic metropolis of France and it is located very closed to Paris (only far from 120 km). Thanks to the different restorations of the center, the quality of the inhabitants is changed: The old architecture is shown and enhanced. For example, the Martroi's place has been completely rehabilitated which is a great pleasure now for the walkers and visitors. Furthermore, the city is now closer to its royal river: The Loire; which is designated as a UNESCO World Heritage Site. Thanks to the different accommodations, the Loire's edge is more attractive and convivial. The Loire's place is nowadays one of the most visited place in Orléans.

New shops and centers in construction will add more dynamism in the center of the city. Consider as a history and an art city, Orleans is very famous thanks to its different events: the Joan of Arc's celebration and the Loire's festival every other year. The modernity of the city gets better thanks to the two tramlines, the construction of a new hospital in La Source (the biggest construction site in France with a financial investment of 700 million euros) and next year, the arrival of new students in the center of Orléans where is a good place to live.

Université d’Orléans

The University of Orléans is very pleased and proud to host SEFI 2015 and to welcome educators, engineers and representatives of industry from more than 30 countries.

SEFI 2015 Conference theme “Diversity in engineering education: an opportunity to face the new trends of engineering” finally meets, in the field of engineering, the challenge of all universities around the world : ensure that education and

Training meet the needs of labour market in a competitive environment, both now and in the future.

I am sure that the presentations will drive to discussions, ideas and exchanges. I hope that SEFI-Orléans experience will lead to new initiatives and active networking between all the participants.

Welcome again to University of Orléans, our medieval university definitely rooted in the future. Have a great stay, studious but friendly in our city!

Youssoufi TOURÉ
University of Orléans
President

Polytech Group

Recognized public engineering education
The 13 schools in the Polytech group fall within the public service (university tuition fees) and their degrees are accredited by the French Accreditation Board for Engineering (CTI).

Solid scientific and technological background
Polytech engineering students come from preparatory classes for Grandes Ecoles (CPGEs), University Institutes of Technology (IUT), Bachelors programmes or the Polytech Engineering Student Pathway (PeiP), and receive high-level scientific education before choosing a speciality.

Specialist engineers and “Polytech” engineers
Polytech Engineers specialise in order to be quickly operational upon leaving school. They are prepared to work in a world where technologies are becoming multi-tech, or “polytech”. With more than 80 majors, the Polytech group allows engineering students to customize their study programmes based on their career aspirations.

A culture of innovation
In constant contact with university research laboratories, competitive clusters and international research networks, Polytech engineers acquire a true culture of innovation through hands-on experience.

An international dimension
Because business and technology know no borders, Polytech engineers all experience international culture during an internship abroad. They have a good command of English, based on a professional test.

More than 80 engineering majors divided among 12 major scientific fields
13 public engineering schools (ANNECY-CHAMBÉRY - CLERMONT-FERRAND - GRENOBLE - LILLE - LYON - MARSEILLE -MONTPELLIER - NANTES - NICE SOPHIA - ORLÉANS - PARIS-SUD - PARIS-UPMC - TOURS)

3 types of study programmes: students, apprentices, employees
+ 14,000 students, with 10,400 engineering students, 1,250 apprentice engineers and 2,830 PeiP students (Polytech Engineering Student Pathway)
65,000 engineering alumni
1,800 internships or study trips abroad per year
1,200 PhD students
125 laboratories and research teams associated with the schools.
Partnerships with **leading research laboratories** in all fields

René LE GALL

Director of the Polytech Group

Polytech Orléans

It's a great pleasure to welcome you to Orléans, France, to the 43rd Annual Conference of **SEFI – the European Society for Engineering Education**. The last SEFI Conference held in France, in Paris in 2000, was organized by Paris Tech, both at ENSAM (Mechanical and Industrial Engineering School) and at Telecom Paris.

The theme of the 2015 SEFI Annual Conference, "Diversity in engineering education: an opportunity to face the new trends of engineering", will be explored through various innovative pedagogical approaches to improve engineering education in these areas: diversity in engineering education and institutions, gender and diversity in innovation teams, diversity and inclusion as business cases in technical research, and engineering education as a vector for social advancement.

For many of us, the SEFI Conference is one of the highlights of our year. It is an opportunity to find out what is happening in the field of Engineering Education, to catch up with colleagues and to make new friends.

With five exciting and varied keynote presentations and university-business plenary round table that will allow us the opportunity to explore engineering skills challenges with our industry colleagues, the conference is going to be busy but, we hope, fulfilling.

Please don't forget to participate in the Working Group meetings and workshops that are open to you.

In addition to the conference program, we offer you the opportunity to take part in complementary activities such as a tour of historical Orléans or a tour of the FRAC (Regional Contemporary Art Foundation). There will also be a reception at the Groslot hotel, a tour of the castle of Chambord, a special tour of the nuclear plant in Dampierre en Burly, and a gala dinner at the Chateau de la Villette.

I wish everyone a very fruitful and successful conference, both scientifically and socially. Have a great time in Orléans.

Christophe LÉGER

Director of Polytech Orléans

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Delegate Information

Meeting Venue

Polytech Orléans
8 Rue Léonard de Vinci
45072 Cedex 2 Orléans
Email : contact.polytech@univ-orleans.fr
Telephone : 02.38.41.70.50

Wi-Fi

Your access to WI-FI will be provided with your conference package upon registration

Registration

Hall Pascal, Polytech Orléans

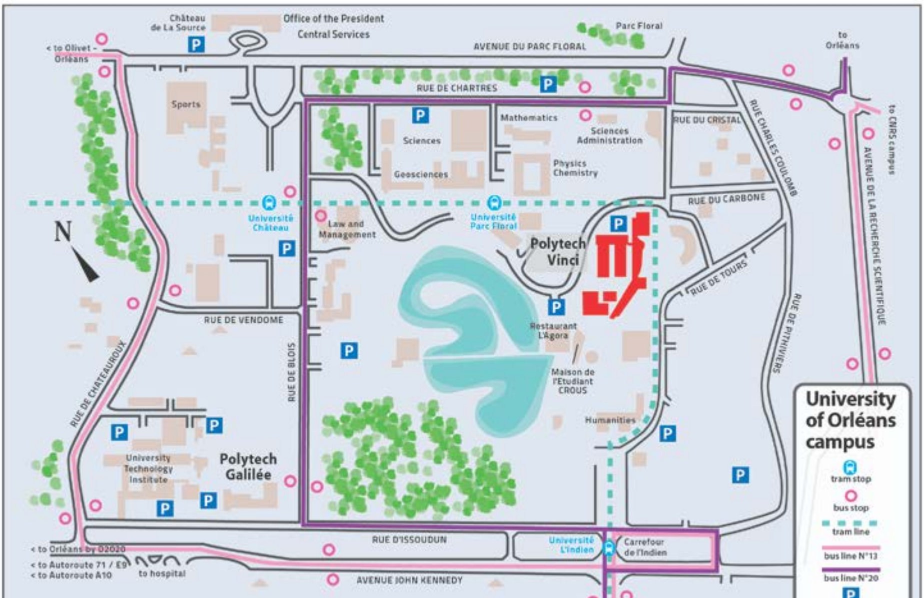
Badges

We invite you to wear your badge at all times during the conference and during the social events. Would you lose your badge, please address yourself to the conference team at the registration desk who will provide you with a replacement

Cloakroom

You will be able to leave your belongings in the Pascal room 002 during the whole conference

Campus Maps and Floor Plans



Polytech Orléans Vinci site: Latitude: 47.844261 | Longitude: 1.938959

Programme Monday, June 29

Time											
9:00	PP skills meeting I (Pascal 001)										
10:00–12:00	Coordination meeting of all the SEFI WGs Chairs (30 persons) (Pascal 101)						Board of European Students of Technology (BEST) (Pascal 001)				
12:00–13:00	Registration desk (Hall Pascal)						Board of Directors (BoD) meeting (Pascal 101)				
13:00–14:00							Lunch of the SEFI board of directors				
14:00	SEFI 2015 Opening Ceremony (Amphithéâtre Cabannes)										
15:00	Plenary session 1: Laura TILLY, Head of the Global Diversity Office at Daimler AG (DE) (Amphithéâtre Cabannes)										
16:00	Coffee break (Hall Pascal)										
17:00	Parallel session I	Workshop Curriculum and open and online EE (Navier 102)	Workshop Sustainability and EE (Pascal 202)	Workshop Attractiveness and EE (Joule 104)	Diversity in EE (Navier 101)	Mathematics and EE (Navier 103)	Gender in EE (Navier 105)	University - business : coopperation and inspiration (Pascal 203)	Engineering Education Research (Pascal 101)		
18:00–19:00	Get together party (Hall Pascal)										

Polytech Orléans
site Vinci
8 rue Léonard de Vinci
45100 Orléans

SEFI conference meetings

SEFI workshops

SEFI facilities

SEFI social events

By invitation only

Programme Tuesday, June 30

Time										
7:30–8:00	Registration desk (Hall Pascal)									
9:00	Plenary session 2: Teri REED, Texas A&M University (US) (Amphithéâtre Cabannes)									
10:00–11:00	Parallel session II	Queeca project meeting (Pascal 202)	Meeting of the SEFI European Engineering Deans Council (Pascal 101)	New education tools for EE (Joule 104)	Diversity in EE (Navier 101)	Language issues in EE (Pascal 203)	Learning specific formats for EE (Pascal 101)	New learning concept for EE (Navier 105)		
	Coffee break (Hall Pascal)									
12:00–13:00	Parallel session III	Queeca project meeting (Pascal 202)	Gender and diversity (Navier 102)	Engineering education research (Pascal 001)	Curriculum development (Navier 101)	Mathematics and EE (Navier 103)	Industry and EE (Pascal 203)	New learning concept for EE (Pascal 101)	Engineering Education Research (Joule 104)	
13:00–14:00	Lunch 300 persons									
14:00–15:00	Plenary session 3: University-business cooperation round table (Amphitheatre Cabannes)									
15:00	Coffee break (Hall Pascal)									
16:00–17:00	Parallel session IV	Queeca project meeting (Pascal 202)	EPICES Project Workshop (Pascal 101)	Continuing of lifelong learning EE (Navier 101)	Eco design sustainability in EE (Navier 103)	Engineering Education Research (Pascal 202)	Attractiveness of EE (Navier 102)	Education concepts specific for EE (Navier 104)	The importance of the intership (Pascal 203)	Physics and EE (Joule 104)
17:00	Tramway trip									
18:00	FRAC visit					Tramway trip				
19:00	15 minutes walk					Orléans visit				
20:00–21:00	Reception, Orléans town hall hôtel Groslot									

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Programme Wednesday, July 1

Time										
7:30–8:00	Registration desk (Hall Pascal)									
9:00	Plenary session 4: Christophe MORACE, ENSTA Bretagne (FR), and Alison GOURVÈS-HAYWARD, Telecom Bretagne (FR) (Amphithéâtre Cabannes)									
10:00–11:00	Parallel session V	Workshop on Mathematics and Engineering Education (Pascal 101)	Workshop on QAEMP Active learning (Pascal 202)	MathWorks technical workshop (Lagrange 007 & 008)	Education concepts specific for EE (Navier 104)	Accreditation, quality, assurance and globalization of EE (Navier 102)	Entrepreneurship and EE (Pascal 203)	Physics and EE (Navier 101)	Integration of research in engineering education (Navier 103)	
	Coffee break (Hall Pascal)									
12:00–13:00	Parallel session VI	MathWorks technical workshop (Lagrange 007 & 008)	Poster session (Reception Hall)	Ethics in EE (Navier 102)	Curriculum development (Navier 104)	Education concepts specific for EE (Navier 105)				
	Lunch 300 persons									PP skills meeting II (by invitation only)
14:00	Bus trip									
15:00									SEFI Conference 2016 organizing comittee	
15:00–18:00	Castle of Château de Chambord visit					Dampierre en Burly nuclear plant visit		St Laurent des eaux nuclear plant visit (by invitation only)		
18:00	Bus trip									
19:00–22:00	Conference Gala Dinner Château de la Villette SEFI Leonardo da Vinci Medal and SEFI Fellowships Ceremony									
	Bus trip									

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Programme Thursday, July 2

Time										
7:30–8:00	Registration desk, Hall Pascal, site Vinci									
9:00	Plenary session 5: Jette Egelund HOLGAARD, Aalborg University (DK) (Amphithéâtre Cabannes)									
	Coffee break (Hall Pascal)									
10:00–11:00	Parallel session VII	Workshop on Quality assurance and accreditation (Pascal 101)	ReadySTEMgo project Workshop (Navier 105)	Open and distance learning - MOOCS (Navier 101)	Diversity in EE (Navier 102)	Education concepts specific for EE (Navier 104)	Employability of engineering graduates (Pascal 203)	Students as key actors in engineering education change process (Navier 105)		
12:00	Closing ceremony and best paper ceremony (Amphithéâtre Cabannes)									
13:00	Lunch 150 persons									
14:00–15:00	SEFI General Assembly Amphithéâtre cabannes									
16:00–17:00	Board of Directors (BoD) meeting (with newly elected members) (Pascal 101)									
18:00	Bus trip									
19:00	Walk around the water mills of Loiret									
20:00–22:00	Optional dinner Loiret restaurant									
	Bus trip									

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Social Programme

Monday // 29th June 2015

Get together party at the Polytech Orléans
Hall Pascal from 18h00
Dress code is smart/casual

Tuesday // 30th June 2015

FRAC visit from 17h00
Orléans visit from 18h00
Reception, Orléans town hall hôtel Groslot from 19h30
Dress code is smart/casual

Wednesday // 1 July 2015

Castle of Château de Chambord visit from 15h00
Dampierre en Burly nuclear plant visit from 15h00
Saint Laurent des eaux nuclear plant visit from 15h00
Conference Gala Dinner
SEFI Leonardo da Vinci Medal and SEFI Fellowships Ceremony
Castle of Villette from 19h00
Dress code is smart/casual

Thursday // 2 July 2015

Walk around the water mills of Loiret from 18h30
Optional dinner, Pavillon bleu from 19h30
Dress code is smart/casual

Monday /// 29th june /// Parallel session 1 : 16h30-18h00

Workshop	Workshop	Workshop	Diversity in engineering education	Mathematics and engineering	Gender in engineering education	University – business : cooperation and inspiration	Engineering education research
Pr. C.RIOJA **Pr.DE VRIES** Curriculum on Open and Oline Engineering Education	**Pr. J.HOLGAARD** Sustainability and EE	**Pr. K.SCHREY** Attractiveness and EE	**59904. C.LEGER** AVOSTTI: a project dedicated to increase gateways between curricula	**55489. J.VANDEROOST** Engineering and science positioning tests in Flanders: powerful predictors for study success?	**57493. P.LUCHT** Teaching research-based gender competencies in STEM: The study program GENDER PRO MINT	**56715. E.SJOER** Collaborative PhD projects: together towards innovation	**54849. S WERNER** International Studies in Engineering Results from more than 12 years of experience in offering the most comprehensive international engineering programme at German universities
			56692. TW.RIDGMAN Comparison of Learning Styles of British and Yemeni Students	**56773. S.BORN** A mathematical lab for undergraduates	**56828. LM.SANCHEZ-RUIZ** Gender performance in an Aerospace Engineering Maths subject with innovative pedagogical approach	**56645. P.HYOTYNEN** Tools and inspiration for engineering education development through stakeholder cooperation	**54367. S.CHANDRASEKARAN** Improving Student-Industry Engagement through Project/Design Oriented Curriculum
			56635. S.ISHEN Gender and Diversity in Engineering MOOCs, a first Appraisal	**56274. I.CIPTOWIYONO** Engineering Students' Difficulties in Learning Complex Numbers	**55688. S.ISHEN** Forcing Quality and Sustainability in Gender and Diversity	**56072. R.CREPON** Using common Learning Resources between Academia and Industry: from Practice to Theory	**54365. M.PINXTEN** Fighting increasing dropout rates in the STEM field : The European readySTEMgo Project
			56608. B.ROTH MINTivation-Motivation1 a multilevel school program	**56141. K.LOUATI** A continuous evaluation for a new pedagogy: Mathematics for teaching engineers	**52051. K.BEDDOES** Professors' Perceptions of How Men and Women Students Experience Engineering Education Differently…Or Not	**56641. J.LIN** The Main Mode Analysis of University-Enterprise Cooperation on Engineering Education	**52586. D.ADAIR** Cultivation of critical thinking in undergraduate engineering education
			56613. A.MOROPOULOU Women role in engineering education in innovation teams in terms of scientific and gender diversification		**56694. S.MURSU** Reselection of Engineering Studies – Are Women in Finland Opting Out of Technology	**56648. P.HAMMAR ANDERSSON** A flow based approach to authentic learning in social oriented teaching	**51010. E.GUR** On the Necessity of Midterm Exams in Electrical Engineering Courses

Tuesday /// 30th june /// Parallel session 2 : 09h30-11h00

Meeting	Meeting	New education tools for engineering education	Diversity in engineering education	Language issues in engineering education	Learning specific formats for engineering education	New learning concepts for engineering education
Dr. M.MURPHY SEFI European Engineering Deans Council	**QUEECA PROJECT MEETING**	**55488. T.DE.LAET** How to remove the gender bias in multiple choice assessments in engineering education? Experimental validation and theoretical analysis using prospect theory	**56526. EJM.JANSEN** Long term, interrelated interventions to increase women's participation in STEM in the Netherlands	**55522. L.P.JENSEN** Does language and different educational background influence the learning outcome on international Bachelor educations?	**56749. M.KJELLBERG** Challenges in implementing PBL: Chalmers formula student as a case	**54688. T.ITO** The Effects of Spiral Educational Method through PBL : KIT Project Design Program
		56751. C.DEMAZIERE The effect of introducing on-line quizzes in a virtual learning environment and implications for the flipped classroom	**56434. CF.LAI** Influence of Integrating Creative Thinking Teaching into Project-based Learning Courses to Engineering College Students	**54727. R.KARCHNER.OBER** German for specific purposes (GSP) – a pathway to studies in engineering at university of Duisburg-Essen	**56481. M.BURMAN** How to coach engineering project-based learning?	**54823. D.CHOULIER** On line course and learning scenarios for innovative design teaching
		56690. L.SAARIKOSKI Intercultural, Reciprocal and Multidisciplinary Learning Case Study	**55396. RG.KLAASSEN** Cross Institutional Comparison of Curricular Change in Dutch Engineering Bachelor Programmes	**54318. A.I.CHUCHALIN** Integrated approach to teaching ESP based on MOOCs	**56517. R.CLARK** Developing a robust Self Evaluation Framework for Active Learning : The First Stage of an Erasmus + Project (QAEMarketPlace4HEI)	**55884. S.SUHONEN** Enhancing Learning in Integrated Physics Laboratory Course: Physics, Mathematics and Communications
		56471. J.HOLVIKIVI Student Collaboration and Independence from Day One in Higher Education	**54955. E.DE.GRAAFF** Intercultural aspects in PhD supervision	**57576. F.SAGEBIEL** How to influence gender stereotypes to increase attractiveness of engineering	**55043. D.GIORDANI** A PBL experience to simulate a business environment in a discipline of chemical engineering course	**56628. P.ANDERSSON** Facilitating creativity as a core competence in Engineering Education
		55960. HL.CHRISTIANSEN Improving report writing by peer assessment using Coursera	**57501. T.TOLKACHEVA** Why and how to engage students in the learning process			

Tuesday /// 30th june /// Parallel session 3 : 11h30-13h00

Meeting	Workshop	Worshop	Curriculum developpement	Mathematics and engineering education	Industry and engineering education	New learning concept for engineering education	Engineering education ressearch
QUEECA PROJECT MEETING	**S.IHSEN** Gender and diversity	**Pr.R.CLARK** Engineering education research	**56744. G.KLADIS** Project-based Learning as an Effective Developer of Young Engineers' Curriculum	**55838. D.VELICHOVA** Is there a special Maths for engineers?	**57573. J.POIRIER** FIRE: Education program in Refractory Engineering	**56508. YC.HSU** Using Brainstorming and Appreciation of Novel Tech to Enhance Creativity in School Engineering Projects	**55524. LP.JENSEN** Using consultation in student groups to improve development of team work skills amongst more reluctant students
			56474. J.HOLVIKIVI Adoption of a New Project-Based Learning (PBL) Curriculum in Information Technology	**56884. E.TRIANTAFYLLOU** Encouraging Students to Reflect by Flipping the Mathematics Classroom	**56562. P.FAGRELL** The Unspent Resource – Industrial Adjunct Professors as a Potential Source for Developing Engineering Curricula	**56520. A.DEDERICHS KOCH** Teaching Mechanical Engineering and Humanoid Robotics with respect to Gender and Diversity Aspects	**55255. A.KALMAN** Study of correlations between efficient learning habits and the study achievement indicator
			55855.MED.VAN.DEN.BOGAARD A heuristic to understand curriculum change: towards comparing 3 course programme overhauls within the Dutch 3TU coalition	**53534. J.PEUTEMAN** Electric kart project to develop research-related skills for engineering students	**56408. M.VAN.DIGGELENAND** Stimulating feedback conversations: design and evaluation of a feedback tool in Industrial Design Education.	**56476. K.KOVESI** A case study of teaching interdisciplinary collaboration for engineering students	**55111. JT.VAN.DER.VEEN** Engineering in Dutch Schools: Impact on Study Choice
			55777. SM.PUENTE Combining online and face-to-face tutoring to enhance learning physics concepts	**55856. M.KARAMEHMEDOVIC** Mathematical beauty in service of deep approach to learning	**56407. M.VAN.DIGGELENAND** Avoiding the traps: seeking for good practices and trends for future Industrial Design Education	**55107. L.MORELL** Disrupting Engineering Education to Better Address Societal Needs	**55019. P.KOLLENBURG VAN** Is Fontys engineering's honors program educating the brilliant engineer?
						54694. S.WADHWA Ascertaining Affective Domain in Engineering: A New Learning Concept	**54956. L.VAN.DEN.BROECK** Creating an optimized diagnostic test for students bridging to Engineering Technology

Tuesday /// 30th june /// Parallel session 4 : 15h30-17h00

Workshop	Workshop	Continuing of lifelong learning engineering education	Eco-design sustainability in engineering education	Engineering education resarch	Attractiveness of engineering education	Education concepts specific for engineering education	The importance of the internships	Physics and engineering education
QUEECA PROJECT MEETING	**A.LANTHONY** **A.FRANCOIS** EPICES PROJECT	**56595. B.NORGAAD** Work Based Learning in Industrial Engineering	**56147. A.PEREIRA.MEDRANO** Teaching Circularity using CES EduPack	**57160. D.SHERIDAN** Ça ira: The Need for Reform of Engineering Education	**55365. S.K.BARNES** Writing Learning Objectives that Engage Future Engineers: Hands-on & Minds-on Learning Activities	**60823. C.LEICHT-SCHOLTEN** Building bridges - Integration of gender and diversity perspectives in engineering education	**56716. R.VIZIOLI** Supervised internship data evolution and the internationalization of engineering courses	**56704. D.TIMMERMANN** Using Potential to Help Students Understand Voltage: First Steps in Implementing Effective Instruction
		56389. B.FATAHI Research-Based Computer Games to Train Civil Engineering Students to Be Lifelong Learners	**56598. L.CLEMMENSEN** Student Employment and Study Effort for Engineering Students	**56632. M.M.JAKOBSEN** A scientific approach to teaching – to reach innovative pedagogical approaches nationwide	**54789. RH.HWANG** Enhancing the programming skill in high school engineering education via flipped classroom and peer assessment	**56726. A.WINTER** Tutor Training Using Role Play and Video Analysis for the LearnING Center, a Study Room at TUHH	**56472. E.GOOLD** Professional Formation of Engineers: Enhancing the First Year Student Experience	**56746. P.HOCKICKO** Comparison of the Entering Students' FCI Results – Tampere UAS and University of Žilina
		56680. I.GAST Team-based Professional Development in Higher Education		**56559. B.WILLIAMS** Globalization of engineering education research: a citation analysis of ASEE and SEFI conference papers	**54788. A.BAGIATI** Supporting K-12 STEM reform through K-12 STEM Learning Workshops at Singapore University of Technology and Design	**56721. MM.CIAMPI** Engineering Opportunities for Engineers	**51310. S.MALE** Supporting students learning despite difficult workplace interactions	**55862. JP.PURANEN** RC-car as a Small-scale Measurement Setup for Physics Labotory Course
		54705. G.LE.BOT Interdisciplinary E-learning: an engineering perspective		**56489. M.SVEDIN** A strategic approach to graduating	**54867. L.RADEMACHER** "Creativity + Construction" as part of the orientation program MINTgrün	**56718. C.BRITO** K12 Enhancement Program: Engineering the Future of an Entire Young Population		**54811. P.HOCKICKO** Early Identification of Problems in Physics Learning and Suggestion of Intervention Tools for the Freshman Students in STEM Education
		56512. G.BUSKES Design and Implementation of a first-year engineering design subject		**55678. E.HOFLAND** "Roles" in the Bachelor's and Master's programmes in Engineering Technology	**56485.D.LOWE** The Validity of High School Performance as a Predictor of University Undergraduate Engineering Performance	**54832. S.WADHWA** Activity Based Learning: Overcoming problems in implementing OBE in Engineering Education during transition phase		

Wednesday /// july 1st /// Parallel session 5 : 09h30-11h00h

Workshop	Workshop	Workshop	Education concepts specific for engineering education	Accreditation quality assurance and globalisation of engineering education	Entrepreneurship and education engineering	Physics and engineering education	Integration of research in engineering education
Pr.D.Velichova Mathematics and engineering education	**Pr. K.SCHREY** QAEMP active learning	MATHWORKS technical	**54452. I.JORGENSEN** Three Step Development Model used for Active Learning in Electrical Engineering	**54798. PS.SHAMRITSKAYA** Developing the Unified Accreditation System for Engineering and Technology Programmes in Russia	**55778. M.DYRENFURTH** The innovation—cognitive science interface: Implications for engineering and technology education	**54747. L.MUSILEK** Archaeometry – an example of interdisciplinarity in engineering education	**56388. B.FATAHI** Application of Research-Inspired Assessment to Enhance Students Learning in Civil Engineering
			56344. JV.MAELE Making way for the intercultural in engineering education: New spaces for embracing the tensions	**54046. PA.HSIUNG** Departmental Refinement Measures for Engineering Education Accreditation	**54684. D.MAY** Entrepreneurship and gender in higher engineering education in Germany	**54759. WH.COSTE** The World Trade Center Analyses: Case Study of Ethics, Public Policy and the Engineering Profession	**56028. L.GESCHWIND** The teaching-research nexus in engineering education: A case study
			59252. TU.GANIRON Development and Validation of Module Presentation of Selected Topics in Physics for Architecture Students	**67613. E.GUBERTI** The introduction of a EUR-ACE based system for Quality assurance and accreditation of Engineering Education in Central Asia: outcomes and lessons learnt	**54817. H.PAATALO** Development of entrepreneurship education at universities of applied sciences	**55889. SJ.SUHONEN** Students' Online Activity on a Fully Online Introductory Physics Mechanics Course	**54813. J.BERNHARD** A tool to see with or just something to manipulate? - Investigating engineering students' use of oscilloscopes in the laboratory
			56444. U.BEAGON 'Where there is no Engineer' Using a problem based project to develop graduate attributes in first year engineering students	**67742. J.VERMEERSCH** Coaching stakeholders involved in external program evaluations	**55826. D.COADOUR** Codesigned and odesigned and coconstructed leadership training of engineers	**54928. T.TILLOCHER** Engineering and research education in Plasma technology	**57576. F.SAGEBIEL** How to influence gender stereotypes to increase attractiveness of engineering
			61369. S.GROSS Multi-concept use of low-cost hardware for engineering education	**56395. MI.ODILIA** Assessing the role of mechatronics engineering, based on it graduate profile by knowledge areas	**54863. JM.GUTIERREZ** The Colibri Project: Overcoming diversity in blended e-learning activity preparation	**56419. JA.TIILI** Development of Simple Public Assessment Sheet and its Use in Elementary Physics Laboratory Course	

Workshop	Poster Session M.HOFFMANN	Ethics in engineering education	Curriculum developpment	Education concepts specific for engineering education
MATHWORKS Technical	**56826. E.BALLESTER** Industry collaboration in a Master degree	**56039. R.TORMEY** The Formal and Hidden Curricula of Ethics in Engineering Education	**56748. E.LONDERS** Concept Mapping as an Innovative Tool for Curriculum Development	**56582. E.TILLEY** Pedagogic experiences in problem-based learning environment focused on human-centred design
	54024. E.RICK "A la Modes:" The Role of Expressive Modalities in the Teaching and Learning of Design Thinking	**56475. A.KOSKINEN** E-learning of ethics, awareness, hacking and research by information security majors	**56780. A.BERGLUND** Co-creation beyond the expected: Generating new knowledge through interdisciplinary learning	**59260. TU.GANIRON** Effectiveness of Arabic Language as a Medium of Instruction in Enhancing the Performance of Students in Architecture Studio Courses
	56824. L.REMON Computational Fourier Optics Simulation using a virtual laboratory	**56447. B.LUND.CHRISTIANSEN** Teaching & Learning Ethics in BEng programmes at the Technical University of Denmark	**56728. AM.JOLLY** Integrated Mechatronic Design with Project Base Learning	**54394. JP.MENN** Generic model for international assembly instructions for special machinery assembly
	55972. R.POZZI Teaching sustainability to industrial engineering students		**67622. H.GERAEDTS** Motivation blockers of first year Mechanical Engineering students at the Fontys University of Applied Sciences	**55043. D.GIORDANI** A PBL experience to simulate a business environment in a discipline of chemical engineering course
	56730. D.SEGOVIA On the application of e-learning in engineering education			**54385. T.BURKE** Using Theory to Improve Design Instruction in a New Common First-year Programme for Engineers
	56147. A.PEREIRA Teaching Circularity using CES EduPack			
	55855. MED.VAN.DEN.BOOGARD A heuristic to understand curriculum change: towards comparing 3 course programme overhauls within the Dutch 3TU coalition			
	56654. P.HYOTONEN Employability of engineering graduates – Case: Results of Finnish Engineering Graduate Feedback Survey 2014			
	56072. R.CREPON Using common Learning Resources in Academia and Industry From Practice to Theory			
	56745. H.TAUSCHER Integrating foreign studies within the constraints of European Harmonisation: A BIM e-learning course			

Thursday /// july 2nd /// Parallel session 7 : 10h00-11h30

Workshop	Workshop	Open and distance learning - MOOCS	Diversity in engineering education	Education concepts specific for engineering education	Employability of engineering graduates	Students as key actors in engineering education change process
Pr.AM.JOLLY **Pr.B.REMAUD** Quality Assurance and accreditation	**Pr.G.LANGIE** ReadySTEMgo project	**55480. E.ROMERO.BRUZON** Experience of the design of a MOOC in Engineering for the learning of microcontrollers	**55032. C.DRAUDE** Diversifying a Car Body Development Course : Integrating Intersectional Gender Studies Expertise in Engineering Education	**56745. H.TAUSCHER** Integrating foreign studies within the constraints of European Harmonisation: A BIM e-learning course	**56654. S.KOKKO** Employability of engineering graduates – Case: Results of Finnish Engineering Graduate Feedback Survey 2014	**56774. LM.SANCHEZ.RUIZ** Defining the engineering student of 2030
		55858. JA.TIILI Students' Experiences on Modern Fully Online Introductory Mechanics Physics Course	**55842. M.PETERS** Getting round pegs into round holes: getting students onto the right Engineering Programme	**55111. JT.VEN.DER.VEEN** Engineering in Dutch Schools: Impact on Study Choice A quantitative analysis	**55366. N.STRENGER** Higher Education Institutions as Key Actors in the Global Competition for Engineering Talent	**54692. C.LASSUDRIE** Score distribution as a tool to reveal group dynamics in student projects?
		56765. P.DE.VRIES The Value of Engineering MOOCs from a Learner's Perspective	**55625. PA.SANGER** Cross Cultural Diversity in Engineering Students in America and Europe	**56735. J.CHANDRAN** A Project/Design approach in an Electrical Engineering Course	**51172. J.ANDREW** Managing the Multiplicities of Graduate Level Education! Are Master's Students' Expectations Matched by their Experiences	**65700. G.NAHAS** Social Sciences in Engineering Education
		56686. G.SAUNDERS Anytime, Anywhere – The development of an online course in Research Methodologies	**56528. A.HUNGER** Diversity in Engineering Education: Good or Evil for International Programmes?	**54048. H.HALLEZ** On Using Test-Driven Development to Tutor Novice Engineering Students using Self-Assessment	**55850. I.BLANCKAERT** Development of a broad and approachable format for didactic professionalization in a multicampus context	**56711. I.BAKAS** Essential qualifications of modern engineers in Europe and how the university provides for them: The Greek paradigm
		56077. O.BERNAERT MOOC and Serious Game An educational Approach on Transfer and Action				**55568. V.WYNS** Student and industry involvement in quality assurance

Keynote presentations and speakers

Dr Christophe Morace

Dr Christophe Morace is an Associate Professor of Intercultural Management at ENSTA Bretagne, in France. He completed his PhD on Intercultural Competences for Managers and Engineers at Freie Universität Berlin. He started his academic career after 12 years in industry as an export and key account manager in French, German and Japanese Companies. His research focus is on Intercultural communication in companies, management of international teams and the intercultural aspects of engineering education. He has published many journal articles, peer reviewed papers and book chapters and regularly taken part in national and international conferences, such as CDIO, IAIR, QPES and SEFI.

Dr Alison Gourvès-Hayward

Dr Alison Gourvès-Hayward is an Associate Professor and Head of the Modern Language Department at Telecom-Bretagne in France. She was educated in Great Britain, France and Ireland, where she completed her PhD in Intercultural studies at Dublin City University. She has extensive experience in education, interpreting, translation and managing multicultural teaching teams. Her research interests include telecollaborative intercultural learning, self-assessment, and intercultural competences for student and practicing engineers. She has published extensively in this field and given many academic papers and invited talks at national and international conferences, such as CDIO, IAIR, SEFI and SIETAR.

When is an Engineer, not an Engineer?

An interdisciplinary Approach to Intercultural Management for Engineers

Keynote Speakers
Christophe Morace, ENSTA Bretagne (FR)
Alison Gourvès-Hayward, Telecom Bretagne (FR)

Over the last two decades, there has been a move towards standardization of educational norms, with, for instance, the UNESCO 4 pillars of learning (Delors et al 1996), or the Key competences for Lifelong Learning European Reference Framework (2004). Similar developments can be observed in Engineering Education, with initiatives such as EUR-ACE®, a European accreditation board, or the CDIO syllabus (Crawley et al 2011). Such initiatives draw on various national and international accreditation boards and indeed strong alignment can be found among them.

However, along with the establishment of shared objectives, the need to address the diversity of Engineering Education, to integrate different voices and perspectives and to adapt to local and global needs is also recognized. Indeed, as Hoffmann et al (2011) point out, engineering is not culturally neutral and contemporary practices are: “embedded in institutional configurations, national strategies and cultural norms”. According to Brodeur (2012), social location has an influence on the way reality is experienced and there is a need to examine the underlying cultural values, such as different understandings of the ethics of globalization, behind engineering programme strategies.

This tension between unity and diversity has long been a preoccupation of the SEFI community, as has the need to include the Humanities and Social Sciences in Engineering Education (Evangelou 2010), although work on Intercultural or global competences remains relatively limited (Smith 2010; Van Maele et al 2013). At the same time, in recent years, many educators have pointed out the need to transform educational practices to accommodate the vast amount of knowledge which is readily available but which requires skills, such as critical, synthetic and analytical reasoning, to access, process, make sense of and accept or reject such information, along with increased communication, creative and networking competences across disciplinary and geographical borders (Pink, 2005; Wagner 2010; Serres 2012). In this increasingly changing and mobile world, the question of intercultural competences is at the core of the debate.

In this plenary, which takes the form of an interdisciplinary and intercultural dialogue, we present our teaching and research model for Intercultural Management for Engineers. Firstly, we describe and analyse our two-tier pedagogical approach, which combines Intercultural Management and Communication theories and experiential learning. Using a concept called “interity”, developed by Demorgon (2010) and based on insights from the French philosopher and mathematician, Couturat, we encourage the students to negotiate a common frame of reference and action. This symbolic space, which Kramsch

(1993) calls a “Third place”, represents a dialogic process which occurs at the moment of rupture between the presuppositions and expectations of speakers from different cultures (Zarate 1986; Kramsch, 1995) and enables students to gain first-hand experience of the realities of diversity management. Our main objective is to use the diversity represented by cultural and individual differences to proceduce new synergies

In the second part of the plenary, we focus on our Intercultural Management Competence Model (IMCM) which draws on 10 years’ teaching and research focused on the identification, development, assessment and analysis of Intercultural Management competences. The model combines the five *savoirs* developed by Byram and Zarate (1994), the cultural dimensions described in the Intercultural Management literature, Demorgon’s multiperspectivist approach (2010) and insights gained from our interviews with practicing and student engineers in an international context. The starting point for our reflection is the dichotomy between the questions: When is an engineer not an engineer? and a comment made by a Spanish engineering student: “We all speak the same language, we are all engineers”.

Dr. Teri Reed

Dr. Teri Reed received her B.S. in petroleum engineering from the University of Oklahoma and spent seven years in the petroleum industry, during which time she earned her MBA. She subsequently received her Ph.D. in industrial engineering from Arizona State University. An advocate for research-informed approaches to engineering education, curricular reform, equity, cultural humility and policy, as well as student recruitment and retention efforts, Dr. Reed has made significant contributions nationally as well as at Arizona State University, the University of Oklahoma, Purdue University, and Texas A&M University where she has spent her academic career.

Dr. Reed helped establish the scholarly foundation for engineering education as an academic discipline through co-authorship of the landmark 2006 JEE special reports "The National Engineering Education Research Colloquies" and "The Research Agenda for the New Discipline of Engineering Education." Dr. Reed's teaching interests include statistics, interdisciplinary and introductory engineering, diversity, and leadership. Her research interests include statistics education, concept inventory development, assessment and evaluation of learning and programs, recruitment and retention, diversity, and equity. She has received funding from the National Science Foundation, the U.S. Department of Education, various private foundations and industry.

She is a fellow of the American Society for Engineering Education (ASEE), and a member of the Institute of Electronics and Electrical Engineers, the Society of Petroleum Engineers, and the Institute of Industrial Engineers. She serves as an ABET Engineering Accreditation Council evaluator for ASEE, is the past co-chair of the Undergraduate Experience Council, and chair of the Diversity Committee. Dr. Reed served as a reviewer of the U.S. National Academy of Engineering's (NAE) 2008 report, Changing the Conversation: Messages for Improving Public Understanding of Engineering, and 2010 report, Standards for K-12 Engineering Education? She begins serving as the Women in Engineering ProActive Network (WEPAN) president-elect in the summer of 2015.

She has received a number of professional honors, including the 2015 ASEE William Elgin Wickenden Award for the best research paper written in the past year of the Journal of Engineering Education, 2013 ASEE Sharon Keillor Award for Women in Engineering Education, election as a 2010 fellow member of ASEE, the 2008 ASEE Outstanding Service Award from the Educational Research and Methods Division, a 2007-2008 Committee on Institutional Cooperation Academic Leadership Program fellow, and in fall 2012 Purdue University's One Brick Higher Award, one of Purdue's highest honors given by the university president.

Life in a Fish Bowl: A Conversation on Inclusive Efforts in Engineering Education

Keynote Speakers
Teri Reed, Texas A&M University *(US)*

As we celebrate this year's theme of "Diversity in engineering education: an opportunity to face the new trends of engineering", we are encouraged to reflect on our thoughts, conversations, initiatives, and even intentions to achieve or promote equity and heterogeneity in our environments. Very well intentioned decisions or even programs can lead to surprising ramifications, interpretations, or consequences. Most of us want to do the right thing, want to support and encourage inclusion of heterogeneous populations and success in engineering and beyond, but many of us struggle with knowing what actions we can or should take that will contribute positively to diversity and inclusivity. Just like asking fish if they like living in water, we are often blind to the experience of the culture we live in day to day. However, this tends not to be the experience for those from marginalized cultures or those different from the dominant culture. An innovative framework developed at the Simmons School of Management for promoting equity in organizations can help guide our thinking about ways to achieve intentionally equitable, inclusive environments. The four perspectives have both benefits and drawbacks and are shaped by our assumptions as to the cause of the differences between groups. There are certainly places and times to employ strategies from each perspective, as long as we understand the potential ramifications for choosing to do so. Though this four frame model was developed with regard to gender equity, it can apply to all groups who are underrepresented, including those based on socio-economic status, race, ethnicity, and ability status.

Dr. Laura Tilly

Since March 2014, Laura Tilly has been Head of the Global Diversity Office at Daimler AG. Laura Tilly started her career at Daimler in 2003. During her dual studies, she gained experience in different divisions within Germany and abroad. Laura Tilly completed her studies in Business Administration at the Berlin School of Economics.

While holding several manager functions at Daimler, Laura Tilly gained a broad knowledge in Human Resources. As Head of the Global Diversity Office, her focus centers around topics like gender diversity, generation management, internationalization and working culture. Laura Tilly is convinced that diverse employees and openness for inclusive leadership are key success factors in the economic success and sustainable future position of a company.

Keynote Speakers
Laura Tilly Daimler (DE)

Diversity Management at Daimler

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- Our Diversity Statement signed by the Board Members underlines the importance of Diversity Management.
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- Diversity is a strategic success factor of Daimler.

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Diversity shapes our future

Dr. Jette Egelund Holgaard

Associate Professor within the field of Sustainability, Technology and Organizational learning at the Department of Planning; Aalborg University.

She has a M.Sc. in Environmental Planning and a Ph.D. in Environmental Communication. Both degrees are from Aalborg University. In her work on environmental communication in business relations she draw attention to the need for engineers that were capable of aligning their thinking, communication and actions to sustainability in their everyday profession to develop, produce and diffuse sustainable technologies. Since then she has been focused on teaching and research aiming to develop sustainability competencies as a natural part of the engineering identity.

Dr. Holgaard is now affiliated to the Aalborg Centre for Problem based Learning (PBL) in Engineering Science and Sustainability under the auspices of UNESCO, where she have the special responsibility to make use of a PBL framework to enhance engineering education and innovation for sustainability. She has published more than 80 publications related to this field. In her keynote entitled "*Embedding sustainability in engineering identities*" she will discuss the challenges of education for sustainability in the many shades of engineering education.

Keynote Speakers
Jette Egelund Holgaard Aalborg University (DK)
Aalborg Centre for Problem Based Learning in Engineering and Sustainability under the auspices of UNESCO, Aalborg University

If the engineering profession has to take an active part in facing the grand and complex challenge of sustainable development, it is not enough that sustainability is added on to engineering, as a disciplinary domain, it has to be integrated in engineering education practise or even embedded in the core identity of being an engineer.

New pedagogies, like Problem Based Learning (PBL), capture the multi-dimensional vision of engineering by letting the students work with real life problems calling them to analyse societal and user contexts and collaborate to solve interdisciplinary problems. At the Aalborg Centre for Problem based learning in Engineering Science and Sustainability under the auspices of UNESCO, we continuously develop the PBL pedagogy to embrace Education for Sustainable Development (ESD).

However, likewise a change towards PBL, a change towards ESD hold specific challenges as to convince students as well as staff to embed sustainability in the way they think of and practise engineering. In this keynote, I will discuss these specific challenges, and argue that the institution will have to consider selection, translation and internalisation processes.

Whereas the selection processes relates to the content and the challenge of selecting what is relevant to the different disciplines, the translation processes refer to the way we translate the somehow abstract and value-based concept of sustainability into an engineering discourse. Finally, internalisation is needed, at institutional and research level, not only to tell but also show that sustainability is part of engineering practise.

Together with a pedagogical platform supporting a collaborative and interdisciplinary system view on engineering, this is seen as key elements to "adopt" sustainability into the everyday life of engineering.


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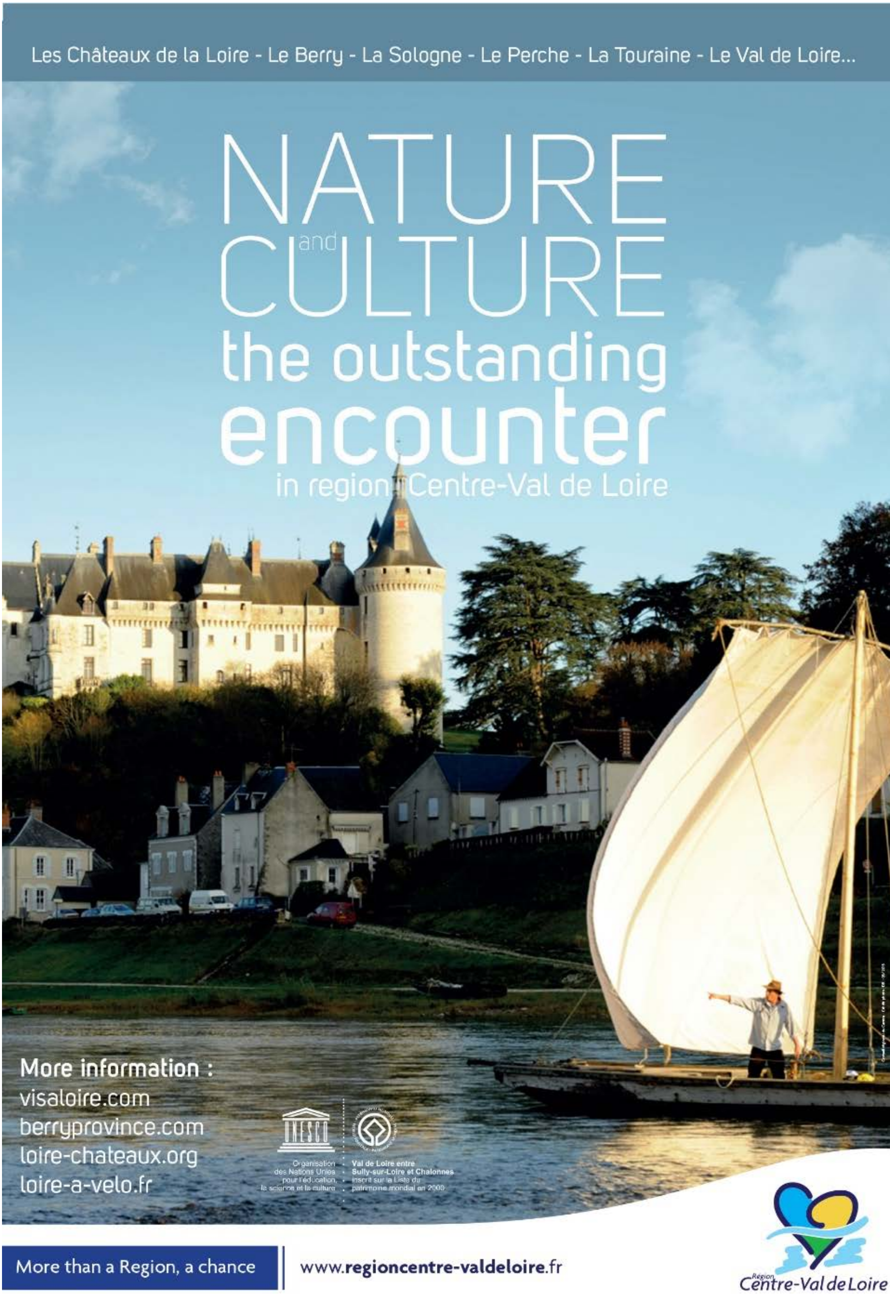

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CHAPTER 1

Eco Design sustainability in Engineering Education

Teaching Circularity using CES EduPack

56147. PEREIRA-MEDRANO Ana G. , Claes FREDRIKSSON

Granta Design Ltd, Cambridge, CB1 7EG, UK
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In a world of finite resources, a new systematic perspective that replaces the concept of waste with one of restoration and reduces the use of raw materials is of great interest. One such perspective known as circular economy is restorative by intent and design. Materials use and engineering will play a key role in the transition to this concept. Hence, helping engineering students to understand circular economy and its implications is an important part of Sustainable Development and Design teaching.

Closing loops of material flows is central to Circular Economy. These loops can be analysed in terms of mass flow, if you are interested in resource issues or logistics, but also in terms of, for example, energy use, carbon emissions or cost. In this presentation, we have explored a way to use the Eco Audit tool from the widely used CES EduPack educational software as a means to analyse the latter properties based on a Bill of Materials of a given product, some basic production data and product life scenarios. This can be called a Circularity Audit. A linear Eco Audit represents the *Cradle to Grave* properties (energy, carbon footprint, and cost) of a product estimated for the: *Materials production*, *Manufacture*, *Use* and *Disposal* phases as well as total *Transports*. In order to analyse the full loop, estimated *Grave to Cradle* properties have to be considered, which is possible for the scenarios of *materials recycling* and *product re-use*.

Circular economy metrics for product design have recently been developed by the Ellen MacArthur Foundation and Granta Design in collaboration funded by Life+1. They include a Material Circularity Indicator (MCI) that allows assessment of the circularity of a product and the tracking of progress towards more circular design.

In this paper, we have prepared two examples of how to use the Eco Audit tool and MCI to analyse a closed loop and circularity properties, in order to help students learn more about product life options. Firstly, we show a comparative set of Eco properties and cost across the product lifecycle, for the four end of life scenarios. Secondly, we show the total Eco properties, cost and MCI information over a product’s lifecycles starting from the first, linear life, through an evolution of lives: reuse, remanufacture, recycle. This approach is useful to introduce the circularity concept to engineering students for a number of reasons, including constrained resource awareness, Design for Sustainability and introduction to product lifecycle management concepts.

1 The Circularity Indicators Project funded by Life+, more information here: http://www.ellenmacarthurfoundation.org/business/metrics

Student Employment and Study Effort for Engineering Students

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The aim of this paper is to examine which factors effect student employment and study effort in a setting where engineering students are financially supported both such that their education is free of cost but also such that they receive financial support for living costs while studying.
In addition, we wish to answer if the full-time student is under demise in these settings as opposed to settings without financial support [1, 2]. The research consisted of a web-based survey amongst all students at the Technical University of Denmark (DTU). Employment had an influence on the study effort, but the majority studied full-time. Like in a study from Norway [3], the students in this survey had fewer employment hours and studied more than those in studies from e.g. UK and US [4, 5, 6]. Government financial support seems to limit the amount of hours university students spend on paid work but not the percentage of students who take on paid work. Thus, full-time studies with benefits of increased capabilities and experience gained through employment could be aided by proper policies.Additionally, one of the highest impacts on study activity was the perceived study environment. The engineering students have four hours of confrontation with an instructor for each five ECTS points course.
It is to be expected as they generally spend a majority of their studying hours at the university. This study is to our knowledge the first to study student employment and study effort for Danish engineering students.

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CHAPTER 2

Engineering Education Research

International Studies in Engineering:

Results from more than 12 years of experience in offering the most comprehensive international engineering programme at German universities

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At German universities, a total of 275 engineering degree courses (36 on bachelors level and 239 on masters level) are implemented as international study offers. The international study programme of the faculty of engineering at the University of Duisburg-Essen is outstanding as it offers the only study programme in Germany that covers a comprehensive range of engineering disciplines under the roof of one common consecutive structure. The name of the programme is **I**nternational **S**tudies in **E**ngineering (ISE) and it is jointly offered since 2002 by the four departments of the faculty of engineering, namely

• Department Civil Engineering
• Department Electrical Engineering and Information Technology
• Department Computer and Cognitive Sciences
• Department Mechanical and Process Engineering

The ISE programme covers the full spectrum of the engineering departments in the faculty and consists of seven bachelor courses and nine master courses. Some of them are implemented with different profiles or as interdisciplinary courses but all follow the same structure. All ISE courses on bachelor's level

- consist of a first common year of studies, in which the most fundamental engineering basics are taught
- use English as language of instruction in all classes of the first common year of studies
- Introduce German as language of instruction only after the first common year. However, some classes are taught in English. The overall relation for every degree course is 50% in English language and 50% in German language.
- require at least a study period of one semester abroad, mandatory for all German students (to be spent at a partner university or a company)

Currently, more than 2,000 students are enrolled in one of the ISE courses, with approx. 90% coming from abroad. Therefore, within the ISE programme we can discover and observe diversity in many facets. Within this paper we will present findings from more than 12 years of experiences in offering ISE and dealing with many different aspects of diversity and heterogeneity, such like

- our concept to compare entrance qualifications from different countries
- a new way to prepare students
- a new curriculum in teaching German language to engineering students
- a flexible structure that allows students to obtain a double qualification after completion of a bachelors and a master course
- a structure that allows easily to transform a single ISE degree course into a double degree course to be jointly offered with one of the faculties partner universities.

Improving Student-Industry Engagement through Project Oriented Curriculum

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Abstract

Industry expects a creative and innovative academic practice that provides students with valuable practical knowledge focused on graduate ready skills for future careers. The learning environment in engineering is inadequate for students to become a skillful graduate. The practical role of engineering is gained through working on real world problems in an industry collaborative environment through projects[1, 2].Industry academia collaboration seems to be actively increasing in the development of engineering education in various parts of the globe. The close relationship between industry and academia is a vital component of the engineering pedagogy to improve student engagement in industry through projects. By engaging students with industry, students will acquire global perspective about the core attributes expected in future engineering jobs [3, 4]. In today's large-scale industrial market, companies tend to prefer graduates with design skills attained through the project approach. Thus, universities should open their doors and accept the challenges of interacting with students with industrial experiences and expectations. This paper is focused on improving student-industry engagement through project-oriented curriculum. Through quantitative and qualitative research, the paper shows the industry perspectives and students views on university and industry collaboration. The research results show that students and industry can possibly maintain their engagement by providing regular feedback, reviewing goals and objectives, improving communication, keeping focused, and sharing a similar vision.

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Targeting increasing drop-out rates in the STEM field: The European readySTEMgo Project

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Considerable progress has been recently made in increasing enrolment in Science, Technology,
Engineering and Mathematics (STEM) study programs. High drop-out rates in STEM programs, however, tend to undermine the beneficial effects of all current attempts to increase student enrolment in these programs. The European readySTEMgo project aims at reducing these high dropout rates in STEM programs. More specifically, the main goals of the project are threefold. The first target is to identify all key predictors of study success (i.e., key STEM skills) in the first year of university. Second, by means of existing instruments, a diagnostic test will be developed to identify students at risk of dropping out. Third, the project aims at constructing an effective intervention tool in order to support those students at risk. Ultimately, the outcomes of the readySTEMgo project could directly target Grade 12 students who are struggling with the upcoming choice of a study program by identifying and remediating students with an increased propensity to dropout in the subsequent year. As such, this tool will enable secondary school students, teachers and guidance counselors to tackle potential problems before the onset of students' university career.
The majority of studies investigating dropout in STEM programs and predictors of study success in the first year have been conducted in the US and the readySTEMgo project aims at filling this gap by implementing a large-scale transnational study in Europe. More specifically, the project will be carried out by six university institutions in different parts of Europe (Hamburg University of Technology [Germany]; University of Zilina [Slovakia]; Katholieke Universiteit Leuven [Belgium]; Budapest University of Technology and Economics [Hungary]; Aalto University [Finland]; and University of Birmingham [UK]).
As a theoretical basis, we endorse the operational definition of college readiness by Conley [1]. Conly discriminates between four key dimensions: (1) *Key cognitive strategies* (e.g., inquisitiveness – problem solving); (2) *Academic knowledge and skills* (writing – research – core academic subject knowledge); (3) *Key academic behaviors* (metacognitive self-monitoring – mastery of study skills); and (4) *Contextual skills and awareness* (university as a culture).
To date, a large number of studies have successfully identified potential predictors of study success although it should be noted that the list is long and that there is little agreement on the key predictors. It is commonly accepted that a strong prior curriculum, high prior achievement and positive academic self-efficacy beliefs are among the main predictors of successful completion of the first year. In this SEFI presentation, an overview will be presented of the entry requirements for entering a STEM study program and the most recent dropout rates in the participating countries. Based on Conley's framework, the predictive role of the following variables will be discussed in greater detail: prior curriculum & achievement, academic skills (academic language skills, scientific reasoning) motivational factors (self-efficacy beliefs, goal orientation, goal commitment & intrinsic motivation), self-regulatory learning strategies (time management, effort regulation), and student approaches to learning (deep vs surface). In this respect, special emphasis will be placed on first generation students (i.e., students where neither parent graduated from university) and the academic challenges that these students might experience [2]. Finally, a longitudinal research plan will be presented in order to quantitatively investigate first year drop-out.

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Cultivation of Critical Thinking in Undergraduate Engineering Education

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The quality of students' and engineers' thinking, and how they think, determines the quality of what they design, produce or make. Moreover, students and engineers today largely work with and, unquestioningly contribute to, the policies and agendas of the socially accepted market driven, pro-development standpoint [1]. So, in addition to the importance of critical thinking during technical development, critical thinking is also important to positioning students and engineers from a stance of social justice, and so allowing them to question effectively the efficacy of developments. Just as is found in many professions, engineers now need, more than ever, strong critical thinking skills to deal with a world of increasingly rapid change and complexity.

In this work a definition of what the authors conclude critical thinking actually is will be given, based on the many ideas which can be found in the literature. The results of a small survey of how students view critical thinking in relation to themselves and how necessary they feel critical thinking is, will be reported as will how a preliminary initiative to cultivate more and systematic critical thinking within various mathematics modules found in an undergraduate engineering course was implemented and assessed.

It has been concluded that most students already consider themselves as effective critical thinkers, which may or may not be self-delusion. Also, it was quickly recognized that although workshops and seminars on critical thinking have their place to initiate awareness, a systematic semi-implicit approach over a period of time is very necessary to cultivate critical thinking. That is, once the principles of critical thinking are grasped and, importantly accepted by the student, then a period of time is necessary for cultivation, practice and hopefully becoming second nature.

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On the Necessity of Midterm Exams in Electrical Engineering Courses

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Grading students to reflect their actual knowledge has always been a matter of controversy, since there are many parameters that can affect the final grade of a specific student. In this paper the author focuses on one specific issue that is how to comprise the final grade of a course from several ingredients. In many electrical engineering undergraduate courses the lecturer needs to decide whether to give a midterm exam that will have an impact on the course's final grade or place the full weight of the course on the final exam.

In 1976 Weldon [1] suggested that midterm exams are important as a feedback to the students (and lecturer) to see whether or not they are on the right track, but showed a qualitative rather than a quantitative measure of how midterm exams can assist students. In 2007, McDaniel et al. [2] discussed the effect of midterm exams but in the context of improving the knowledge itself. Two years later Vaden-Goad [3] showed that using multiple elements (including midterms) to generate the final grade can improve the motivation of students and improve their persistence, however, this paper does not address the actual correlation between succeeding in relatively small tasks and succeeding in a large scale final exam. In this paper the author tries to give a quantitative measure of the correlation between midterm exams and final exams by comparing the final grades in final exams of several courses for students that attended the midterm exam and for those who did not.

The work shows that on a scale from 0 to 100, first year students who took the midterm exam scored 8.1 points more on an average in the final exam than those who did not take the midterm exam. Second year students who took the midterm exam scored 16.4 points more on an average in the final exam than those who did not take the midterm exam, and third year students who took the midterm exam scored 25.8 points more on an average in the final exam than those who did not take the midterm exam. Thus the correlation between attending the midterm exam and succeeding in the finals increases along the years. The work also addresses gender differentiation. In the first year female students who took the midterm exam scored 24.7 points more on an average in the final exam than male students. On the second year the difference drops to 15.1 points and on the third year female students scored 4.4 points less than male students. The explanation might be connected to the fact that female are a minority (7.8%) among electrical engineering students.

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Using consultation in student groups to improve development of team work skills amongst more reluctant students.

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Aalborg University has used Problem Based Learning since 1974. Each semester the students make one project in student groups (15 ECTS) supervised by one or two supervisors. The other 15 ECTS of the semester is split into three courses where exercises often are solved together in the students groups to enhance peer learning. From the practice in Aalborg it is know that as freshmen students working in groups often find it difficult to collaborate and to use their full learning potential from being a team. It seems obvious that teambuilding and help to develop team work competences could be very useful for the new teams. This was documented by Professor Kolmos in 1999 [1]. To improve the potential of project work a special course is offered to help the students develop their skills in cooperation, learning and project management (CLP).

This course has proven very helpful for most of the engineering students but students from some educations are more reluctant to follow the course and do the exercises than other. Students studying Bachelor in IT (BAIT) has for two years showed less interest in the course than e.g. Software and Computer Science students. The consequences of this are that some BAIT students don't develop their team work skills and competences to the level that is expected. This has been identified by comparing process analysis that each student group has to write after the first semester to reflect on their skills in team work and come up with ideas to improve their performance in the next project.

Each lesson in the CLP course is approximately 50% lecturing and 50% exercises. It was decided to try and activate the students more in the autumn 2014 and to follow up on some of the key exercises. The implementation involved student groups handling in written answers to exercises from two key lessons on group contract and time planning. Then the lecturer visited each group 2 weeks later to discuss the exercises and the lessons learnt by applying the methods in the daily project work.

The effect of the changes in the course is analyzed by comparing both the written Process Analysis and individual answers from the students to relevant exam questions taken from a written exam of the course. The results show significantly improvements in the quality of the Process Analysis and the development of the student's team work competencies. Only 3% failed the course exam compared to 19% the year before.

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Learning styles and habits
How does BME (Budapest University of Technology and Economics) study?

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Successful universities keep on investigating and studying how they could develop their academic activities and make them more efficient to meet the demands of the current legal, economic and cultural environment. However, for this, first, the formal, informal and nonformal learning habits of the students should be investigated with reference to the ’lifelong learning’ paradigm, and you should get to know the education conditions typical at the university. In a project of unique initiative, the university’s Student Representative Body (Hungarian abbreviation: EHK) suggested in November 2013 that it wished to investigate the students’ learning styles and habits in detail with the help of a questionnaire survey. EHK considers it a top priority that the university’s students should get as high quality education as possible and is committed to raising student quality.

This motivation gave rise to the idea that in order to further raise academic standards, we should get to know the students’ learning conditions, habits and methods so that in the knowledge of the former, we could put forward innovative ideas or provide the leadership of the university and the teaching staff with a device to support decision making. Accordingly, in
February and March 2014, EHK conducted a questionnaire survey among BSc and MSc students and students attending undivided programmes, in which nearly one third of those approached (~6,000 people) took part.

The questionnaire consists of two main parts. In the first part, the topics of student background, learning habits and styles, and student attitudes were investigated in great detail.
In the second, students were asked to complete a Kolb test. Processing and analysing the information gathered, we tried to find correlations between learning styles and strategies, environmental impacts, certain individual characteristics and success in university studies.

The ultimate objective of the study is to draw specific conclusions on the basis of the correlations detected, which may then serve the purposes to support decision making and develop education in the near future.

Engineering in Dutch Schools: Impact on Study Choice

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Since 2004 a growing number of 'Technetium' schools in the Netherlands have introduced engineering projects in their curriculum[1]. Goals include stimulating learner's creativity and broadening their horizon with respect to engineering studies and related jobs. Throughout their school career students work on authentic tasks originating from companies and institutes. The final assignment connects with a Polytechnic or University. As many projects incorporate engineering elements we expect study choice impacts. We found a shift in learner preferences towards design-based engineering studies.

Research questions

(1) Do Technasium students select engineering studies more often?
(2) Do these students perform better compared to students with no Technasium background?

Method

We checked student numbers, results and dropout rates for students originating from Technasium schools over the period 2009-2013 [2].

Results

From our 2633 freshmen a total of 89 students (78 male, 11 female) followed this new engineering trajectory throughout their school career.This group favors studies like Industrial Design and Mechanical Engineering showing a shift away from traditional Science studies.
Study success measured is similar: Technasium students: 49+/-16 ECTS versusall science & engineering students: 49+/- 14ECTS. We also find no significant difference in dropout-rates after 1 year: Technasium students 14% versus all science & engineering students 15%.

Study choice by learners from …	Design and Construction based Engineering	Other science & Engineering Studies
Technasium schools	48%	52%
All schools	37%	63%

Conclusions and discussion

Despite the small numbers we already see significant effects that may grow if engineering education is introduced in more schools. Engineering at secondary schools does pay off, with still some challenges to attract more girls. Further analysis will show whether we are attracting new groups of students or moving students from science towards engineering.
Finding similar study success is a good starting point for an educational innovation like Technasium. Engineering studies should take into account that new students may have a background in design and engineering and will be eager to engage on new challenges.

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Is Fontys engineering's honors program educating the brilliant engineer?

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Abstract

The Electrical and Electronic (E&E) Engineering Department of Fontys University of Applied Sciences, the Netherlands has decided to have a personalizedprogramin cooperation with companies for students who want to excel in engineering. In September 2009 the PROUD program for excellent engineering – **PR**ogram**OU**tstanding**D**evelopment – has been introduced. This program provides the students with early industrial experiences and skills in their field of study on top of their bachelor program from year two onwards.

The engineering educational programs in the Netherlands are expected to be evaluated based on a newly defined assessment system based on competencies for engineers when they graduate with bachelor degree. The new system is based on eight competencies that the graduate will achieve at the end of his/her study as can be seen in Figure 1. The to be achieved competences at the end of the study are: to analyze, to design, to implement, to control and maintain, to manage, to advise, to do research and to be a professional engineer. Each universityshould define for each competency the level (1, 2 or 3) that their students will achieve at the end of thebachelor phase.
This enables the universities to differentiate in their engineering programs.One of the goals of the PROUD program is to enable the participating honor students to reach the highest level defined for each competency.

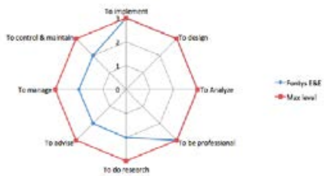

Figure 1 The Dutch engineering competences with the expected competency levels for Fontys graduates. [1]

It is assumed that all students achieve the highest levels regarding: to analyze, to design, to implement and to be professionalusing the Fontys curriculum. Therefore it is expected that the PROUD program is giving a boost to the remaining four competences, please see Figure 1. Thisresearch will focus on how to define and assess the levels of competencies and investigate whether the current outcome of the PROUD program reaches these four other highest levels.This research ultimately answers the question whetherour current PROUDprogram educates the brightest engineers or how to improve this program to reach that goal.

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Creating an optimized diagnostic test for students bridging to Engineering Technology

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In Belgium students can choose, without admission restriction, between a professional and an academic bachelor's degree. The purpose of a professional bachelor's degree is to prepare the student for a professional occupation. An academic bachelor's degree on the other hand is intended to acquire all the necessary knowledge and skills to start a master's programme. In order to stimulate a flexible lifelong learning system a student with a technical professional bachelor's degree can follow a master's programme in Engineering Technology provided that he successfully finishes a bridging programme. Such a bridging programme counts a maximum of 90 ECTS points and has the intention to focus on all the missing competences to start a master's programme. In practice 30% of the technical professional bachelor graduates start a bridging programme to Engineering Technology. The Faculty of Engineering Technology at KU Leuven counts almost 900 bridging students and this number increases every year. Unfortunately almost 50% of these students, hoping to become an industrial engineer, drop out. We aim to reduce the dropout rate by focusing on early orientation, positioning, and intervention. In this paper we discuss the development of a diagnostic test that gives every student a prediction of his future study success in the bridging programme. Last year we implemented a diagnostic test that was originally designed for freshmen in academic bachelor's programme in Engineering Technology. This test focused on three topics: mathematics, academic language skills, and scientific reasoning. However, there was no correlation between the test score of the bridging students and their subsequent official exam scores [1], which suggests that other skills are required to predict study success of bridging students. In order to identify these essential skills, we have organized three different focus group discussions: one with bridging students, one with experienced faculty members, and one with educational and psychological experts specialized in test construction. Two major stumbling blocks for study success in the bridging programme were determined: basic mathematic knowledge and skills on one hand, and study behaviour and 'time on task' on the other hand. Based on these data, a new battery of tests will be developed, consisting of an optimized mathematics test, the LASSI
(Learning and Study Strategies Inventory) test and a cognitive test (based on the CHC-model).
A pilot will be organized during the second semester of the final year of the technical professional bachelor's programmes. The purpose of this pilot is to analyse the predictive validity of the optimized test for subsequent exam scores of bridging students.

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Ça ira: The Need for Reform of Engineering Education

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Abstract
All countries, but especially the member states of the OECD, require a supply of well-qualified engineering graduates to maintain their economic growth rates. Estimates of the required STEM (Science, Technology, Engineering, Mathematics) graduates vary, from a 2012 report by President Obama's Council of Advisors on Science and Technology, that stated that over the next decade, 1 million additional STEM graduates will be needed in the US [1].

A key difficulty for Engineering is the continued gender imbalance, with only a minority of females taking the disciple, in a world where female students are performing better each successive year, and are now a majority of third-level students.

This creates a conundrum: female students have the academic qualifications to get into engineering programmes, but lack the desire, whereas male students have the desire, but lack the qualifications. There are two possible solutions to this problem. The first is to persuade a greater percentage of females to take engineering programmes; this has been tried for many decades, with limited success. This paper looks at the other solution to the problem, the provision of courses to take students who do not meet the required professional level requirements to that point.

This is something that has happened almost by chance in the Dublin Institute of Technology (DIT). DIT was originally founded to provide engineering skills in the craft area, and has grown organically over the years to provide honours degree level and postgraduate programmes in many disciplines. Students who do not have the requirements for professional engineering programmes study technician programmes (Level 7 in the Irish framework) for three years, and then transfer to the third year of the professional engineering programme (Level 8).
Results over the past decade have been good, with transfer students significantly more likely to achieve high quality degrees (2:1 or 1) than the students who left school with the better grades that got them directly into the Level 8 engineering programme. Our results demonstrate that it is better to alter the programmes to meet the students need, rather than to alter the behavior of students to meet the programme needs.

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A scientific approach to teaching – to reach innovative pedagogical approaches nationwide

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ABSTRACT
This paper is about interdisciplinary common initiatives to enhance and encourage quality of engineering education nationwide, by means of a scientific approach to teaching. To reach innovative pedagogical approaches it is seen as important to stimulate collaboration and knowledge sharing across discipline borders. STEM, referring to the academic disciplines of science, technology, engineering, and mathematics is in Norway an important field addressed by education policy to improve competitiveness and technology development. Recruitment, to reduce dropout and to increase throughput within STEM is an area of priority.

The Norwegian Association of Higher Education Institutions (UHR) is a cooperative body for Norwegian universities and colleges, whose purpose is to develop Norway as a knowledge based nation of high international standard. Within UHR academic strategic collaboration in the STEM-fields consists of the National Faculty meeting of Natural Sciences (NFmR) and the National Council for Technological Education (NRT), where all Deans within these areas are members. Together with the national center for recruitment to STEM higher education they have started a common top-down initiative with a goal to facilitate a bottom up initiative for a scholarly approach to planning, carrying out, evaluating, assessing and reviewing teaching, a Scholarship of Teaching and Learning (SoTL) practice. Among others, answers in a survey within mathematics (2989 students and 80 teachers) which documented a lack of formal educational and didactic skills among teachers, underlies the initiative. Many students also rated teacher expertise as high, but educational and didactic skills as inadequate (http://www.uhr.no/ressurser/temasider/samarbeid_arbeidsdeling_og_konsentrasjon/matematikkundersokelsen).

To encourage a SoTL approach among higher education teachers has been a main goal. To encourage and give credibility to a SoTL approach it has also been used for the development of these national initiatives. Experiences from LTH, the Faculty of Engineering at Lund University in Sweden, which is very active within the area of teaching and student learning, and from DTU, the Technical University of Denmark as well as from Norwegian Centres of Excellence in Higher Education, have been considered and incorporated during the process.

The paper will present the scholarly approach to planning and carrying out the 1st Norwegian STEM conference on teaching and learning, its background and results. It will evaluate, assess and reflect on the process and the experiences from this national initiative to achieve a scholarly approach to teaching and learning within the STEM area.

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Globalisation of engineering education research: a citation analysis of ASEE and SEFI conference papers

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There has been an increasing focus on the importance of a global approach to Engineering Education Research (EER) in recent years (Borrego and Bernhard, 2011; Cheville, 2012)and in a
paper published jointly by the European Journal of Engineering Education (EJEE),and Journal of Engineering Education (JEE) in 2010 it was suggested that "the field ofe ngineering education research is going global" (Jesiek, Borrego & Beddoes, 2010). If this had already occurred we would assume that EER scholars in different parts of the globe would cite a global range of authors in their publications. When the authors tested this hypothesis for two leading archival journals, JEE published by ASEE (American Society of Engineering Education) and EJEE published by SEFI (the European Society of Engineering Education) they found that although the scholars whose work was published in the European journal cited a geographically wide range of authors, those in the US-based JEE tended to predominantly citeUS authors (Williams et al, 2014).

Given that the number of scholars whose research appears in the proceedings of the annual conferences of SEFI and the ASEE considerably exceeds those published annually in their two journals, analysis of the conference proceedings should provide a broader and more representative sample of the EER carried out on the two sides of the Atlantic. Hence we carried out a bibliometric analysis of the works cited in recent SEFI and ASEE conference proceedings to investigate to what extent authors cited a global range of well-known authors.

The cited authors were separated into three groups based on geographic location: US, Europe, and Other (all other countries). Citations of specific well-known authors were counted in all the papers in the ASEE conference proceedings for 2010 and 2014 (1400 and 1700 papers respectively) and SEFI proceedings from 2010 to 2014 inclusive (833 papers in all). Selfcitations were not included.

Citations in ASEE conferences are dominated by sources with US affiliations whereas the SEFIdata show that whileUS sources are frequently cited, European and Other authors are also well represented. This suggests that in citation terms,European EER is global but US EER is not.

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A strategic approach to graduating

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In this study we investigated if students' approaches to learning in their 3rd semester of a master program in engineering can be associated to their study results. Fifty students answered the short version of Approaches and Study Skills Inventory for Students (ASSIST), with a response rate of 61%. Some open questions about the students' education were added and the responses were analysed together with study results one year after the questionnaire was distributed.

Results show a positive correlation between graduating on time (results administered before the end of the fifth semester) and a strategic approach to studying, especially with the ASSIST sub scale achieving. These students also thought that the education has taught them to solve real world problems based on scientific principles as well as communicative skills. Students with a high score in surface approach to learning show a correlation with not graduating in time and of having a stressed view of the future. These students had lower grades, less contact with a relevant working place and did not consider the education to have taught them critical thinking or how to cooperate.

“Roles” in the bachelor’s and master’s programmes in engineering technology: definitions and corresponding learning outcomes

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Research has shown that students’ ideas and beliefs about the nature of engineering have an effect on their learning process. An informed view can improve students’ attitudes and motivation towards their studies [1]. The nature of engineering is not only based on the disciplinary specialization but also on professional skills that make a graduate more or less suited for a specific ‘role’ in the professional field (for example management or R&D). Companies attach importance to these roles when recruiting engineers. These roles require different competences. It’s our intention to have attention for these roles in the curriculum of our bachelor’s and master’s programmes in engineering technology, alongside the traditional disciplinary story. In this paper we report on the first step we have taken to prepare this programme modifications: which roles are used in the professional field? Which learning outcomes are associated to each of these roles?

Treacy and Wiersema (1992) pointed out three main roles within the professional environment, namely operational excellence, product leadership, and customer intimacy. We have analysed 7.672 job offers for engineers in Flanders. Based on the definitions by Treacy and Wiersema, we divided the job offers among the three different roles and discovered that companies look with almost comparable intensity for each of these three specified profiles. On the other hand, Lauwers et al (2013) distinguished between eight different roles for engineers: product engineering, process and automation engineering; maintenance engineering; quality-, prevention-, environment- and safety engineering; project engineering; R&D engineering; planning and work preparation engineering; method engineering and the commercial field. This division of roles was also based on an analysis of relevant job vacancies and a subsequent discussion with two engineer recruitment agencies to correct the results.

We employed a qualitative method to select the most appropriate model for our graduates. We conducted a dozen of in-depth interviews with HR-managers of companies hiring engineers.
Also, we surveyed representatives of companies on several engineering job fairs. The outcomes of this study will help us to make the programmes in engineering technology match better with the interest and profile of each individual student from day one of their studies.

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CHAPTER 3

Mathematics and Engineering Education

Engineering and science positioning tests in Flanders: powerful predictors for study success?

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A new battery of positioning tests for Science and Engineering was broadly implemented in Flanders in the summer of 2013. The goal of the non-mandatory and non-binding positioning test is to allow future students,with a clear choice for engineering or science, to position themselves with respect to the required prior knowledge and skills and to stimulate students to participate in a remediation program if necessary.
For each engineering or science bachelor under study, a specific positioning test was designed. The composition of the test varies among different bachelors, as each bachelor requires specific prior knowledge and skills. For example, the positioning test for the bachelor of engineering science measures the ability of future students to solve scientific problems and compares a student's mathematical skills with the required prior knowledge. The positioning test for the bachelor of engineering technology and science (mathematics, physics, informatics on the one hand, chemistry, biochemistry, biology, geology and geography on the other hand) additionally tests the academic potential of the future student (such as academic literacy, logic reasoning).The positioning tests were organized during the summer of 2013 and drew 859 (engineering science), 183 (science), and 62 (engineering technology) participants across four
Flemish universities.

For the different bachelors, our goal is to relate the study success in the first year to the score on the positioning test. Moreover, we analyze why the predictive power of the positioning tests and its different components is not equal for the bachelors under study. Additionally, the predictive power of the positioning test is compared to other predictors such as overall score in secondary education, math score in secondary education, number of hours of math in secondary education, and gender. To this end we analyzed the results of the positioning test, and the study success in the first year January (1st semester), June (2nd semester), and September (after second chance) for the three bachelor programs under investigation.

The study leads to the following conclusions:

- Most students with a very low score (<6/20) obtain very bad results in any of the bachelor programs. It is difficult to remediate their prior knowledge deficiency on top of a regular study program.
- Passing the positioning test is no guarantee for study success. Other features such as motivation, study effort, study method, and stress-handling are important.
- Designing one single positioning test to predict study success in any science and engineering bachelor is a Utopian dream, some commonalities among the tests are however desirable.

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A mathematical lab for undergraduates

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The author is teaching a 'mathematical lab course' for first year students at the TU Berlin. It is offered in a special framework of an orientation year for students interested in STEM, but not yet decided. Most of them will choose an engineering career. The lab offers an occasion to actually use mathematical models and methods for some purpose. Simultaneously most students follow the first year maths courses, which are mostly if not entirely void of applications.

The lab starts with an introduction in programming with python. The introduction uses examples of mathematical modelling in different fields. The critical part of the lab is the formation of small groups with a 'project'. Ideally the students are supposed to identify an interesting tiny research project, but there have been other projects that were exploring methods of ideas of some well-defined field. A typical project will require some theory but also have a practical goal, in most cases a program that either simulates some scientific phenomena or operates on data (images, audio) or controls a robot.

In any case the students have to organise themselves, document their work, understand the mathematics and the programming relevant to their task and write the program. The autonomous character of this work is quite different from the usual undergraduate classes. The paradigm of 'undergraduate research' requires an equilibrium between guidance and freedom. It can be hoped that the experiences of such a lab can have long term motivating effects. This lab (and other labs with a similar approach) is offered to all students of the 'orientation year', it's not an elite course. Projects of quite different degrees of difficulty are possible and can be equally rewarding for the students.

We present in detail the organisation and methods of the lab, where it succeeds and where it fails. Some individual cases suggest that students that have particular difficulties in finding themselves at home in a large university can profit from the early experience of autonomous work in small groups. Apart from that, the course gives a context for real applications of first year engineering mathematics. A frequent difficulty of engineering students to come to terms with mathematics may thus be relieved.
The motivating examples for the course have changed with time, we have some reason to believe that a broad spectrum of possible modelling fields is more apt to attract female students to the course.

Engineering Students' Difficulties in Learning Algebra Complex Numbers

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Having a good sound of mathematical knowledge is one of generic aspects included among the engineering education outcomes stipulated internationally [1-2]. One of the particular mathematical competence required for electrical and electronics engineering (EEE) students is mastery the concept of complex numbers [3-4]. This competence includes ability to: (a) explain the meaning of the letters used in symbolic complex numbers both algebraically and geometrically, (b) convert from one form to another forms, i.e. basic, polar, and exponential forms, (c) solve complex numbers operations, e.g. addition, subtraction, multiplication, and division, (d) find the power and roots of complex numbers using De Moivré Theorem, and (e) solve a real-world engineering problem, i.e. alternating current (AC) analysis.

The dichotomy conceptions of complex numbers, i.e. structural and operational, and a threephase theoretical framework of concept formation are described [5].

We conducted a study to explore EEE students' difficulties in learning algebra complex numbers. The subjects were 151 Year 1 EEE students in Semarang Polytechnic of Indonesia. They were given 2 hours to complete the 3-item complex numbers test. Because students were not interviewed, interpretations are based on analysis of students' written work. Student's work was coded at different levels. Responses were first coded question by question. Each question was coded for accuracy. The correct responses were then checked for variation in explanations and conversions. Next the errors were coded into five categories: (a) partly correct explanations with essential meaning missing or misrepresented, (b) partly correct conversions with essential cognitive elements misinterpreted, (c) changing meanings and conversions midway, (d) correct meaning, correct conversions but failure to keep the goal in mind, (d) lack of conceptual knowledge necessary for the solution of the 3-item test.

Finally, we compared and contrasted the difference responses between the technical and academic senior high school graduates.

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A continuous evaluation for a new pedagogy:
Mathematics for teaching engineers

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Many studies have shown the alarming decline affecting the interest of young engineers for the study of abstract sciences such as mathematics. It appears that the cause of decline lies primarily in the way sciences are being taught.
Consequently, the Engineering School of ESPRIT has opted in recent years for curricular renewal for the training of engineers using active methodology such as problem-based learning method.
The implementation of such a teaching device has affected all the disciplines namely the most theoretical of them such as mathematics.
Today, it is clear that the mathematics course in its new form:Team Based Learning and thanks to its application content; close to real world as well as the collaborative working, enhances the competitive and dynamic atmosphere in class. While, the evaluation tools which remain classic appear to be incompatible with the new technology. It is thus essential to proceedin this respect. For that purpose, we thought about a continuous and regular tool assessing the student individually at the session but also at the end of the each session.

First, this work will be subject to a methodology synthesis of course in team based learning through an example analysis taken from first-cycle mathematics curriculum, then a description of the new evaluation method.
We will endeavor to support our choice by proving the efficacy of this method through comparative statistics of results obtained using two different evaluation methods. We will provide statistics at the course evaluating the acquisition percentage of objectives; we will also provide other statistics showing the degree of assimilation at the end of each chapter.

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Is there a Special Maths for Engineers?

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Recently, we can register many calls for improvements in the basic knowledge of secondary school graduates who become first-year students at universities worldwide. These needs appear mostly in connection to reading, writing, calculating and other "old-fashioned" skills, among which logical reasoning and mathematical skills become one of the less developed in the course of secondary education. A steady knowledge of mathematics is a good background and necessary pre-requisite of a future successful engineering career. Technical universities in particular provide higher education based primarily on these skills. Therefore, many efforts have been given to finding suitable ways of how to improve the mathematical knowledge of engineering students. Teachers were usually striving to find some new didactic methods that would be working more effectively, for the utmost benefit of students. Innovations were aimed to make the study material to be more comprehensible, better readable for less prepared students, freely available and accessible via all information and communication technologies.
There appeared also a general call and a tendency started to be fostered towards needs to create a new kind of so called "engineering mathematics", which could be more appealing and easier to grasp for students at technical universities and in engineering study programmes.

In this paper we would like to bring few remarks and ideas in connection to this call for specific mathematics to be taught at technical universities. Undoubtedly, mathematics at engineering study serves as a tool used to solve various kinds of technical problems. Often it is necessary to use some very advanced parts of mathematics in order to find solution to new unforeseen problems arising from the rapid development of technology nowadays. Basic mathematics knowledge is absolutely necessary in order to understand these advanced parts of mathematics, which is itself developing in the same rapid rate as all other disciplines. To our knowledge, even more mathematics is necessary today than it was ever before, specialized, more sophisticated, theoretical and advanced, and definitely less easily comprehendible.

We will bring arguments to support some of the above ideas and discuss how to proceed in order to teach mathematics better and with proper understanding. There will be various questions posed, to be analyzed and discussed, such as: Does exist a special engineering mathematics? Are there different methods how to comprehend mathematics in various sciences? What kind of mathematics should be taught to engineering students – current or traditional? Is there not just 1 mathematics that can be suitably applied in various disciplines?
What is a suitable Mathematics curricula in engineering education? How to build a bridge between theoretical modern mathematics and practically oriented engineering disciplines?

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Encouraging Students to Reflect by Flipping the Mathematics Classroom

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Over the past years, engineering education has been challenged to embed creativity and innovation into undergraduate and postgraduate programs, in order to produce graduates who can easily adapt to these changes [1]. Moreover, a number of engineering programs have arisen that transcend the division between technical, scientific and creative disciplines (e.g. Architecture and Design, Media Technology, Sustainable Design). In relation to mathematics education, this new development has led to a transposition from an industrial use of mathematics, where it is employed intensively by mechanical and construction engineers as a tool in order to develop products and build constructions, towards a situation where mathematics is increasingly used as the actual building blocks in various new digital products and creative expressions. This transposition has implications on how mathematics should be taught in such engineering studies.

This paper presents the introduction of the flipped classroom model to a statistics course at the department of Media Technology, Aalborg University Copenhagen.Aalborg University applies the Problem-Based Learning (PBL) pedagogy in all its programs, which supports student-centered learning and group work [2]. However, we have found that mathematics courses at Media Technology follow mostly the one way transmission model (lectures as presentation of information)[3].Therefore, we decided to introduce the flipped classroom approach in mathematics related courses for Media Technology students for aligning them with the PBL pedagogy. The flipped classroom model, which employs computer-based individual instruction outside the classroom and devotes classroom time to group activities with the teacher as facilitator, is well justified by the core principles of PBL. In this paper, we also show how the flipped instructional model enhances reflection in the learning and teaching process [4]. To that end, we use examples of how we employed reflection in our flipped statistics course.

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Electric kart project to develop research-related skills for engineering students

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Nowadays, an engineering curriculum not only provides solid scientific and technical skills, also more generic competences are important. Therefore when educating engineering students, the organization of a learning trajectory stimulating problem and project based learning is mandatory.
This learning trajectory includes several intermediate steps, i.e. classical laboratory sessions, a multidisciplinary project work, project based laboratories and a final master thesis. Throughout the learning trajectory, the principle of instructional scaffolding is implemented i.e. the students gradually develop autonomous learning strategies in a sequence of projects characterized by an increasing complexity.
The multidisciplinary project work is performed in the third semester of the academic bachelor program when the students already have a basic scientific and technical background. Project groups of five or six students are supervised by a coach. The main goal is the development of a whole range of cognitive, meta-cognitive and social competences in combination with technical and research-related skills. The students have been involved in various innovative projects. In particular, the development of an electric kart is an attractive approach.
Designing and building an electric kart within the scope of a project work is not new and many experiences are described in literature. Here, a different teaching approach is used starting from a kart in working order. During the first semesters of the academic years 2012-2013, 2013-2014 and 2014-2015 the project mainly focused on condition monitoring and EMC-related aspects that are closely related with the research activities at KU Leuven. In this way, engineering research and education are linked, resulting in stimulating research-based learning.
Since the starting up of the multidisciplinary project work in the academic year 2005-2006, a number of evaluations of this project work have been performed among the students and they agree the project work helps them to develop ?soft' skills. Evaluations by the student groups participating the electric kart project reveal they were successful teams although they experienced time pressure, they had the possibility to gain new knowledge and to make technical choices, they needed to reflect critically about the research results, satisfaction concerning the transparency of the evaluation system including the peer- and self-assessment.

Mathematical beauty in service of deep approach to learning

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In the fall semester of 2014 I taught the course 'Introduction to Numerical Algorithms' at Technical University of Denmark, using the textbook of Chapra [1]. The class consisted of 86 bachelor engineering students. The lectures used basic calculus and linear algebra to explain the operation and analyse the performance of numerical algorithms for root finding, optimisation, data fitting etc. After each lecture, the students worked in small groups, where they mostly applied standard implementations of the algorithms in MATLAB® to solve practical numerical problems. Similar to this divide in the nature of the course content, the students themselves fell into two categories – those with primary interest in practical MATLAB® programming, and a smaller group with a strong interest in a mathematical approach to numerical algorithms. My challenge was to reach and satisfy both groups of students while adequately covering both the theoretical and the programming aspects of the course. The textbook was practically oriented and sometimes omitted rigorous justification for important statements regarding the properties of the algorithms. Also, some of the programming problems (which were the basis for the written group reports and hence significant in the final assessment) could be solved without a deeper mathematical understanding of the algorithms. This could have motivated a surface approach, rather than the desired deep approach to learning (as defined in Biggs and Tang [2, pp. 24—28]).

To encourage the deep approach, I introduced rigorous proofs of key elements of the theory in the lectures, trying to emphasise the beauty of the mathematical structure underlying many of the algorithms. For example, I showed the optimality of the golden ratio □as a parameter leading to the Golden Section Search optimisation algorithm; I derived the least-squares equation system occurring in linear datafitting; and I derived formulas for numerical quadrature and expressions for the associated error, as well as elaborated on adaptive integration by explaining Richardson extrapolation rigorously. During lectures, I tried as much as possible to involve the students in the mathematical derivations, by asking questions and soliciting propositions for the next step in the derivation. My hypothesis was that all this would provide intrinsic motivation and lead to a deep approach to learning for at least some of the students. A subset of the students immediately showed activation and motivation during and after the lectures, and were clearly satisfied with having the additional mathematical content in the course. In the final course assesment, some students complained at the complexity and difficulty of the derivations, but the overall assessment was positive. In this paper I shall present in detail the results of the experiment, as observed during class and group exercises, in the written group reports, in the final oral examinations, and in the course evaluation.

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CHAPTER 4

Language in Engineering Education

Does language and different educational background influence the learning outcome on international Bachelor educations?

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Aalborg University has used Problem Based Learning since 1974. Each semester the students make one project in student groups (15 ECTS) supervised by one or two supervisors. The other 15 ECTS of the semester issplit into three courses where exercises often are solved together in the students groups to enhance peer learning. In autumn 2014 a new International Bachelor education in Robotics started. It is a interdisciplinary education involving mainly automation, production, electronics and IT. The teachers for the first-year students come from five different departments and have experiences with international students on master level but lack experience with international freshmen. 31 students was enrolled; 6 foreign and 25 Danish. The Danish students have no experience with English as the primary language when studying.

Each student group makes a process analysis after the first semester. In this analysis, they reflect on their skills for working in project groups and come up with ideas to improve their performance in the next project. Analyzing these process analysis showed that 3 out of 5 groups struggled with problems concerning members of the group not participating in group meetings and supervisor meetings. Comparing these with the process analysis for other kinds of engineering students show that these problems are worse than usual for freshmen students.

During the first semester, the supervisors noticed that not all students were fluent in English; this made it difficult for some students to participate fully in the discussions but also in writing and reviewing the project report. A 5 ECTS mandatory course have the goal to help the students develop their skills in cooperation, learning and project management (CLP) and working with problem based projects. The lecturers of this course also noticed the limited English skills among some of the students. They also noticed that in three of the groups the group members was not participating equally in the project work.

We therefore decided to investigate why the students on this new international education on average performed more purely than students on other Danish spoken Bachelor education within engineering. We decided to focus on two parameters; The influence of having English as the official language on the education and the student's differentiated educational background. The objective for the investigation is to identify and analyses the influence of these two parameters on the individual student's performance. The performance is addressed through group work and learning and the team performance in project work and writing.

The research will be carried out in February with structured interviews with each student. Validations of the results are made by discussing the results with the groups' supervisors and teachers. The results will be presented in the paper. Depending on the type of conclusion suggestions for improvement in the semester will be made.

German for specific purposes (GSP)
A pathway to studies in engineering at University of Duisburg-Essen

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Since 2000, the faculty of engineering at University of Duisburg-Essen (UDE) is offering the most comprehensive international engineering program at German universities under the name **I**nternational **S**tudies in **E**ngineering (ISE). At the beginning of the year 2015, more than 2000 students are enrolled bachelor- or master-courses. For these degree courses, international students have to possess German language skills at B1 level as minimum requirement according to the Common European Framework of References for Languages (CEFR), as 50% of the ISE-degree-courses are offered in German language, starting from the second year of study. Before acceptance into the study programmes students have to provide evidence of their knowledge of German.

This paper presents preliminary results of two pilot surveys comprising 5-point Likert-scale items. The study has been carried out at the faculties of engineering, University of Duisburg-Essen and Universiti Kebangsaan Malaysia in order to identify and analyze the perceptions of the students' needs on which students take priority when it comes to learning German for specific purposes.

First, we provide an overview of the current state in teaching and learning German for Specific Purposes (GSP) to international engineering. In the second part of this paper, results of a needs analysis are presented in order to identify attitudes, beliefs and key competences when learning German. We shall then focus on the design of relevant language materials and show results obtained to date. The first questionnaire has been designed to analyze language needs and interests of the students. It consists of 6 parts (biographical data, interest/importance, content of material, language priorities, language skills, perceptions and preferences). The results of the second questionnaire provide insights of how students evaluate and assess GSP material for teaching. It consists of 7 sections; biographical data, importance of this type of materials, general evaluation, perceptions of contents, general comments, usefulness, and perceived difficulty of the tasks. The preliminary findings suggest that international students would benefit from subject-specific German language courses as they feel that they can practice language skills needed for their studies more effectively. The results serve as constructive information with regard to the development of GSP-courses and practice material.
Keywords: Internationalization, needs analysis, German for Specific Purposes (GSP), language teaching, teaching material

Integrated approach to teaching ESP based on MOOCs

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Conference topic: Language issues in engineering education

Globalization of the labor market opened new international opportunities for graduates of technical schools and provoked significant changes in requirements to qualification of a modern engineer. To be successful, students of engineering programmes should not only acquire professional knowledge, but also develop good communication skills. Engineering education in countries where the native language is not English – such as Russia – is influenced not only by a new vision of a professional engineer, but also by the need to develop foreign language skills to enable competitiveness of their graduates in modern society. The importance of learning foreign languages and ability to apply them in technical communication has increased dramatically.
Taking into account the recent processes of intensification and integration in engineering education and a new role of communication skills in the profile of a modern engineer, the existing approaches to teaching foreign languages should be modernized. Although urgent attempts to find new solutions are observed in Russian institutions of higher engineering education, the current language courses are not integrated into engineering curricular to the extent that could enable global competitiveness and successful international careers for their graduates.

Inthisarticletheauthorsproposeawaytoorganizeanessentiallynewapproachtoteachingforeignlang uages based on Massive Open Online Courses. MOOCs are considered as a didactic tool where engineering content is provided in a foreign language, which offers a unique opportunity for non-English speaking engineering schools to build a naturally integrated course of a foreign language for specific purposes. In January 2014, Tomsk Polytechnic University in Russia initiated an experiment aimed at testing the didactic potential of MOOCs in ESP courses. The project attracted great interest of the University students and proved efficiency of using MOOCs as a new education tool for teaching English for Specific Purposes to engineering students.

How to influence gender stereotypes to increase attractiveness of engineering

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From different European Commission projects horizontal gender segregation was found, resulting in a low number of female students in engineering in most of the European countries. In INDECS (Sagebiel 2004) we found that engineering could become more attractive for young women if curricula would include more interdisciplinary non-technical subjects and if the pedagogy would include some single sex education especially in the beginning of degree courses. Womeng (Sagebiel 2006) showed that the masculine definition of engineering together with the male image and less information about the profession make for the lower number of female students. In PROMETEA (Sagebiel 2010) still existing gender stereotypes together with a low gender awareness biased even research in engineering and this went along with gendered division of labor in SET organizations as well as in the European societies at large. Results from MOTIVATION “Promoting positive images of SET in young people under gender perspective” focus the importance of gendered media, peer groups, teachers at school as role models and initiatives/ projects to attract young females for engineering (Sagebiel et al. 2009). Especially drawings revealed a narrow knowledge of science and engineering. Results show for media that more diverse and realistic job images should be integrated in youth media like magazines and soap operas. To change the situation editors and producers should look for industries’ and universities’ support. Essential is that they meet the teenagers’ interests in SET presentation as relevant topics for the audience. Female SET related role models should be created to reduce gender stereotypes. Initiatives aiming at making SET attractive and fun are not enough. A more attractive curriculum can contribute in stimulating the interest in SET. Teachers` training is necessary especially for rising gender awareness and further their pedagogy. For pupils, the influence of teachers is huge. They serve as role models for SET jobs and their teaching skills influence positively or negatively students’ perceptions of the discipline. Family relations seem to be mostly traditional in all countries with Slovakia being a big exception. Initiatives for appealing young people to SET should start at an early age and organizers should ensure safe funding for years ahead including funding for evaluation. Late teenagers may demand other kinds of activities like creating inventions, for example visiting and working in academic
SET environment, and/or having mentors. Cooperation and networking between initiatives/ projects and academic/ non-academic institutions and companies would improve success.
The paper will summarize and discuss the results from different European projects about measures to increase gender equality in engineering degree courses.

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CHAPTER 5

Learning Specific Formats for Engineering Education

Challenges in implementing PBL: Chalmers formula student as a case

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Over the past two decades, we have witnessed several worldwide calls for reform in engineering education. Despite these calls there is still a significant gap between educational research and practice [1]. Previous research has demonstrated that faculty are aware of student-centred teaching methods, believe in them and try them out, but find it difficult to deal with unexpected issues that arise and thus often return to more traditional teaching methods [2]. It is therefore important to identify, describe and deal with different types of challenges or barriers that have a direct bearing on educational development.

In this paper, we use a case-study approach to identify and describe key challenges in relation to implementing project- and problem-based learning (PBL) in engineering education. Based on the first author's experiences of running and developing the PBL course Chalmers Formula Student over six years, we give a thick description of challenges in connection to running a large multi-disciplinary Design-Build-Test, DBT, project. We also describe how these challenges have been addressed over the years. As a theoretical lens for identifying and describing these challenges, we draw on an extended constructive alignment framework [3].

The challenges we identified do not only concern student learning or course design, but also the organisation of the course within the university and of the teacher team, different levels of communication: multicultural and cross-disciplinary within the teams, as well as external communication between the teacher team and the university, industry and society. Further challenges comprise the recruitment and composition of teams consisting of students with different skills as well as providing possibilities for the student teams to develop ownership of the project. It is also a challenge to run an industrial project and course in parallel, manifested here in the "two-hats" issue for the person acting as examiner and project manager.

Some of these challenges we identified in a workshop discussing challenges with PBL courses, held by the authors at the international CDIO conference 2014 and attended by a broad spectre of teachers. The challenges discussed mainly concern course design, organisation, activities and especially assessment, which are the obvious and most important challenges when first implementing PBL methods. After some time managing a PBL course, this is especially true for large DBT projects, the full scope of challenges will unveil.
These different challenges highlight the complexity of implementing PBL courses in engineering education and point to the importance of providing faculty with adequate support.

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How to coach engineering project-based learning?

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The Faculty of Engineering Science of the KU Leuven has over ten years of experience in providing project-based learning (PBL). In the course 'Problem Solving and Design' (P&D), students are confronted with technical and social competencies, such as teamwork and project management, in order to master the abstract theories presented in lectures [1]. During these projects, the students are coached by PhD students, further referred to as teaching assistants
(TAs) [2]. However, the TAs coaching P&D encounter several specific challenges and problems. Since a correct interpretation of the coaching role is crucial for a successful PBL and a qualitative learning process of the students, the coaches need to be professionall trained and supported [3]. Therefore, the faculty decided to create a didactic training module specifically for TAs who coach P&D sessions.

In this paper we will describe on one hand the above mentioned challenges and problems and on other hand the development of the educational training module 'Coaching Problem Solving and Design' to train and support the TAs. This training module is based on the 'teach as you preach' principle and provides guidelines and support for the specific context of PBL. This way, the TAs acquire knowledge about the teaching format and learn how to handle typical problems that occur during PBL.

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Developing a robust Self Evaluation Framework for Active Learning: The First Stage of an Erasmus + Project (QAEMarketPlace4HEI)

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In ensuring the quality of learning and teaching in Higher Education, self-evaluation is an important component of the process. An example would be the approach taken within the CDIO community whereby self-evaluation against the CDIO standards is part of the quality assurance process.

Eight European universities (Reykjavik University, Iceland; Turku University of Applied Sciences, Finland; Aarhus University, Denmark; Helsinki Metropolia University of Applied Sciences, Finland; Umeå University, Sweden; Telecom Bretagne, France; Aston University, United Kingdom; Queens University Belfast, United Kingdom) are engaged in an EU funded Erasmus + project that is exploring the quality assurance process associated with active learning. The development of a new self-evaluation framework that feeds into a 'Marketplace' where participating institutions can be paired up and then engage in peer evaluations and sharing around each institutions approach to and implementation of active learning.

All of the partner institutions are engaged in the application of CDIO within their engineering programmes and this has provided a common starting point for the partnership to form and the project to be developed. Although the initial focus will be CDIO, the longer term aim is that the approach could be of value beyond CDIO and within other disciplines. The focus of this paper is the process by which the self-evaluation framework is being developed and the form of the draft framework. In today's Higher Education environment, the need to comply with Quality Assurance standards is an ever present feature of programme development and review. When engaging in a project that spans several countries, the wealth of applicable standards and guidelines is significant. In working towards the development of a robust Self Evaluation Framework for this project, the project team decided to take a wide view of the available resources to ensure a full consideration of different requirements and practices.

The approach to developing the framework considered:

a) institutional standards and processes
b) national standards and processes e.g. QAA in the UK
c) documents relating to regional / global accreditation schemes e.g. ABET
d) requirements / guidelines relating to particular learning and teaching frameworks e.g. CDIO.

The resulting draft self-evaluation framework is to be implemented within the project team to start with to support the initial 'Marketplace' pairing process. Following this initial work, changes will be considered before a final version is made available as part of the project outputs. Particular consideration has been paid to the extent of the framework, as a key objective of the project is to ensure that the approach to quality assurance has impact but is not overly demanding in terms of time or paperwork. In other words that it is focused on action and value added to staff, students and the programmes being considered.

CHAPTER 6

New Learning Concepts for Engineering Education

Using Brainstorming and Appreciation of Novel Tech to Enhance Creativity in School Engineering Projects

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Keywords: Creativity, Design, Extracurricular

ABSTRACT

This study hosts after-class reading clubs as a method to foster creativity. In this club, teachers can set additional time to invite experts to share new tech with the members. In addition, teachers with design backgrounds can guide students in brainstorming to develop design-thinking skills without affecting regular classes. It is discovered from the students' end-of-semester projects that besides choosing more diverse topics, the students are also much more concrete in expressing their created content through project mechanism and programing code design. Furthermore, 43rd Annual SEFI Conference June 29 - July 2, 2015 Orléans, France diverse co-curricular stimuli assist in strengthening the students' initiative and creativity fostering. In conclusion, the students have shown significant improvement in creativity through their performance in engineering projects in their school's regular classes.

Teaching Mechanical Engineering and Humanoid Robotics with respect to Gender and Diversity Aspects

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The basic principles in engineering mechanics and robotic courses such as kinematics or rotation matrices have the reputation of being difficult and primarily of academic interest. Thus many students consider those courses simply as annoying prerequisites to subsequent engineering courses, resulting in low levels of motivation. But instead of repeating the same topic over and over, a student-centered learning unit is presented. In the new developed study course the experimental work exemplifies the practical benefit of seemingly abstract concepts using the humanoid NAO robot, solving tasks, e.g. the “throwing of a ball”. This simple “human activity” is a complex programming task in humanoid robotics, considering not only the construction, the static and the dynamic stability of the robot but also planning the robot’s behaviour and the human-robot interaction.

Utilizing robots does not only enhance the acquisition of subject-related knowledge, but also fosters meta-disciplinary competences like spatial sense, logical reasoning, and self-learning ability. Finally, the robot-enhanced learning unit allows for an individualization of the learning process, increasing students' involvement and motivation. The presented learning unit is student-centered in the sense that participants construct an understanding of the covered material in an active, collaborative way following the famous saying “Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand”, occasionally attributed to Confucius. The experiences gained in the presented study course facilitates the development of an interactive learning tool with respect to gender and diversity aspects.

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Ascertaining Affective Domain in Engineering Education: A New Learning Concept

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Engineers always play a critical role in the development of the society and in critical situation which enforces to possess critical thinking, problem solving, collaboration skills, decision making, communication skills, integrity, realizing human values, being compassionate and accountable etc. which enable them to work for the welfare of mankind. Much of the research has emphasized to have such types of skills among the engineers but increased demand and massive production of engineering graduates have led to poor quality of education and consequently skill shortage. Brown, Ferrill, Hinton and Shek have listed out motivation, initiative, compassion, accountability, empathy, advocacy, commitment, respect and selfconfidence as attributes of affective domain which help to reflect behavioral changes making them professionally competent. **[1]** The authors ascertain that the cognitive domain has been always emphasized in engineering education more than the affective domain, albeit the affective domain is substantial for engineers

Leading Universities of India have already recognized the importance of the affective domain and have started to design courses with special focus on the untouched set of affective characteristics among the engineers. Gujarat Technological University, a technical University in Gujarat, India also accepts the importance of affective domain and has introduced a course titled “Contributor Personality Development Program” in the first year of Bachelor of Engineering. However, the exam-oriented mind set of the students with much more emphasis on the technical skills have generated a demand to come up with new teaching pedagogy to develop/focus/concentrate on the affective characteristics among the first year students.

This paper presents a unique pedagogical framework focusing on the development of affective domain among the first year engineering students. The affective domain, arguably the most complex**, [2]** is about students’ values, attitude, emotions, appreciation etc. The authors have adopted this as a case study offering a conducive, student- centered learning environment that motivates and enhances students’ engagement with their peers, friends, teachers and the /institute . This paper discusses a new learning concept, specific to engineering education for the smooth transition of the students to real contributors and lifelong learners by acquiring some indispensable 21st century skills through a pilot project in which more than 500 students from various faculty has been assessed.

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A case study of teaching interdisciplinary collaboration for engineering Students

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Application of interdisciplinary project teamwork is an emerging teaching practice in engineering education. However, to put together students from different disciplines in a project team is not sufficient to teach them how to collaborate efficiently. Teaching only the traditional teamwork skills is not enough for successfully interdisciplinary collaboration [1]. The aim of this paper is to explore the main difficulties and opportunities of this teaching practice from a multi-case study of interdisciplinary collaboration between engineering students specialized in multiple engineering fields and students specialized in communication.

Interdisciplinary collaboration differs widely from engineering students' usual project teamwork where they work together in their own technical domain. Still, in their future professional practice they should work in close collaboration with other team members from various disciplines who might be geographically dispersed or physically present. They need to learn how to work in a virtual environment and create virtual and physical teamwork organization. Nevertheless, project teamwork organization in this interdisciplinary context needs a high collective identification [2] to achieve a better efficacy. The creation of collective identification in a virtual environment caused several difficulties for students like the divergence of shared values between team members, differences in their working methods or collaboration skills. Interdisciplinary collaboration requires engineering students to work effectively together across disciplinary boundaries and create a link between these disciplines. The main opportunity of this project based learning experience was the learning process how to create effectively these links consequent the development of non-technical professional skills [3]. The assessment of these skills is not consistent by the traditional exam based assessment methods. Instead, we considered both formative and summative assessment in a progressive process during this project. Formative assessment was used by tutorial teachers for monitoring the students' progress on a regular basis during the learning period. Summative assessment was practiced at the end of the project by the client on the basis of the collective project outcome.

At the end of the project, high student's satisfaction rate based by self-assessment indicated the positive consideration of this learning experience. This experiment of creating an interdisciplinary collaboration learning process for engineering students shows that it is an efficient way to help them to gain critical collaboration skills. Our study put in evidence the importance to foster the creation of collective identification by conductive teaching practice.

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The Effects of Spiral Educational Method through PBL: KIT Project Design Program

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Project-based learning (PBL)has been recognized as the effective educational program in various courses, e.g. engineering, computer science, bioscience and chemistry.Kanazawa Institute of Technology (KIT) applies PBLtothe backbone of the curriculum, and names it Project Design Program [1]. The program isconsisted of 5 courses as shown in Table 1.They are compulsory for freshmen, sophomores and seniors. The program enhances the innovation ability to work out and specify the best solution of a familiar problem in a team.These courses act as the spiral educational method of raising active engineers.

In this paper,we outline the spiral educational methodconsisted of multiple learning circles, which helpstudents to obtain innovation skills. Circles are constituted by three stages. They are weekly homework, projects within a course, and the repetition between courses.Knowledge and skill are learned repeatedly, and are used in order to tackle project problems so that students can obtain innovation skills.

This paper also reports the educational effectiveness of the spiral method which is confirmed by repeated surveys. The investigation to students' skill level was conducted in the questionnaire mode. As the Project Design Programis compulsory subject, we can get massive data from students who take the courses. The questionnaire was carried out for 1,500 students of class 2012 and 1,700 students of class 2013 for two years.

The growth degree of required knowledge and capability was investigated. The result shows statistically meaningful improvement in innovation skills, which include presentation skills, leadership, idea creation and so on. This is the first report as an analysis result of extensive data about educational effectiveness of spiral educational method through PBL.
TABLE 1 Project Design Program Courses and Main Contents

TABLE 1 Project Design Program Courses and Main Contents

Grade	Freshman		Sophomore		Senior
Course	Project Design Introduction	Project Design 1	Project Design 2	Project Design Implementing	Project Design 3
Main Contents	Experiment methods	Idea creation	Idea into shape	Verification experiments	Graduation thesis

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On line course and learning scenarios for innovative design teaching

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Among professional activities, design is certainly one of the most complexes. It is described (1) as the management of evolving ill defined problems (2) with path dependency due to technical decisions the designer makes. Since, a designer must regularly observe and analyse the "situation" (3) in order to determine his next actions; including the product under design, his means for action, (design tools…), the effects of his technical and non technical decisions and the adaptation to external constraints. Meta-cognition appears both in objectives and as a means for learning (reflection on action) (4). Since its beginning, the module classically included hours of lectures (28h), tutorials (24h) and practice on projects / PBL (21h). Its contents and objectives (Functional analysis and TRIZ tools + abilities to manage the design process) are largely stabilized, but teaching methods continued to evolve, concerning notably the means for meta-cognition and teachers' roles (5); then the adaptation of design projects, the presentation structure of concepts and tools, the use of cooperative means for tutorials, cross evaluations of students intermediate documents and the use of a pedagogic platform.

This paper presents recent developments built inside the French project IDEFI /InnovENT-e (6) whose main goal is to develop formations devoted to innovation generation and management, especially for SMEs developing internationally. In this context, two main actions were conducted. The first one was the generation of an online course (web application) from the existing presentation documents; replacing appreciably 14 hours of lectures. Interactivity was sought (exercises, lexicon…). The second action was the formalization of detailed learning scenarios describing the learning outcomes, duration, conditions, means… and actions of learners and teachers with links to attached documents.

Before moving to distant learning, the last sessions offered the opportunity to test these teaching tools in "face to face" teaching. Without changing the number of hours spent by students and with no modification on design projects, a series of cascade modifications was made possible for lectures and tutorials hours. Tutorials with a large number of students (56) replaced lecture hours. They concern discoveries of TRIZ tools – but not deeper training maintained with small groups. Tutorials were added to regulate students' works. Short and regular episodes of reformulations of concepts punctuate other tutorials. The percentage of time a student spends simply listening teachers continued dropping; up to 20 % (for lectures + tutorials). Finally, the detailed scenarios lead to define 10 rather independent sub-modules. They are still used to adapt this course to other contexts.

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Enhancing Learning in Integrated Physics Laboratory Course: Physics, Mathematics and Communications

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At Tampere University of Applied Sciences, the bachelor's level engineering students are generally interested in active doing in laboratory courses. However, laboratory courses have been considered rather laborious and demanding - in many cases due to the scientific analyzing and reporting requirements. Data analysis skills and reporting skills can be considered as fundamental objectives of engineering laboratories [1] and concepts of error analysis are difficult to students [2]. To enhance student s' perception of their own reporting and analyzing skill level, self-assessment can be used [3]. Despite the clear need, mathematics and communication studies haven't always been well synchronized with the physics courses.

To enhance students' learning, the contents of first physics laboratory course have been changed to an integrated implementation in which the course consists of equal amounts of physics, mathematics and communication studies, 1 ects each. These are instructed by a physicist, a mathematician and a communications teacher, respectively. The key idea is to bring together all the basic skills a student – and an engineer to be – needs related to measurements and their reporting to an instructor or to a customer, for example.

Course overview and its key concepts are presented earlier by the authors elsewhere in more detail [4]. Students have this new course scheduled at the same time at every week, but the classroom, topic and the teacher changes: 1) Physics 2) Mathematics 3) Communications. The teachers, on the other hand, repeat their topics three times to different student groups at the same time slot at his/her schedule in three consecutive weeks. Altogether, there are three cycles of measurement, mathematics and reporting in which the learning objectives became more and more challenging.

In this paper, the learning experiences and outcomes are compared to those of previous implementations of physics laboratory courses. The evaluation of the new teaching method is based on interviews with the instructors and access to their assessment data, together with feedback from students. The new concept is also evaluated in course planners' perspective.

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Facilitating creativity as a core competence in Engineering Education

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In Engineering Education (EE) there is a growing emphasis on providing students with skills and competences within innovation and entrepreneurship. This development has emerged from an identified need for establishment of new enterprises, creation of new possibilities for employment and to contribute to enhanced growth. Engineers are considered to have a key position in this development, and many engineering challenges call for new solutions. Creativity is a prerequisite for the ability to combine present knowledge into new solutions. Hence, creativity is an important subset in innovation. This development gives reasons to reconsider the content in EE and how it is taught. If creativity and innovation are the new key components in academic training of engineers it is also necessary to embrace openness to collaboration and multidisciplinary, holistic views on real life complex problems, and design competences in EE [1]. Still it is well known that there is inertia in Engineering Education to develop new structures and traditions in teaching and learning [2]. In the whole education system there is a growing interest in creative engagement of pupils and students, and the body of research in the area is growing rapidly. Research in this field has an emphasis on the role of the teacher in facilitating creativity, while the question of how to train teachers in teaching creativity is less emphasized [3]. How do we teach creativity to those how are going to teach creativity in EE? At the Technical University of Denmark (DTU) a mandatory teacher training program for new faculty has in its present design been successfully held since 2004. Different approaches to fostering teachers' beliefs of creativity and innovation as teaching methods have been explored in the programme, based on approaches like the ones described in [4]. Based on qualitative surveys and interviews this paper will discuss how the programme influence teachers' beliefs about 1) creativity in teaching and learning, 2) view on creativity as an important engineering skill, and 3) desire to emphasise creativity in their own teaching. The results indicate that while new faculty like to master a traditional way to teach at university, some new faculty is convinced by elements of the course material and thus display another behaviour – embracing new perspectives in EE and being more open to include creativity as a part of their teaching.

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CHAPTER 7

New Education Tools for Engineering Education

How to remove the gender bias in multiple choice assessments in engineering?
Experimental validation and theoretical analysis using prospect theory

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In higher education, exams with multiple choice questions (MPQ) are very common since they allow for testing large groups and giving fast feedback. While multiple choice exams are at first sight considered to be an objective way to assess knowledge of the students, the use of multiple choice exams raises some concerns. This research tackles one important concern: the fair and objective marking of multiple choice exams. A variety of marking methods are available such as number right, elimination testing, and negative marking. A method such as negative marking, which is the standard method at KU Leuven, tries to discourage blind guessing. Literature, both from the pedagogical and psychological field of "assessment" as well as the economic research field of "decision making under uncertainty", has however indicated that negative marking **disadvantages risk-averse students**. Moreover, female students are in general more risk-averse. As such, introducing penalties for guessing can disadvantage female students.

The aim of our research is to investigate if a method called **"elimination testing**" [1], originally designed to measure partial knowledge, is suited for grading multiple choice exams without gender and risk-averse bias in the field of engineering. To this end we did both an experimental and a theoretical investigation. For the **experimental investigation** the elimination testing was introduced in a first year Engineering Science bachelor course "Electrical circuits". For the **theoretical investigation** we used prospect theory (a model from economics for decision making under uncertainty) [2,3] to compare the impact of different multiple choice methods on risk-averse students. Based on both investigations we conclude that **elimination testing is not disadvantageous for risk-averse students.** However, elimination testing results in a higher average score than the well-known negative marking.
Therefore, test builders have to spend even more effort in the design of the question and the alternatives for the correct answer, since students are rewarded for partial knowledge. To alleviate this disadvantage we propose introduce a **new scoring rule for elimination testing that is still gender neutral**.

Acknowledgement
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The Effect of Introducing On-line Quizzes in a Virtual Learning Environment and Implications for the Flipped Classroom

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This paper reports on an *action research* project to improve teaching and learning in an applied physics course, given to master students and in a purely virtual learning environment. Before the reform, the course was designed around pre-recorded lectures available for ondemand viewing, as well as tutorials live-broadcasted with the possibility for synchronous interaction between students and teachers. The teachers were also available to answer questions during dedicated sessions, to which the students had to register in advance.
However, none of the students ever registered for these synchronous sessions. The question driving the reform then became: How could we increase the interaction between the students and the teachers?

Drawing on the idea of *just-in-time teaching* (JiTT) [1], the course was redesigned to also include the following elements: on-line quizzes embedded in the pre-recorded lectures and focusing on *conceptual understanding*; the possibility to pose questions to the teachers while watching the lectures; easy and rapid rating of the lectures and the possibility for students to provide more specific feedback on the lectures; regular synchronous wrap-up sessions designed to address the students' needs and based on the input from the students; and discussion fora.

One interesting effect of introducing on-line conceptual quizzes, together with the possibility to pose questions while watching the lectures, was the dramatic increase in the number of questions posed by the students. Using the revised version of Bloom's taxonomy for the cognitive domain [2] to classify the questions, we found that the level or quality of the questions also increased, reflecting a deeper understanding of the contents. This was also noticed during the wrap-up sessions. Moreover, the conceptual nature of the questions in the quizzes triggered more across-the-course integrative questions from the students compared to the questions by the students when solving the home assignments. In the paper, we will support these findings with data collected from two iterations of the course, and via a learning management system.

This study highlights, in particular, the importance of using on-line quizzes in tandem with the pre-recorded lectures to encourage students to take a *deep approach to learning* when implementing *flipped classroom* models. To better handle and make use of the large number of questions generated in the redesigned course, we will, in the next iteration of the course, let the students discuss selected questions in the discussion fora to also strengthen the element of peer interaction.

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Intercultural, Reciprocal and Multidisciplinary Learning Case Study

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Engineers often work in multi-disciplinary and multicultural teams in the modern globalized working place. Therefore, it is of paramount importance to understand the different mindset of colleagues coming from other professional fields than engineering and their different cultures in order to create a high- performing team based on intercultural competence (Kaufmann, Englezou and Garcia-Gallego, 2014). The current highly competitive business environment demands a more holistic and cross-functional way of thinking and working. Therefore, engineering students need, for example, also marketing skills more than ever before to understand customer value creation. In the same vein, it is beneficial for business students to understand the engineering mindset for optimizing working relationships and customer centricity. Thus new educational methods are being needed both in the engineering and business education.

It has been noticed that authentic learning experiences produce good learning results. The implication would be that real life business situations should be used as cases while designing learning tasks in engineering education. At the same time, universities should also support the development of the operations of the local companies. Universities have become more international and attracted foreign students but often their cultural diversity potential could be better utilized and synergized with those of the local students.

This empirical paper describes the integration of two Finnish BSc courses, one from the engineering faculty, and the other, from the multicultural business faculty during years 2014 and 2015. The aim of the two project based learning projects was threefold: first, to develop the students` diversity management skills and second, to increase the export marketing skills of the engineering students and third, to innovate new business models for a local company. The time span was within an intensive one week period. Students who came from mechanical engineering and international business degree programs were assigned into cross-disciplinary and multicultural teams and a local company provided them a case task related to export marketing of their technical product to be solved during the intensive workshop week.

Findings of the qualitative learning experiments will be presented. Conclusions as to integrate diversity management at the university level and suggestions for the development of the engineering curriculum will be provided.

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Student Collaboration and Independence From Day One in Higher Education

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This paper describes how a novel course structure in the beginning of engineering studies influenced the way students approach study challenges. The student groups consisted of 50 information technology students with a diverse nationality background, majority being young male Asians from Vietnam and Nepal. They were divided into two groups, which both had 5 teachers from different professional disciplines such as mathematics, software engineering, and communication skills in each course implementation. The main idea was to apply project based learning that had already been introduced in many universities [1].Students took four 15 ECTS course implementations during the first year. This study concerns the orientation course and the games (programming) course that were implemented in the fall semester.

The orientation course started with creative team work exercises, followed by both individual and collaborative challenges related to information technology, such as PC assembly, installation of Linux on personal laptops, creating web homepages, editing wiki-pages, studio photographing and image editing. The games course that followed had one large project assignment, to develop and implement a text-based game in Java. The classroom furniture was arranged in groups of small tables that could flexibly be rearranged for team work or lectures.

The teachers were prepared to support and encourage collaboration in all tasks. However, the students quickly adopted a self-directed mode of operation, helping each other instead of asking teachers. A surprising finding of the courses was the fast speed of adopting team working skills even though most of the students had never before been allowed to work in teams. Collaborative work towards a shared goal has proven to be an efficient and inspiring mode of study, and in this case, it was introduced immediately in the first courses. Additionally, students did not depend on university PC installations but they were in charge of their own laptops, which they learnt to administer fluently. Students could use their previous IT knowledge and enhance it in collaboration [2]. The instructors admitted that students have previous knowledge and skills that they are able to use creatively when assignments are structured in an open way.

In the paper, the outcomes of the first courses are compared to earlier years when students took separate small courses in a traditional lecture & laboratory work mode. In addition to the observed increase in self-reliance and collaborative practices, also measurable results such as drop-out rate were significantly better that previously. The results and student feedback are further analyzed in the paper.

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Improving report writing by peer assessment using Coursera

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Key words - Curriculum development, New education tools for engineering education

Report writing is an important skill for engineers. In the course "Introduction to Mobile Communication" at the Technical University of Denmark (DTU) all students must write three reports. Two of them are on a given task in the lab while the third one is much more open as they can decide on a topic themselves. The reports are part of the course evaluation (30%) together with an oral exam (70%). In the previous course design, the students used to hand in all reports by the end of the course. The teacher would then grade all reports and after the oral exam the students would be notified of their final grade. This is the traditional way of doing assessment, so called summative assessment [1]. This year the assessment in the course design is changed. The intension is that the report writing develops from being purely an assessment task to be also a learning task. Thus, there are added a learning objective: "Write and evaluate reports on mobile communication". In order to implement this, the students must get feedback on the reports during the course. I.e., write one report, get some feedback that can be used to improving the second report. For the second report they also get feedback and then finally they have a lot of input for the third and final report. By getting feedback throughout the course the students can gradually improve their report writing and hence do better on the final exam. This method is also called formative assessment – getting timely feedback that closes the learning loop [1].

In the new course design peer assessment is used as the method for formative assessment. It is well known from studies of peer assessment [2] that it is a very efficient way of doing assessment as it saves on teaching resources and supports the students' learning. One interesting finding is that what you really learn from is not only getting the feedback but also giving feedback. Some assumptions about peer assessment can be summarized in two statements that are investigated in this paper:

- The evaluation from students is as good as the evaluation from the teacher
- The students learn a lot from doing the evaluation

To support this peer evaluation process the e-learning platform Coursera has built-in facilities for peer assessment and it was used for implementing the peer assessment for report writing in this case.

Our findings are that the consistencies of the peer grades are quite good, and that there was generally a good relation between the peer grades and the professional grades. Furthermore, analysis of grading distributions from all assessments in the course has been made in order to investigate the improvement in report writing, i.e., the applicability of peer assessment as a learning tool.

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CHAPTER 8

Physics and Engineering Education

Using Potential to Help Students Understand Voltage: First Steps in Implementing Effective Instruction

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In a previous publication, we reported on an ongoing investigation on student understanding of the concept of voltage. Using a worksheet, we had introduced students to the concept of electric potential to deepen their understanding of voltage. After instruction, we had found, that many students still had difficulties with both concepts. Most of their reasoning was inconsistent, which suggested that they were unable to link those concepts. [1]

The purpose of this paper is to report our findings after a revision of the instructional material.

We developed a new worksheet that focuses on the connection between potential and voltage, instead of the individual concepts. Potential is now mostly introduced as an algorithmic approach for determining voltages in a circuit. This approach allows us to confront students with their misconceptions regarding voltage.

Using pre- and post-tests, we measured the effectiveness of this new approach. Compared to the results from last year, a significantly larger percentage of students in the post-test showed a functional understanding of voltages, as they were e.g. able to correctly identify the voltage at an open switch. A similar number of students was able to correctly rank the voltages in a given circuit. The overlap between both groups of students was significant.

This overlap shows that our approach works in principle. However, as the percentage of students with a functional understanding of voltage is not as high as we had hoped for, the instructional material still has to be improved.

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Comparison of the Entering Students' FCI-test Results – Tampere UAS and University of Žilina

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The Force Concept Inventory (FCI-test) is largely used conceptual test concerning introductory mechanics concepts [1]. It can be used to measure the effectiveness of different models of teaching [2, 3] or to monitor the preconceptions, misconceptions and development of the students' conceptual understanding on introductory mechanics.

The students entering the engineering studies have very heterogeneous background in physics. In Tampere University of Applied Sciences (Finland) a student may enter engineering studies either from the secondary school (3 – 4 years at the age of 15 - 19) having secondary school physics studies between 1 to 10 courses, or from the vocational school, having merely no obligatory physics at all. In the University of Žilina, entering students enter the university studies either from secondary "professional" school, e.g. Secondary School of Electrical Engineering", or from grammar schools. Physics background is very different; grammar school students have the opportunity to attend 5-11 classes a week per 4 year studies (1-2 lessons a week in each grade, plus extra optional laboratory lessons mostly in the last two grades of studies) while students at secondary "professional" schools may have only 2 classes a week per 4 year studies or no physics at all. Therefore it is very important to recognize the students' prior conceptual knowledge of physics before entering the engineering physics studies.

In the paper, the results of the FCI test scores measured before the start of the engineering studies between the student group of Tampere UAS and the student group of University of Žilina are presented. The results of the test show that the conceptual understanding varies a lot between students inside the universities, but mainly the results between university students of the same educational history between universities are about the same. Some other similarities and differences are studied and discussed.

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RC-car as a small-scale measurement setup for physics laboratory course

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Physics in engineering education at Tampere UAS is tailored to the needs of different degree programmes as much as possible. This includes lectured courses as well as laboratory work where students can perform measurements from their own professional area. Clearly conveying the applicability of physics is seen as an important goal [1]. Topics and how they are covered affect students' perception on importance of laboratory work that can often be viewed as laborious.

New physics laboratory assignment demonstrating mechanical oscillation was designed specifically for degree programme in Automobile and Transport Engineering. Students in automobile engineering programme need to understand the purpose of a vehicle suspension system and which physical quantities are used to describe its performance. As an example students should be familiar with different shock absorber tests used in vehicle inspection.

It is difficult to bring real-sized suspension measurement systems into physics laboratory so a cost-effective small-scale measurement setup was built for a radio-controlled racing car that has a real suspension system with springs and shock absorbers. With this setup the significance of different physical quantities can be clearly observed. Seeing and simultaneously measuring these quantities, for example resonance frequency, in operation will concretize students' understanding of the subject. Students' apprehension is analyzed by comparing answers given in the laboratory reports to the answers given in a pretest they filled before the laboratory assignments. It is also investigated if the students are able to see the physical phenomena behind the results and transfer their small-scale results to the real world.

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Early Identification of Problems in Physics Learning and Suggestion of Intervention Tools for the Freshman Students in STEM Education

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This paper presents initial research results detecting problems in learning physics in the educational process of the students of the Faculty of Civil Engineering at the University of Žilina. We represent the research methodology, the form of results´ processing and their evaluation. We analyse a test, its validity and students´ answers so that we find possible alternatives on how to help students, during lectures, eliminate wrong apprehension of physics processes. Our findings have revealed absence of basic knowledge in the field of physics. This research aims to continue with the elimination of misconceptions and the development of conceptual thinking by using intervention tools. One of the effective way how we can eliminate problems in learning physics is the application of video-analysis method and the use of computer simulations for enhancing students´ visualisation and conceptual understanding.

Experiments and visualisation tools play an important role in science education. Interactive and dynamic computer animations, simulations and video analysis, in particular, are one of the effective ways of learning abstract concepts. Computer animations help concretise abstract complex concepts and phenomena in science education, thus help students learn more easily and more effectively.

Our previous research confirmed that students´ competencies were developed and their knowledge was increased when working with the program Tracker and PhET sims, so the application of VAS method (Video Analysis and Simulations) has significantly influenced the level of students' knowledge. We performed various surveys at technical universities confirming that using video analysis and simulations in the educational process results in enhanced knowledge compared to that gained through teaching by traditional methods [1,2].

We have demonstrated that watching video recording process of braking and subsequently performing video analysis using these videos in an appropriate and attractive way forms correct students' conceptions of car braking distances. Using videos affected the level of the students' knowledge and their understanding of physical phenomena in a positive way [3].

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Archaeometry – an example of interdisciplinarity in engineering education

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Archaeometry is the application of techniques typically used in the natural sciences and engineering for dating and analysing archaeological materials and objects of cultural heritage. More than a hundred years since the earliest use of scientific methods for a deeper understanding of culture from the past, archaeometry has developed into a discipline that links physics, chemistry, information sciences and construction of instrumentation with historical and archaeological studies (in the sense of cultural history). It requires close collaboration among specialists from all these disciplines. Therefore, it can be included in the curricula of universities dealing with applied sciences and engineering, at least as an optional course.

Two main goals of archaeometry are to date various artefacts and archaeological finds (see, e.g.
[1]) and to analyse the materials of various objects of cultural and historical importance (e.g. [2]).The analytical techniques used in archaeometry are based on physical and chemical principles, and can also be used for material analyses in industry, agriculture and food production, in various fields of research, etc.. They can therefore be mentioned in general lectures on the application of various physical and chemical techniques, together with references to their usability for cultural heritage. References of this kind add variety and interest to the students' own cultural environment. However, dating methods such as radiocarbon dating are specific for archaeometry, and need to form an independent part of lectures.

The paper deals with the ways in which archaeometric methods are included into the curricula on applied physics at the Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University in Prague. It mentions aspects of archaeometry that are pointed out to our students (we are educating physicists and engineers and not archaeologists and art historians, and we emphasize that these two groups of specialists always need to collaborate to obtain reliable results and interpret them). We also discuss how students accept archaeometry, how it is reflected in the research carried out at the faculty, and the participation of students in this research.

The curricula at the Faculty are heavily loaded with courses in mathematics and physics.
Excursions into interesting interdisciplinary applications can help students to appreciate that mathematics and physics are not necessarily dry sciences, but that they can have very colourful outputs.

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Students' Online Activity on Modern Fully Online Introductory Physics Mechanics Course

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The pressure to produce high quality university-level online education has increased over the years. The pilot implementation of a fully online introductory mechanics course in engineering education was carried out in Tampere University of Applied Sciences in autumn 2014 in the time period of 8 weeks. Course outlines and study methods, were presented in SEFI2014 conference by authors [1]. The following materials and activities were offered to enhance studying:

- Written theory summaries
- Video clips explaining theory
- Example calculations and homework - including video solutions
- Weekly group assignments (not assessed, answers commented)
- Assessed measurement assignments every other week (weight 20 % of grade)
- Assessed week exams every other week (weight 30 % of grade)
- Final exam (weight 50 % of grade)
- Discussion forums in Moodle
- Weekly instructor's call time (online)

As in the online implementation, the teacher does not meet the students face-to face, the real learning activity of the students has to be found out using the log files of the online learning environment. The interesting questions are:

1. How does the students' overall activity change during the course period?
2. How does the student activity vary among weekdays and time of day?
3. How does the amount of active students change during the course and why?

As the summary of the results, the overall activity in terms of opened study activities decreases during the course and it heavily concentrates on the deadlines of the assessed assignments. The student activity appears strongly in the evening hours and on the weekends. More precise figures and explanations will be presented in the paper. The authors suggest that even in asynchronous studying the course contents should be strictly scheduled – it seems to be the deadlines that make students to take actions.

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Engineering and research education in Plasma technology

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Plasma technology engineering is not very well-known by undergraduate students and very few engineering schools dedicate a complete semester to this subject. The plasma state is often considered as the fourth state of matter and basically consists of an ionized gas. 99.99 % of the
Universe is made of plasma. They are also present in a natural state on earth (boreal aurora, lightning, and ionosphere). Although they are not very well-known by the general public, plasmas are used for most of high technology devices. Indeed, one of the main applications of plasma technology is related to micro and nanotechnologies.[1] For instance, in a clean room of production of Integrated Circuits for memories or microprocessors, more than 50 % of the equipment consists of plasma reactors. Plasma technologies are also used for many other applications in materials industry (coating, functionalization), in chemical industry (gas abatement, gas production …), in medical industry (plasma sterilization, plasma treatment…) and in many other industries.
Most of the industrial plasmas are created by electrical discharges from various types of electrical excitations: Direct Current, Alternative Current, Radio Frequency, microwaves, pulsed power…[2]

At Polytech Orleans [3], a complete semester is dedicated to plasma technology in a master level within two courses of 120 hours each, called "Plasma Sources" and "Plasma Processing". A strong collaboration was created with the GREMI lab. This collaboration involving companies is very beneficial and necessary if we want the students to have access to expensive and state of the art equipment. A plasma is a very complex medium. Many different prerequisites are usually required in physics and chemistry to have a deep understanding of the mechanisms involved in such a medium. However, it is also important to teach the complex technology beyond it, which includes vacuum systems, gas injection, cooling, electrical power supply and optical and electrical diagnostics. Our educational program in plasma engineering comprises theoretical and practical aspects. In the "plasma sources" course, students attend lectures on the different types of discharges and reactors at low and atmospheric pressures. They also have classes on spectroscopy, which is one of the most used diagnostics in plasma technology. Practical works are also included in the course. In the second course dedicated to "plasma processing", they learn processing in chemistry, in medical and in microtechnology applications. They also have classes on materials, diagnostics and simulation. Some practical works are also provided. During the whole semester, students carry out a project in parallel to their courses where they have to design a complete reactor. They all work on the same project, which is divided into different tasks that are managed individually by small groups of students. At the very end of the project, the students have to provide a complete file including all the different parts of the designed equipment.

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Development of Simple Public Assessment Sheet and its Use in Elementary Physics Laboratory Course

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Traditional physics curriculum in engineering education has always included some laboratory work. In the laboratory courses students develop their engineering, scientific and reporting skills, which all are important in engineering profession. The typical negative feedback from the laboratory course before the use of the public assessment sheet often included following.

1. "The ects credit was too low compared to work"
2. "One teacher gave better grades than the other"
3. "The basis of the grades were not clear"

To meet the challenge, the key idea was to create simple public assessment sheet, a table, which describes in writing the detailed basis of assessment of the different parts of laboratory reports. Similar tools have also been used elsewhere [1]. The goal was to improve not only the students' feedback, but also students' learning outcomes in reporting and overall quality of assessment. The main benefits of the assessment sheet were expected, that it brought openness in the assessment, it eased the teacher's work and could motivate students to better reporting quality.

First years, the assessment sheet was used only as summative assessment tool from teacher to student to grade the reports. The feedback concerning the assessment changed and the assessment process got more coherent.

The last step of the development process included students' self-assessment of their own reports before returning it to teacher. Students include the assessment sheet as an appendix of their laboratory report. They self-assess their own reports according to the same criteria as the teacher. The last step is implemented during spring 2015. Data of student experience concerning the combined self-assessment and teacher assessment is gathered on a survey.

The paper describes the overall development process of the usage of the assessment sheet, the students experience on combined self-assessment and teacher assessment and the results in learning outcomes of students reporting skills.

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CHAPTER 9

Students as Key Actors in EE Change Process

Defining the Engineering Student of 2030

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Marc Prensky (2001) defined the digital natives as the *first generation to grow up with the new technology* [1]. Since then, new citizens of the digital world started to study in our classrooms, having new needs in teaching and learning matters due to the implementation of what it is called information technologies.

Steve Jobs, between 2007 and 2010 introduced in our homes and normal daily life the versatility of the touch screen interaction that opened a completely new global horizon. Thereafter new ways of teaching started to emerge in order to fulfill the hunger of knowledge that suddenly and without realizing was in our digital fingerprints. Triggered by curiosity, looking at the new devices are our kids, the university students of 2030.

The use of smartphones with its apps in any context and place is starting to introduce a completely new model of student in kindergartens and primary schools. These new students have new abilities, new ways of thinking, new ways of interact with peers, and of course, new ways of learning. It is natural to think that the brain structure is changing. In fact, John M. Grohol (2008) states "*any person can affect his brain simply by doing something repetitively, or doing something differently*".

Once these new students arrive at universities, a new model of face-to-face master class has to be offered where Instant, Global and Digital Knowledge engage their expectations and enhance their new way to look at the world among others.
In order to build the model that the 2030' students will demand we should first know how those students would look like.

The present work sets the common characteristics of those future engineering university students that are growing up at the same time that new digital teaching strategies are starting to emerge at our universities. To know "how" they are building up their knowledge is keystone in the success of the new curricula of Engineering University Studies

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Score distribution as a tool to reveal group dynamics in student projects ?

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Telecom Bretagne is a French graduate engineering school in Information and Communication Technology. Our students need to be prepared, as engineers, to cope with complex projects in fast-changing environments. To this end, we have developed project based learning where students are placed in practical situations close to those they will experience in their future career. In particular, during a final-year project, some of our students are required to perform a technical and economic study with constraints which can vary all along the project. The students work in large teams (around 15 students) and have great freedom regarding their team organisation, which is a key of the project's success. This method contributes to the diversity in engineering education.Analysing and understanding this organisation, its triggers and its consequences are trivial neither for the teachers nor for the students. Therefore, we need tools to support and facilitate this analysis.

We have chosen to experiment score distribution as a tool but its analysis is not obvious. We made the hypothesis that distribution performed by the students of a project team could be a tool to reveal, analyse and understand team organisation and dynamics. So, a jury gives a unique and final score to the team. The students of the group are then free to share this score with their own algorithm. The only constraint to be observed is that the average score must be equal to the initial group score.

Based on the study of eight groups over four consecutive years involved in a complex project management, we analyse the hypothesis that score distribution reveals teamwork dynamics. We propose a discussion of the advantages and limits of this tool. Five groups didn’t use the score sharing possibility. Three other groups used it but in different ways: authoritarian, positive or corrective. Although this tool reveals great solidarity between team members that painfully but successfully overcomes difficulties, it also reveals hidden tensions between individuals. More generally, it highlights the team management process. The way the score is distributed can reveal not only the organisation of responsibilities and the individual involvements, but also the weight of some egos, the communication processes, implicit organisation rules and the student feedback on the project.

Nevertheless, this tool has to be considered with great care since it can be biased. For instance, our study is made on third year students of an apprenticeship based program. Therefore, they knew each other for two years when they started the project. Moreover, they had a homogeneous technical background but diverse professional experiences as interns. We have tried to take these parameters into account when analysing their score distribution mode.

In the future, we aim to improve the experiment and analyse feedback over a longer period and, if possible, over different students profiles.

Social Sciences in Engineering Education

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The last few decades have seen many changes in how different groups in society perceive the terms “engineer” or “engineering”. While these terms are used mainly for applied fields of knowledge, they are now, however, not restricted only to hard science as was previously the case. Moreover, the engineers while exercising their profession are no longer confined in factories, construction sites, or design offices, but are more and more exposed to intensive human contacts in sometimes unexpected contexts. These major changes had a direct implication on the vision we historically had about engineering and engineers and have influenced the way decision makers came to look at engineering education.

What precedes raises the following questions: Do we need a new approach to engineering curriculum in the near future? What flexibility do we have to adopt strategically to make this approach respond to societal demands? And finally, what international consensus is needed to recognize the regional and national specificities while assessing the quality of the delivered programs?

In this presentation, and relying mainly (but not only) on the Lebanese context (the graduates of the Lebanese Schools of Engineering play an important and significant role throughout the Middle East), we emphasize the importance of adopting a new approach to engineering education and try to develop certain main axis of change in the curriculum. The paper will focus on the following points:

1. The first part will be devoted to describing the actual status of engineering education and the social needs for widening its educational objectives.

2. The second part will deal with the learning outcomes and competencies that engineers should acquire before graduating, and the needs for a multi-faced engineering education to respond to the changing demands of the labor market. This will imply a flexible structure of the curriculum, mainly in terms of content and of learning methodologies.

3. In the last part, we will elaborate the importance of an international recognition of this approach to engineering education in order to ensure its quality and to avoid penalizing institutions that choose to respond to such societal needs.

The presentation will be based not only on a literature review but also on interviews with stakeholders, fresh graduates, head of companies etc.

Essential qualifications of modern engineers in Europe and how the university provides for them: The Greek paradigm

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At a time, when the mobility of engineers in Europe is heavily promoted, students from various engineering fields studying at the Aristotle University of Thessaloniki convened with academics and professional engineers in order to examine the ways that the university contributes in offering students all the skills needed to face the requirements of the European job market. Special attention was paid to the study cycles, given that in Greek universities, which have not yet complied with the Bologna Process, the educational system used is five years of integrated studies. Main topics tackled at first were the educational system and mobility, while after the evaluation of the most important skills needed, the impact on the quality of the educational process which offers these skills, after a potential separation of the integrated study cycle into two distinct ones was discussed.

According to the opinions expressed during these discussions [1], students seem to be satisfied with the quality and quantity of technical and scientific knowledge offered via the existing educational system. They believe it is sufficient for a future academic or professional career path. On the other hand, concerning the development of soft and self-presentation skills, most of the students feel that what they gain from university is not enough. Furthermore, the vast majority of participating students agreed that, even after their graduation, the workings of the job market still seemed elusive and obscure, leading to personal frustration and uncertainty over their future steps.

Some of the most important points that were made[1] regarded: a) the problematic curriculum b) the examination system c) the big number of new entries each year which eliminates any chance of an efficient and interactive educational procedure d) the lack of correct orientation and information flow to the students about the culture of mobility and the opportunities it bears and e) the bureaucracy which prevents many students from applying for Erasmus+ programs because of the difficulty in acknowledging subjects between the host and home (Greek) university.

In conclusion, despite the fact that students numbered many advantages of the existing educational system (5 years integrated), in their opinion, a two-cycle educational system seems more desirable and appropriate in order to comply with the European mobility culture. As a result, we conclude that the current affairs of the existing educational system should undergo sensible yet substantial changes, leading to a new paradigm that could offer reconciliation among the integrated and the multi-cycle educational systems.

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Student and industry involvement in quality assurance

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Over the last few decades, university education has adopted many methods and models from the business environment when it comes to quality assurance. Several factors contributed to this evolution: the growing independence of universities by decreasing state funding, students that act more and more as 'clients' of the Higher Education Institutes (HEI) and the competitive climate that HEI enter in a globalized society.
An essential factor in total quality management, a business model that is being integrated in most HEI's, is the involvement of stakeholders in quality assurance. The educational developers of the Faculty of Engineering Science at the KU Leuven identified the three main stakeholders (excluding stakeholders employed by the HEI itself) and contemplated how these three could be integrated in the Faculty of Engineering Science's quality assurance processes.
Efforts were made to strengthen the bond between the Faculty and its stakeholders, on which we will report and share good practices. The three main stakeholders are Faculty's students, the industry and, forming a bridge between the two, the Faculty's alumni. We are aware that many other stakeholders exist, but we will be focusing on these three groups. At the KU Leuven, students are already involved in quality assurance, both at university, faculty and programme level. However, they can only participate indirectly through elected representatives.
The Faculty wished to receive direct input from a large number of students and conducted a large scale KONDOR survey [1] (translates into Quality system concerning Education Development and Realization) that was developed by the KU Leuven. This is a concise questionnaire concerning (among other topics) quality of education, transparency of information and international opportunities.
Representatives of national and international industry were already involved in an advisory role at university and faculty level, but not at programme level. Only the Chemical Engineering programme had an Industrial Advisory Board (IAB), where captains of industry were invited to reflect on the curriculum and learning outcomes of the bachelor and master of Chemical Engineering. The Faculty decided to encourage the establishment of an IAB in every programme. The educational developers devised a scenario to facilitate the first meeting of the IAB's.
Lastly, the Faculty reached out to its alumni. A large survey was set up in cooperation with the university's central services and results and experiences will be presented at the SEFI conference.

By strengthening the ties with three important stakeholder groups, the Faculty of Engineering Sciences at the KU Leuven hopes to improve its quality assurance and evolve towards a thorough system of total quality management.

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CHAPTER 10

Industry and Engineering Education

FIRE: Education program in Refractory Engineering

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Abstract

FIRE: *Federation International of Refractories Research and Education* is a network of ten institutions, located in Austria, Brazil, China, France, Germany, Japan and United States of America, offering coordinated programs of excellence in Refractory Engineering Education and conducting international Research Programs.

FIRE is also offering *Ad Hoc* education programs upon request, and organizing periodically seminars and colloquiums on advances in refractory research. FIRE's goal is to stimulate and reinforce the higher education system in high temperature (refractory ceramics) materials engineering in order to fulfill the cultural educational and research related needs of the Refractory Industry. The activities within the - FIRE are briefly reviewed to show how cooperation and competition can be merged together for the benefit of all: the engineering education and the refractory industry.

Suggestions on how to develop more educationally effective and more seducing programs (M.Sc and Ph.D) are being made.

The Unspent Resource - Industrial Adjunct Professors as a Potential Source for Developing Engineering Curricula

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Mobility in the form of people moving between academia and surrounding society is one of the most direct and supposedly effective forms of knowledge transfer. Mobility in terms of adjunct faculty from industry is often used by higher education institutions (HEIs) as a means to strengthen research and research education. More seldom are adjunct faculty members used in the development of the curricula of bachelor and master level programmes even though companies collaborating with universities claim that one of the main reasons to collaborate is the connection with education and thus the competence of the future.

The main reason to introduce adjunct professors in the higher education system in Sweden in the mid 70's was to increase resources in research education. This new resource was, and still is, funded by the company where the adjunct professor has his employment. However, the expectations from key stakeholders; the university, the company and the adjunct professor have never been under scope. Furthermore, the actual balance between research and education and the overall work-load situation for adjunct professors has never before been investigated.

In this paper, the situation for adjunct professors has been studied at two HEIs with the purpose to investigate their balance of work, their interests and their possible intention to change the balance to more education at bachelor and master level. In addition, the stakeholders, i.e. the "parent" companies and the two HEIs were asked the same questions. Data from 31 interviews have been used in the study. The analysis is building on previous research in e.g. knowledge transfer [e.g.1], entrepreneurial universities [e.g. 3], collaboration in higher education [4], academic drift [5] and from policy reports. The results show that both industry and adjunct professors have an interest in education at bachelor and master levels.
The bottleneck is, as always, lack of time as the adjunct professors normally only spend one day a week at the university. Furthermore, the HEIs have other expectations, such as research and even research funding from the adjunct professor and his/her company. The adjunct professors represent a resource which is expended but perhaps not expediently spent due to stakeholders' different expectations.

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The Main Mode Analysis of University-Enterprise Cooperation on Engineering Education

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Abstract
University-enterprise cooperation to carry out the engineering education is the key to successfully cultivate engineering talents, the design and selection of university-enterprise cooperation mode are directly related to the effectively cooperation of university-enterprise. Based on the author's in-depth analysis and research of university-enterprise cooperation practice, this paper induces the eight types of university-enterprise cooperation mode: systematic and comprehensive cooperation mode; modular cooperation mode; project-based cooperation mode; ordering cooperation mode; cooperation mode of substitution internship; cooperation mode of learning and working alternation; multi major joint cooperation mode; and course replacement cooperation mode. For each of above modes, the paper gives the clearly definition, specific analysis and evaluation of the features and application condition, including advantages and disadvantages, etc. and points out the problems needed attention when adopting a mode, in order to provide the useful suggestions and reference for higher education institutions to carry out university-enterprise cooperation.

Keywords: engineering education; university-enterprise cooperation; cooperation mode

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Stimulating feedback conversations: design and evaluation of a feedback tool in Industrial Design Education.

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Feedback is a crucial way to facilitate students' development as independent learners
[1]. Accordingly, students of the department of Industrial Design at the Eindhoven University of Technology (TU/e) frequently receive written feedback from their teachers, i.e., lecturers of Bachelor and Master learning activities. Despite the potential power of feedback [2,3] educational scientists, policy makers, teachers and students have (shared) concerns regarding the perceived lack of impact of written feedback on practice [3]. At the department of Industrial Design, from the Technical University of Eindhoven, these concerns were recognized. Against this background, this paper is written. First, we will describe how a study of a large database of written university teacher feedback in the department of Industrial Design (university level) led to a new feedback tool based on a new conceptual framework for feedback. Second, we will describe how the feedback tool was implemented and adopted in practice. Thirdly, we derive implications from the implementation of the tool and present a scenario for a redesign of the current feedback tool. In the close future, the newly redesigned tool will be used actively in Industrial Design education, also for the purpose of further investigating how the quality of written feedback evolves and redesigning educational processes around feedback tools.

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Avoiding the traps: seeking for good practices and trends for future Industrial Design Education

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Higher education in the field of Industrial Design as an engineering discipline is one of the most promising drivers of 21st century skills such as constructively dealing with uncertainty and open challenges, self-directed learning, action and reflection, inter-disciplinary communication and teamwork, creativity, problem-solving and design thinking. Current education programs in this field invest in the holistic development of future designers by means of resource-intensive coaching and mentoring activities aligned with and tailored to the personality and needs of the student. However, such an approach is costly and will become less feasible in the upcoming years given less financing per student. Against this background, the Department of Industrial Design of Eindhoven University of Technology has started a large project that aims at proactively approaching an educational transformation towards taking the best of the current approach, innovating it based on educational trends and best practices and offering it without overhead to growing numbers of students. In short, the overarching research question of this large project is, how to shift and transform higher education in Industrial Design. This paper reports on the first phase of the large project and aims to: (1) describe the intended characteristics of a self-directed and competence centered educational program for Industrial Designers; (2) determine the strong and weak points of such an educational program; (3) derive promising insights, trends and developments from the educational literature for distinctive, innovative and feasible/realistic educational programs for Industrial Design Education; and (4) describe which innovative and potentially useful educational concepts exist in the global design education. To determine the characteristics of a self-directed and competence educational program we researched relevant policy documents, consulted the educational guides and reviewed the articles consulted in the policy documents. To establish how the educational programs were implemented and experienced we reviewed evaluation questionnaires completed by students from the last two years, explored videotaped material from the education day in which the educational staff of the educational programs discussed important topics related to the quality of the program, studied portfolio's written by teachers to receive their teaching qualification and use the results of the accreditation committee.
Next, we analyzed the results and determined the strong and weak points of the educational program from comparing the intended, implemented and experienced perspectives on the educational program.
Then, we reviewed the literature to find trends or hints for arranging our educational program.
Following, we compared and analyzed useful educational concepts in the global design education. In the paper, all the findings are combined, and several future scenario's for our educational program are described.

CHAPTER 11

Entrepreneurship and Engineering Education

Formal and Hidden Curricula of Ethics in Engineering Education

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In recent years, a commitment to professional ethics and professional responsibility has been included among the learning outcomes required of engineering education programmes in many counties [1, 2]. So, how should engineering ethics be taught? There is evidence - both within engineering education and more widely - that discussing dilemmas in formal education does lead to increases in measured moral reasoning ability [3, 4, 1]. It has also been argued that ethical issues should not be taught as if they are only the individual responsibility of a particular engineer, but should rather be understood as embedded in a broader social and political context within which engineering decisions are taken. This may require more than the introduction of ethics courses; instead, it may require rethinking engineering education [5].

The 'hidden curriculum' concept may be useful in this context. It suggests that, alongside the 'formal curriculum', students also learn some things implicitly through the social and organizational nature of their studies. Hence, discussion of dilemmas that do not have a single clear resolution can seem to students to be out of synch with the culture of engineering education which is often focused on narrowly technical solutions [6]. Similarly, if assessment is highly competitive and individualistic, students may, implicitly, become more self-serving in their decision making. In such contexts, courses addressing ethical issues may be swimming against the cultural tide of the programme as a whole.

This paper explores the role of the hidden curriculum in engineering education, drawing on quantitative data from a very large study of moral reasoning among engineering students (almost 1,000 participants with longitudinal test data at two time periods). The study also uses an innovative measure of moral reasoning (the Engineering and Science Issues Test) [7], which was translated and used in a French language context for the first time.

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Entrepreneurship and gender in higher engineering education in Germany

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In the past years European economic and employment policies increasingly underline the strategically important role of higher education institutions (HEIs) in boosting Europe's innovation potential through supplying highly skilled labour[1, for references see additional document]. Two key priorities are particularly emphasized: The first is to embed entrepreneurship into higher education curricula in order to further develop the knowledge triangle that integrates education, research, and innovation with each other [2].This particularly counts for applied disciplines such as engineering [3]. The second priority is to enforce gender equality in labour force participation and increaserepresentation of women in skilled employment [4]- which is again most evident in engineering - by incorporating gender issues in teaching plans and creating more awareness for gender balance in labor markets [5].These objectives have subsequently been incorporated into national and regional policies. In Germany, funding for knowledge and technology transfer for economic and societal applications is already a central instrument in policy strategies of federal and state level ministries of education and science [6,7].

The question now is in how far these policies are already put into practice at universities in Germany. Curricula documents can serve as a database for a first-hand insight, which bases on the assumption that if entrepreneurship and gender is taught at the universities it must be visible in these documents.Hence, this research brings together entrepreneurial and gender research with research on higher engineering education. The connected research questions are the following: In how far is entrepreneurship and gender manifested in curricula of selected German technical universities? How and by whom are these topics taught? The methodology for this research is mainly based on content analysis. Therefore the mechanical engineering curricula for bachelor and master level from nine leading German technical universities (TU 9) were analyzed (for this abstract a focus was put on TU Munich, RWTH Aachen and TU Berlin).

First findings show that entrepreneurship is represented in all of the curricula, even ifthe way how it is represented differs significantly. On the one hand there can be found educational modules that fully address entrepreneurship. On the other hand there are quite a number of modules that tackle the topic of innovation only in one or two parts of the full course. Comparing these result with the results on the gender topic is pretty disappointing. Only in one of the curricula there could be found one course that had the term gender in its description and teaches gender sensitivity. For the full paper this research will be broadened to all TU 9 universities and more detailed results will be explained. Moreover it will be examined how in terms of teaching methods entrepreneurship and innovation as well as gender and diversity are taught in present engineering education practice.

Development of the entrepreneurship education in Universities of Applied Sciences

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To achieve working places and incomes to a nation it is necessary to have new businesses and especially people who create them. Normally the engineers are employed by big companies. Because they are not crowing and creating new jobs as before, it is essential to create new setups. In the beginning of the career of an engineer the main task is to develop products and to pursue innovations. To achieve an innovation the product has to be produced and after that sold and delivered to the market. This is the reason why entrepreneurial thinking and ability to create new businesses are needed. An important role of the universities of applied sciences is to provide engineering students with convenient knowledge and skills[1]. It has been found that the students who have participated entrepreneurial courses are more positive towards entrepreneurship in the future [2]. The key role is to find, encourage and teach suitable engineering students to become entrepreneurs. Traditionally the entrepreneurial skills have been taught by business or management schools. Nowadays however, it is becoming more common that the engineering universities are attaching the entrepreneurial courses in the curricula like economics and management. [3]

The purpose of this research isto investigate if the engineering students of Oulu University of Applied Sciences are interested in creating own company or learning entrepreneurial skills and the reasons why they want it and why not. Interesting matter to find out is how the entrepreneurship attitude is developing during the four years studies and why. The role of the curriculum, teachers and the objects of the university will be analyzed concerning the elements which develop and activate entrepreneurial readiness. A good source to evaluate the influence of the education of a university are graduated engineers who are working in the companies and part of them are running their own business and thus having strong perspective to the efficiency of the university concerning the entrepreneurship.

In the research will be discussed the remedies to achieve a better attitude of students towards the entrepreneurship. The findings can be used as a base for curriculum development and education methods in bachelor and master education for engineers. The research is a continuation of the international innovation project realized with Fontys University of Applied Sciences and reported in the year 2014.

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Codesigned and coconstructed leadership training of engineers

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This article describes a new leadership training in an engineering school that is based on reflexivity and action. This leadership activity is a new training module dedicated to the final year students of the school (European master degree).
The purpose of this training module is to discuss with students the questions and issues related to team management, leadership and evaluation, with the aim to learn how to manage these collective situations. Indeed, leadership training is difficult to implement. Teachers often make use of case studies to illustrate the best practices. However, leadership is action, a praxis that is mainly learned through the reality test: the experience of others, then our own. [Lapierre, 2006].

Therefore, we have chosen to support a student experience to embody a leadership training, which provides an opportunity to develop the necessary organizational and practical skills of a leader. During four days, the students switch between the university and a military compound where they operate for two days and one night, living a survival experience. Outside of these situations, students are also mandated to build the evaluation process, in collaboration with the teachers. In the first part of the paper, the context and the main objectives of this training session are detailed. In a second part, we give details about the practical organization. Then, we focus on the tools we used to co-construct the evaluation process.

Finally, the data produced are analyzed using linguistic analysis software to identify the students' perception of the role of a leader and of a team member: what are the main behaviours and attitudes they point out to reach the objectives of the missions. We draw perspectives to improve the training, our data collection and analysis methods.

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The Colibri Project: Overcoming diversity in blended e-learning activity preparation.

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Colibri is a three year project co-funded by the Erasmus + Strategic Partnership, starting in 2014. The project is being carried out by seven academic and three industrial partners from a total of eight different countries. The main objective of the project is enhancing the quality and relevance of the learning offer in education by developing new and innovative approaches, and by supporting the dissemination of best practices. This is in the focus of increasing labour market relevance of learning provision and qualifications and promoting the take-up of innovative practices in education by supporting personalised learning approaches, collaborative learning, by making use of ICT and Open Educational Resources, and by exploring the use of blended and virtual mobility.
The overall idea of Colibri is to implement new and innovative teaching methods, and to establish a Living Lab of students from different universities, study directions and countries/cultures for a systematic testing and evaluation. An interdisciplinary joint master course on *Future Internet Opportunities* is part of the Living Lab, followed by 28 students from the partner institutions and given by more than 10 different teachers. Both the teachers and the students represent different fields within computer science, electrical engineering, telecommunications, business informatics, management of technology, management of innovation and entrepreneurship.

When organizing the course, we needed to face some of the fundamental challenges of diversity that are also being seen, at a smaller scale, in everyday teaching situations due to student mobility and increasing amount of students:
Not all students in the class have the same academic background
Students come with different learning styles and traditions
We try to overcome this challenge by using of self-assessments activities, Personalized IT supported teaching approaches so students can choose different ways of learning, and by practicing collaborative learning even across physical locations.
This paper presents the process followed when the course. Complex (but unnegotiable) matters had to be carefully considered when structuring and preparing it, such as remote student group work, blended mobility, or interdisciplinarity.
The ideas described in this paper may serve as guidelines when preparing similar activities in the future.

CHAPTER 12

The Importance of Internships

Supervised internship data evolution, due to the internationalization of engineering courses process

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This paper analyzes the changing between 2006 and 2014 of supervised internship course data in the Department of Mechanical Engineering at Polytechnic School of USP, and the main impacts caused due to the internationalization of engineering courses process, mainly through programs that allow double graduation – in Brazil and in a second country – and the internship in companies abroad [1, 2], giving the students the opportunity of acquiring various technical and organizational knowledge [3]. However, depending on the company profile, this learning, may possibly not represent a trend of globalization, but just a different culture besides Brazilian [4] or, in other cases, the company is a global company with similar patterns as in Brazil, and contribution is much more cultural and a second language contact.

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Professional Formation of Engineers: Enhancing the First Year Student Experience

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While misconceptions and stereotypes about engineering make it more difficult to attract students to engineering education, there is also evidence that many students in engineering education are not familiar with different career choices. At the same time accredited engineering study programmes require that graduates demonstrate achievement in specific competencies and characteristics, however many engineering graduates enter the workforce ill-equipped for the real-world of engineering practice.

This paper explores first year engineering students' perceptions of how technically focused courses relate to real-world engineering. Included is a description of the compilation of a portfolio of engineering practice that is used to integrate examples of engineering practice into first year student learning at the Institute of Technology Tallaght Dublin. A qualitative approach is used to explore the impact of the portfolio on students' preparation for their future profession and on their on-going engineering education. The results show that engineering education built only on technical and mathematical sciences and lacking in learning about engineering practice is impoverished. This study provides evidence for a requirement to better match engineering education with engineering practice.

Supporting students learning despite difficult workplace interactions

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Students report the opportunities for learning provided by an internship or work experience include gaining an understanding of engineering practice, developing competencies, networking, awareness of the relevance of engineering studies, awareness of possible future roles and future employers. However, these learning opportunities can be negatively affected by undesirable workplace practices such as bullying and discrimination which may be due to gender, culture, disability, sexual orientation or age. We can't protect students from these types of interactions but we can help them deal with them when they occur.

This paper describes a workshop run for undergraduate students to increase their awareness of issues often encountered by students that may result from workplace culture such as discrimination, differing expectations and stereotyping. Participants in the workshop were sensitised to the importance of visual cues in generating perceptions of people that we haven't met and the impact this has on stereotyping. Through a series of role plays participants explored how to interpret and respond to situations as they arise from their own and other student's experiences.

Participants reported that the workshop increased their capacity to recognise even subtle instances of workplace bullying and discrimination and hence increased their resolve to not participate in, support or promote such behaviour. This awareness also improved their confidence to deal with the negative behaviours themselves and support others that may be experiencing them. The results suggest that all students would benefit from incorporating a series of such workshops in professional development activities.

CHAPTER 13

Diversity in Engineering Education

AVOSTTI: a project dedicated to increase gateways between curricula

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Diversity is the key for the future of higher education. In France, the first historical attempt to reach this diversity was to open Grandes Ecoles to students others than those coming from Classes Preparatoires aux Grandes Ecoles, it was in the 70's in schools that became 40 years after to the network Polytech, at this time the decision to open one third to professional bachelors, one third to students of universities and one third to students from CPGE was considered as innovation!
Nowadays with the diversification of curricula in the secondary schools and at the university, it is necessary to understand the logic of the choices made by students concerning their orientation.

The French Government decided in the end of 2011 to allocate money to pedagogic innovations through a call for project named IDEFI (Initiatives for Excellence in Innovative Courses), the aim was, for the first time to give value to teaching and to the efforts made by institutions to innovate in this field. The Polytech Network submitted a project called
AVOSTTI (Accompanying Scientific and Technic vocations towards the title of engineer).
This project was accepted among 37 and lasts from 01/05/2012 to 31/12/2019, it includes 2 facets, one concerning French students and the other international students.
European enterprises need engineers to face complexity of technologies, however very few of the pupils actually intend to study engineering they prefer to study management, law or medicine, which it is why we need to open engineering curricula to new populations of students.

The first gateway proposed is to accompany technologic A Level students to engineering universities. The technological studies have much evolved in the past years and they have integrated sustainable development concepts, however they still have difficulties to recruit (only 30 000 students in 2010). The secondary schools authorities together with Polytech network tries to make them more attractive by proposing studies continuation after A level. That is what is proposed in AVOSTTI, there is now a specific competitive examination that allows them to integrate a path organized together by an IUT (the two first years of professional bachelor) and Polytech.

The second gateway is proposed to students first oriented towards studies in medicine. It is a pity in France but very good scientific pupils prefer to study medicine than engineering, especially girls. However the first year exam in medicine (PACES) is very selective and that is why many of them fail this examination. Polytech proposes them now a one year path to come back to an engineering orientation. Engineering studies are more and more oriented to biomedical applications, so this curricula is a really good idea.

AVOSTTI is being developing at this time, the paper will present in detail the French curricula and the path used for this program

Comparisons of Learning Styles of British and Yemeni Students in Engineering Education.

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The Institute for Manufacturing at the University of Cambridge teaches students from a wide range of countries predominantly using problem based learning methods. The methods include short term industrial assignments and classroom activities that require a high level of engagement and active participation. While there are many benefits to this system there was also a concern that the methods might disadvantage students from countries where the teaching and learning were based on more traditional lecture based techniques.

To investigate this a study was carried out to compare the preferred learning styles and culture of British and Yemeni students. These cultures were chosen both as being of interest to the authors and being thought to represent a significant cultural divide. A range of instruments were evaluated and it was decided to use the Felder-Silverman ILS to investigate learning styles and Hofstede's cultural dimensions to examine culture. Since the Felder-
Silverman ILS has been publish for a number of countries this enabled the authors to pose the following questions:

1. What are the learning style profiles of British and Yemeni engineering students
2. How do the learning styles of British and Yemeni students compare against each other
3. How do the learning styles of British and Yemeni students compare against those of other nation states
4. Can a relationship between specific cultures and specific learning styles be determined?

The results suggest that engineering students possess Active, Sensing, Visual and Sequential learning styles across all the nations investigated. This supports the idea that there exists a typical learning style profile for engineering students. These finding suggest that it may be possible to develop a standardised pedagogy for engineering education. There was however significant differences in how strongly the three of the preferences were held. The visual preference was similar across all nations possibly because of the normalising effect of teaching though PowerPoint slides and standard computer packages.

Diversity in Engineering MOOCs, a first Appraisal

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Conference Theme: Diversity in engineering education: facing new trends in engineering
Sub Theme: Diversity in engineering education and of engineering institutions
Topics: Open and distance learning – MOOCS, Engineering education research, New education tools for engineering education
Keywords: elearning,mooc. gender and diversity, engineering education

The underrepresentation of women in engineer sciences is a well-known and vastly discussed fact, hence there are quite a few concepts on how to increase the interest for engineer topics in education settings [1].

But what happens when the classroom is virtualised and students from all over the world can participate freely and open in a technical class, like it's the case in Massive Open Online Courses (MOOCs)? Why do some students succeed in these course and others drop out? And is this linked to gender or diversity factors?

The presented work searches to answer the question for gender and diversity issues in the successful participation and the drop out behaviour and reasons of MOOCs of the Delft University of Technology at its virtual campus DelftX, which is using edX, the non-profit platform for online education provided by MIT.To answer these questions, the authors cooperate in a series of online surveys, undertaken with students participating online in the engineering courses at DelftX. First analysis show that, even considering the generally low ratio of female students in engineering courses [2,3], female students show a higher drop out rate at surveyed technical MOOCs than the male. The diversity factor age seem not to influence the drop out behaviour, neither was the higher attrition rate caused by early dropout, but happened throughout the course. On the other hand, we find in all courses female students to be younger than male ones and in line with that, we see less female students in the older age groups above 34 years.These and other matters related with gender and diversity will be investigated in upcoming MOOCs at DelftX. Gender and diversity relevant aspects of engineering education have to be proven for their use in MOOCs.

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MINTivation-Motivation

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MINTivation-Motivation is a multilevel school program to promote the inclusion of girls in STEM fields (German MINT = STEM1), enhance the interest of boys in languages, social science and caring/teaching as well as to improve the achievements of boys in school. It was tested at one secondary school in Munich with a high proportion of immigrants between September 2011 to September 2014. The program was developed and realised by the City of Munich, Department of Education and Sports, Institut for Teacher Development and accompanied by the University of Augsburg.

The three main interventions are on the one hand improving the gender-competences of staff, on the other hand single sex classes (monoeducation) for a limited time in special subjects, e.g. Physics for girls and French for boys for early years teaching and furthermore the co-operation of teachers in subject working groups for several years. MINTivation-Motivation is structured in three transition free periods. First information: acquiring knowledge of gender issues, awareness rising and reflection on one´s own attitudes, convictions and habits. Second development of alternative concepts and approaches and third the implementation of the new ideas in regular lessons in school.

The direct target group of the program was the whole staff, especially the teachers of the single sex-classes and the teachers, who participated in the subject working groups, which were Math, Science, German and foreign languages. Indirectly involved were all pupils of the school, but paticularly the pupils, who were monoeducated in special topics for a limited time (minimum half a year). All parents were informed about the program. Everyone received a letter of the headmaster and the Paedagogical Institut of the City of Munich. In addition the parents of the MINTivation-Motivation classes were personally informed during parent-teacher conferences and could pose questions at any time. The reaction was very positive and the parents welcomed the program.

MINTivation-Motivation produced several positive results. For example, more than 55 % of the girls, who attended single-sex lessons in her first year in Physics in Grad 7, decided to choose the science and technology track instead of the language track in Grade 8. Only 35 % of the girls in the not-directly-treated comparison group opted for the science and technology track, which is round about 10 % more than in not-at-all-treated comparable classes. The boys in the MINTivation-Motivation classes showed higher participation and achieved better results in languages as the comparison group. The pupils and teachers, who took part in the MINTivation- Motivation program, showed improved convictions and an adjusted attitude on gender mainstreaming and gender equality topics.

Starting basis: German constitutional law and several other acts and norms postulate that equality between women and men has to be ensured by the state. The published opinion suggests that equality is already achieved, but the up-to-date figures show that we are still far away from equality. In Germany girls achieve better results in schools and universities but they choose only from a very limited range of not – technical professions mostly with low income, week reputation / image and small promotion prospects. Boys on the other hand score worse in school and do not choose caring and teaching professions. Only 2.5 per cent of the staff of kindergardens in Bavaria were male in 2014. In addition 8 per cent of the boys left school without graduation in 2012 compared to only 5 per cent of the girls. From a business perspective, Germany must expand the capacity and diversity of the STEM workforce pipeline to prepare more students for the best jobs of the future that will keep the country innovative, secure and competitive. From a perspective of human rights, Germany must ensure gender equality and counteract stereotypes in society and schools.

1 German MINT = STEM: Mathematik, Informatik, Naturwissenschaft, Technik = Science, Technology, Engineering and Math

Women role in engineering education in innovation teams in terms of scientific and gender diversification

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A knowledge-based society requires a population with a reasonable level of scientific and technical literacy, capable of becoming active citizens in decision-making processes. The role of women is critical to meet the challenges of the diffusion of engineering sciences in order to engage society in technology and the innovation to strengthen competitiveness for facing the economic crisis and to sustain development [1].

Gender equality leads to economic growth, favors competitiveness and leads to progress in economic growth and innovation. Equal women participation in all the scientific sectors & at all levels reinforces diversification, enhances European development, supports European economy, broadens the impact engineering has on society [2]. "Gendered innovations", that is the processes integrating gender issues into all phases of basic and applied research to assure excellence and quality in outcomes, promote excellence in science and engineering [3].

Diversity and gender balance are vital factors for successful science because it relies on talent, collaboration and interdisciplinary research. [4]

Along with gender diversification, interdisciplinary is considered the basis, which can lead in innovation, leading to the creation of new scientific fields and decisively in problems' solution. Interdisciplinarity in engineering education and especially in innovation teams is attractive and is considered to better satisfy the social and industrial needs of a changing society [5]. Women play a key role in innovation. They are regarded as "champions" in new interdisciplinary research and education fields and they have the potential to become champions in trans - disciplinary and sustainable innovation (economy, society, environment).

Additionally, women role is remarkable in terms of interdisciplinarity. Their presence is significant in various research science and engineering thematic fields (environment, sustainable development, quality of life, art - architecture - urban planning, cultural heritage) [2]. Scientific innovations are increasingly produced by team collaborations and team collaboration has proved to be remarkably improved by women presence, thus leading to advantages for science, education and technology. [6] In this respect, a synergy is made apparent between scientific diversification, in terms of innovation and interdisciplinarity, and gender diversification. This synergy can promote innovation in teams in engineering education.

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Long Term, interrelated interventions to increase women's participation in STEM in the Netherlands

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Traditionally, the Netherlands lag behind other countries in terms of the percentage of girls opting for Science, Technology, Engineering, Mathematics (STEM)-study programs
(Eurostat, 2009; OECD, 2003). In international research a number of determinants for the under-representation of girls/women in STEM have been appointed, including girls' lower self-concepts, non-stimulating learning environments, lack of female role models, stereotyped associations in society about girls/women and STEM, fertility/lifestyle factors, and career preferences of girls and women (e.g., [1-3]). Since the early 1980s, VHTO (www.vhto.nl, WiTEC partner), has been building up knowledge and experience about the participation of girls and women in STEM. VHTO has been deploying this expertise in the whole chain of education – from primary to higher education – through the labour market in the Netherlands.
In the course of time it has proved to be essential to commit interrelated interventions for a long period of time, instead of ad hoc or short term single actions.Implementation strategies are directed towards change in educational policy (i.e., awareness and gender inclusiveness), professional development for staff and teachers, career exploration opportunities and offering counter stereotypes (e.g., support of role models, Girls day and girls code events) at critical junctions/moments of choice in the girls' (school) careers, parents' involvement, and dissemination. Statistics show that in the course more girls (and boys) opted for STEM subjects and higher STEM education, especially in pre-university secondary schools. We will show how policies regarding the under-representation of girls and women in STEM (specifically in education) have developed over the years in the Netherlands and other countries. We will introduce a policy compass that can support institutions to choose appropriate policies and to set up an adequate action plan.

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Influence of Integrating Creative Thinking Teaching into Project-based Learning Courses to Engineering College Students

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In Taiwan, teachers of engineering colleges mostly focus on the innovation and breakthrough of engineering technologies that makes students possibly are limited to the system functionality and integrity. In other words, because of the lack of creative thinking developing and training, students tend to be limited in their creativity when they are doing their homework. However, as the matures of engineering technologies, engineering is transformed to the creative applications of scientific theories that often as unique creations to herald their existence, thus creativity is thought of as the innate character of engineering in future [1-3].

Accordingly, many research approaches have been arisen that aim to enhance creativity in engineering education, such as Project-Based Learning (PBL) that is often adopted for problem solving, self-learning, and leadership skill. The main concept of PBL is that capturing students' interest via the illustration of real world problems, then arise students thinking of applying new knowledge in order to solve the problems [4-6]. This study focuses on integrating creative thinking teaching into PBL courses. In order to push the students in the course can inspire their imagination and creativity effectively, the five stages of project-based teaching period is adopted. Students' creativity analysis was conducted and the results indicated: 1) students significantly enhanced their intrinsic motivation and thinking relationship of self-learning; 2) the evaluation results and teacher assessment results were without significant differences, indicating that approach of integrating creative thinking teaching into project-based learning courses could be perceived as a valid teaching method; 3) the feedback of student learning process and the score of expert creative assessment were highly consistent.

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Cross Institutional Comparison of Curricular Change in Dutch Engineering Bachelor Programmes

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The three Universities of technology of Twente (UT), Eindhoven (TU/e) and Delft (TUD) in the Netherlands each initiated major bachelor programme innovations between 2011 and 2014. The need for shorter study duration, higher pass rates, and lower dropout rates were reasons to instigate these innovations. In addition, at leasttwo of the technical Universities were losing market share. Finally, the programs were not yet adequately geared towards the big challenges of the future and the engineering skills the students needed for this.
This contribution reports on a research project conducted by the 3TU Centre for Engineering Education (CEE). One of the aims of the researchis to findeffective components. The results reported in this project focus at the Intended curriculum (Van den Akker, 2003), the leadership and (organization) process used to implement the bachelor curriculum innovation and the drivers of change leading the institution into a major change process (Graham, 2014).
The leading research questionin this research is “In what way did the three technical universities realise the bachelor curriculum innovation objectives?” Drivers of change, the innovation process and characteristics of the intended curriculum were special areas of interest.

Results suggestthat the drivers for change have implications for the extent to which staff and students are involved in the change process and /or to what extent the studentneeds as a client are leading in determining the nature of the change. Furthermore, the characteristics of the change process are a set of heuristic moves to come to the desired results. In this paper we will share the process and its’ impact on the objectives on the basis of the criteria for sustainable change by Ruth Graham. Finally, we will show that some of the elements of the intended curriculumcontradict between the 3 Universities, whilst theyhad the same goal in mind.

The practical relevance is scaling mutual problems and professionalization through diverse approaches and input of the 3TU Federationtacit knowledge. Naturally, there are many implications of this study we will discuss during the presentation

Key words: Curriculum Development, Engineering Education
Key Theme: Diversity in engineering education and of engineering institutions

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Intercultural aspects in PhD supervision

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Abstract

A PhD is generally considered to be the final academic exam. Traditionally the doctor's degree signifies that the candidate has demonstrated the ability to conduct original research independently. The supervisor used to have the task of safeguarding the academic standard rather than that of a coach training the young researchers to become a legitimate researcher. Over the past decades the conditions for PhD supervision at the European Universities changed dramatically. Within the context of the Bologna process of harmonization of higher education in Europe PhD studies are identified as the third phase. As a consequence of budgetary constraints productivity becomes more of an issue and many universities choose to organise the PhD studies in the form of a doctoral school (1). The role of PhD supervisor has become more demanding and more complex. At the same time we observe an increase of international PhD students.
In general, international PhD students have to make an extra effort to adapt to the academic culture. In addition, international PhD students from a non-western background often face difficulties as they try to adjust to a more individualized and self-directed learning environment (2). How the transition process for these international PhD students proceeds is a result of their challenges when they arrive, the influence of the supervisor and the influence of the institutional set up (3). International students generally need a trustful and guiding relationship with a supervisor, who supports among other things critical thinking and reflexivity, at the same time structuring the initial process and setting goals together with the PhD student.

Building on earlier studies (1, 3) this paper proposes to come up with a systematic approach to the supervision of international PhD students. From a theoretical perspective the paper will discuss the Hofstede model including critiques, like: Ryan, Grant, Manathunga and others.

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Why and how to engage students in the learning process

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Following educational standards and stakeholders requirements, universities define a set of core professional competencies and transferable skills which a graduate should have upon graduation from the engineering educational program. However, formulating a set of core competencies is only the first step that does not guarantee successful achievement of program learning outcomes by graduates. Success of the high quality professional training, in accordance with the principles of outcome based approach, largely depends on the choice of learning and teaching methods. The program should ensure the active participation of students in the training process and provide them all tools to become competent professionals able to solve real engineering problems.

It is important that program leaders pay particular attention to the content of the courses as well as to the forms of educational activities. The main characteristics of engineering educational programs should include learning outcomes meeting the needs of all stakeholders, interdisciplinary content, modular and student-oriented in structure with possibility to follow individual curricula.

This article discusses the requirements and methods of teaching / learning in engineering high school that promote student involvement in the learning process. A comparative analysis of traditional and active learning methods. An illustrative example proving the importance of active learning in training of engineers is provided in the CDIO Standards [1], where students' engagement becomes critically important.

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Diversifying a Car Body Development Course by Integrating Gender Studies Expertise.

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The pilot scheme "GenderING" (ING refers to the German term *Ingenieurswissenschaften*=engineering sciences), located at the Technische Universität Braunschweig, Germany, brings together two very different academic disciplines – Gender Studies and Mechanical Engineering. The aim of the project is to integrate gender and diversity aspects exemplarily in the course "Introduction to Car Body Development". For doing this, we reevaluate existing lecture material and enrich it by confronting the material with gender studies knowledge and methodology. Such a shift in the content of engineering courses requires a didactical reconceptualization based on research-oriented and problem-based learning. In the project, we understand gender studies as a means for reflection. Gender studies focus on in- and exclusions and on marginalized positions. Thus, they help to make formerly invisible or neglected topics visible. Furthermore, the discipline questions hierarchies and power structures and emphasizes the diversity of people, situations and context.

To date, interdisciplinary bridges between engineering knowledge and gender studies have been barely built. Gender and diversity still are underestimated topics in engineering research and development, and in engineering education. Historical examples, such as the development of crash test dummies that were originally standardized to male and non-pregnant bodies, demonstrate that one-dimensional or stereotypical assumptions about target groups can lead to dangers for users, problems of acceptance or economic failures. Empirical studies show that a social and historical contextualization of technical knowledge improves technological products.

"GenderING" aims to show that engineering students, as well as lecturers, can benefit from their encounter with gender studies. They, for instance, learn to contextualize their knowledge; take different perspectives on topics; seek and find alternative technological solutions; connect engineering with the social world throughout all stages of production. In addition to this, Gender Studies prepares young people for a globalized and diversified work environment.

The outcome of this research project will serve as a best practice case for other areas in engineering education. Consequently, a widespread dissemination and dialog with the research community is pursued.

Getting round pegs into round holes: getting students onto the right Engineering Programme.

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Aston University offers a Foundation year in Engineering and Applied Science. The purpose of this programme is to prepare people with the necessary skills and knowledge required to enrol on an undergraduate programme in Engineering and Applied Science.
It is acknowledged there are many misconceptions as to what engineering is. This is further compounded by the lack of knowledge of the different engineering disciplines both by pre-university students and careers teachers [1]. In order to ameliorate this lack of knowledge, Aston University offers a unique programme where students are given the opportunity to have a 'taste' of four Engineering Disciplines: Mechanical Engineering, Electrical Engineering, Chemical Engineering and Computer Science. Alongside these 'taster' sessions, the students study a Professional Skills module where they are expected to keep a portfolio of skills. In their portfolios they comment on their strengths and weakness in relation to six skill areas: independent enquirer, self-manager, effective participator, creative thinker, reflective learner and team worker. The portfolio gives them the opportunity to perform a self-skills audit and identify areas where they have strengths and areas which require work to improve to become a competent professional engineer. They also have talks from engineers who discuss with them their careers and the different aspects of engineering.

The purpose of the 'taster' sessions, portfolio and the talks are to encourage the students to critically examine their career aspirations and choose an engineering undergraduate programme which best suits their ambitions and potential skills.
The feedback from students has been very positive. The 'taster' sessions have enabled them to make an informed choice as to the undergraduate programme they would like to study. The programme has given them the technical skills and knowledge to enrol on an undergraduate programme and also the skills and knowledge to be a successful learner.

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Cross Cultural Diversity in Engineering Students in America and Europe

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In this global world, today's engineer is likely to have to work in global international teams with colleagues from other nationalities. The challenge for many engineering curricula is how to include, in a realistic way, this global dimension and increase the student's awareness of the cultural issues that are encountered. In the Purdue University engineering technology program, an international industry sponsored, multidisciplinary capstone project was created to change attitudes and increase awareness of the challenges engineers will face in global projects. In the international project, half of the team members are students from a non-US university. The full team works on a project proposed by companies with a global footprint in both the U.S. and in proximity to the foreign institution. This global project is carried out using normal internet tools such as email, skype, and blogs. In addition two exchange trips are made with team members traveling to their opposite foreign location. Ideally the first trip occurs near the initiation of the project for planning, organizing and conceptualization. Two projects are underway presently in Germany and Poland with expansion of the program to include France, Finland and Russia in coming years.
In order to assess whether this approach can increase awareness in global cultures, a study was done to determine the existing differences in attitudes among the students of the participating countries. The MGUDS-S cross cultural diversity survey was used to measure what the initial differences might be [1]. This data is used then to develop pedagogical strategies to expand global awareness and ease the execution of multidisciplinary projects.
Data using the MGUDS-S survey was collected from several populations:

- the senior engineering technology capstone class (109) at Purdue University
- the third year electrical engineering class (42) at Leibniz University of Hannover
- the third year mechanical engineering class (117) at Gdansk University of Technology
- final year engineering students in Tambov State Technical University, Russia,
- final year international business students in Northern Arctic Federal University, Russia

When viewed as a whole population, it appears that this generation of students are generally not interested in engaging in cross cultural behavior such festivals, dance, and music. In addition this generation does not appear to appreciate the benefits that can be derived from engaging with other cultures. Despite this lack of interest and appreciation, this generation of students is emotionally comfortable with different cultures. There are other differences between American, German, Polish, Finnish and Russian students discussed in the paper.
While the impact of this study is still being evaluated, pedagogical approaches have been created that address these issues and prepare new engineers to perform well in global teams.

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Diversity in Engineering Education:
Good or Evil for International Programmes?

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"Diversity" versus "Internationalization": Are these synonyms, even supplementing each other – so take it – or are they potentiating each other with their dark sides, so better leave it?

From 16 years of experiences in developing international study programs, authors offer arguments for deciding for one of these conflicting hypotheses. Pros and cons are given for implementing most efficient international programs fitting to the special needs of an institution of higher education (IHO).

First extreme scenario (very common for Master and PhD): IHO is offering quite narrow programs in specific fields in order to attract "best" candidates, supporting a preferred area of research or projects - but limiting diversity and avoiding to invest much for a broad international spectrum. In such cases, Bachelor degree courses are not considered, as they require high investments, implicate risks like high number of dropouts and reputation is low.

Second extreme scenario: Study programme, which are vertically and/or horizontally broad by dimensions. Here, a vertical structure means a chain of consecutive levels of higher education, e.g. from Bachelor to PhD; the horizontal dimension is describing the bandwidth of subjects offered.

The horizontal dimension contributes mainly to the attractiveness for (many) new students: they have better choices of degree course to enter and also to change later from the originally chosen one to another, matching better with personal interests.

The vertical dimension offers quiet different benefits, but also problems: The interfaces between two neighbouring educational phases do not only act as a hurdle for students to progress to the next higher level at their institution, they also act as additional entry points for students from outside. So the higher vertical range of the scenario is, the more levels of educational phases we get and also more entry points of quite different levels of qualification.

Here, Bachelor degree courses are basis for entire educational chain; they create diversity, in nationalities, heterogeneity of pre-educations **Own experiences** show that second scenario results in a very versatile student population, enriching the international flavour. A high vertical dimension causes a "chimney" effect: students who entered at a low level of education are encouraged by good results to enter the next level; some others will decide to leave for a career elsewhere, but are replaced by new freshman on the next higher level. This can lead to higher satisfaction with graduates on all levels, also avoiding a dry-out of student populations on higher levels.

Attractive spin-offs can be derived from broad international degree courses: Together with international partners, matches between own and partner´s curriculum can be arranged, offering a double degree program, based on matching curricula. And as spin-off on second level, exchange programmes can be set up, exploiting the matching curricula of double degrees. By this, bets values is derived from an international program, with highest diversities of students and educational offers.

The full paper will give more numbers and figures for the different scenarios described above.

CHAPTER 14

Gender in Engineering Education

Teaching research-based gender competencies in STEM: The study program GENDER PRO MINT, TU Berlin

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Gender Studies understand [gender] as a historically developed construct. As such [gender] structures social, cultural, linguistic, technological, representative, communicative and natural realities as well as scientific knowledge and practice. [Gender] is itself structured by knowledge as well as social, cultural and technical practices. The Center for Interdisciplinary Women's and Gender Studies (ZIFG) at the Technical University Berlin (TU Berlin) pursues these questions in research and teaching and develops interfaces to convey this state of the art for a multiplicity of disciplines, research projects and activities.

In this paper the newly established and innovative study program GENDER PRO MINT will be presented. [1] This study program at the TU Berlin is a target specific program to train students in gender competencies in science, technology, engineering and mathematics. These gender competencies include comprehensive and field-specific gender competencies as well as reflexive and creative gender competencies. Gender skills include knowledge of gender theories and focuses on gender studies approaches in the STEM field in question as well as on Science & Technology Studies (STS). In particular, the ability to transfer these approaches to a study project or qualifying thesis in a STEM field is being conveyed aiming at the implementation of gender studies perspectives in science and technology. The teaching approach of the study program GENDER PRO MINT draws on research-based instruction of gender and diversity studies. In this way gender and diversity competencies are related to both current research results of gender studies as well as to present research and development in science and engineering.

The process of carrying out a study project can be distinguished into three overlapping phases: Firstly, an in depth understanding of the assigned task needs to be acquired concerning its concepts, theories, methodology and prospected results. Secondly, acquired gender studies competencies in GENDER PRO MINT allow students to analyze how the assigned task at hand is 'gendered' with regard to its concepts, prospected results, applications and uses. During this second phase of carrying out the study project a range of approaches in gender studies in science and technology are being discussed and explored. Thirdly, perspectives of gender as well as diversity studies in science and technology are being integrated into the project. Through re-shaping the initial task assigned in a STEM field the participating students learn how to develop analyses of [gender] in STEM. In order to illustrate this inquiry-based teaching concept in GENDER PRO MINT examples of study projects in engineering, physics, planning and computer sciences will be given. Study projects of students of the study program GENDER PRO MINT convey possible transformations of both gender and diversity studies and STEM fields as possible outcomes of study projects.

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Gender performance in an Aerospace Engineering Maths subject with innovative pedagogical approach

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Traditionally there are degrees in Spain in which there is a greater demand for students of a particular sex. For example, there are more female students in careers related to Health Sciences, Social, Law, Humanities and Arts (Nursing, Medicine, Psychology, Teaching, Fine Arts...). On the other hand, most engineering programs look more appealing to male students. One of the main reasons for this choice is due to stereotypes about what a man or a woman can make, which as all stereotypes need not be true, they have been inculcated in society. Gender stereotypes exert a strong pressure among adolescents, which can determine the choice of one or another university career.

Bachelor's Degree in Aerospace Engineering delivered at the School of Design Engineering ETSID in the Technical University of Valencia UPV, is one of the degrees in which the enrollment of female students is lower than male students. Freshmen of Aerospace Engineering have to perform the following compulsory subjects: Business Studies, Chemistry, Computer Science, Materials Science, Mathematics I, Physics and Technical Drawing.
Mathematics I is a first year annual subject of 12 credits (9 credits of theory/problems and 3 credits of laboratory practice). The contents of the course are calculus and algebra. The CAS used in laboratory practices is Mathematica. An innovative pedagogical approach is followed in both, theory/problems classes and laboratory practices.
In this paper we analyze gender performance of Mathematics I in each of the different blocks: Algebra, Calculus and laboratory practices.

Workshop Forcing Quality and Sustainability in Gender and Diversity

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Conference Theme: Diversity in engineering education: facing new trends in engineering
Sub Theme: Gender in engineering education and of engineering institutions
Topics: Quality assurance engineering education, Sustainability of engineering education

Keywords: workshop, quality and sustainability, gender and diversity
In many public debates the question is coming up more often how effective and sustainable gender initiatives in STEMsector are1. Due to shortage of skilled workers especially in technical professions, demographic change, growing interest in "mixedteams" and not at least the challenge of equal opportunities for women and men, more and more schools, universities and companies have taken measures promoting women in STEM professions. A lot of resources and actors from many different areas (e.g. principals, subject teachers, scientists, women's and equal opportunity commissioners) are involved in planning and implementing projects and policies. However, most of these measures are terminated after the project funding.

Analyzing quality and sustainability of gender measures are often neglected so farby project managers. This doesn´t happen because of missing sensitivity for this question, but quite often because of the missing skills of local actors performing such analysis and interpreting results. All parties are aware that quality assurance and quality enhancement of individual measures and overall offerings would mainly be ensured by effectiveness and sustainability analysis. Thus the need for instruments of quality assurance is great ensuring long-term success. The department of Gender Studies in Science and Engineering has developed a training concept2to teach actors of equality measures performing efficacy and sustainability analysis in STEM motivation projects. The concept was tested and evaluated with actors from various Fields in summer 2014.The aim of this paper is to present these minar concept and the methodical toolbox that has been prepared together with the participants improving the continuous Development of services and activities in the different organizations.
The concept includes instructions for identifying meaningful measurement indicators, gender sensitive collection and analysis of data, interpretation of results and the evaluation of quantitative and qualitative measures and supply effects in relation to the objectives involved.

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http://www.nationalesmintforum.de/fileadmin/user_upload/gerke/NMF/Empfehlungspapier_final_Webversion.pdf(German only)

2 Handreichung zum Seminar: Wirksamkeits- und Nachhaltigkeitsanalysen von MINT Motivationsprojekten aus der Genderperspektive (2014):
http://www.gender.edu.tum.de/tl_files/TUM_GSI/Handreichung%20GSing%20final.pdf (German only)

Professors' Perceptions of How Men and Women Students Experience Engineering Education Differently…Or Not

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Despite over thirty years of research and outreach to recruit and retain female engineering students, women remain significantly underrepresented in engineering. One defining characteristic of prior research and outreach efforts aimed at addressing underrepresentation is that they focus on students. Progress in diversity research now requires new research approaches that focus on faculty, rather than students. Faculty pedagogy and interactions have been shown to play a significant role in students' decisions to leave STEM majors, and female students in particular report experiencing negative classroom interactions. However, no research has been done to characterize what and how a large group of engineering faculty members thinks about gender in engineering education. There is a critical need to identify what and how faculty members think about gender so that effective interventions can be designed to target those ways of thinking, and, ultimately, increase gender equity in engineering education.

This paper begins to addresses that gap in research by presenting findings on how a group of 37 engineering professors from three different institutions in the United States discuss differences in men's and women's experiences in engineering programs. The semi-structured interviews were conducted in the Fall of 2014. The central questions addressed in this analysis are:

- Do engineering professors think men and women experience engineering education differently?
- What do engineering professors think are the most salient differences in the experiences men and women students have in their engineering programs?

The paper will discuss the results in relation to prior literature on students' experiences in engineering education, identify gaps in knowledge, and discuss implications for faculty development.

Acknowledgments

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Working title: Reselection of Engineering Studies – Are Women in Finland Opting Out of
Technology?

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Keywords: engineering graduates, diversity, gender, equality, work-life balance

1. ABSTRACT

Academic Engineers and Architects in Finland TEK is a service and labour market organisation for over 70000 academic engineers and architects in Finland. TEK has been conducting Labour Market Surveys for M.Sc. graduates of technology and architecture for decades. The aim of this survey is to gather information on the labour market situation, working hours and salaries of TEK members, as well as on various current topics. TEK has also conducted targeted surveys regarding Professional Development of it members. This survey provides information on the needs, attitudes and possibilities for professional development of TEK members. Together, these surveys provide valuable insight into the professional development of engineering graduates during their career. These surveys are also tools for developing engineering education and particularly LLL programmes in engineering.

In the 1 Survey on Professional Development conducted in spring 2014, TEK members were asked whether they would now reselect their current field of study. The results showed a remarkable difference between men and women: 77 percent of men but only 59 percent of women stated they would now reselect their field of study. This deviates strongly from the results of the annual Graduate Feedback Survey conducted by TEK in which the reselection rate is 90 percent for both men and women. Since the professional development survey is targeted (with approximately 700 respondents), it was deemed necessary to study this issue in more detail with a larger population. Therefore, the tendency to reselect one's field of study was included in the 2 Labour Market Survey conducted in October 2014 (with approximately 12 000 respondents). In the literature and in previous studies conducted e.g. in United States, the lack of women in Technology is often explained by difficulties in work-life balance and inhospitable climate towards women. However, in the Nordic countries women are encouraged and financially supported to have a relatively long leave of absence when they have children and due to publicly supported daycare, women are relatively equal in the labor market. Therefore, it may be necessary to seek other explanations for the underrepresentation of women.

This practice-based paper presents results from the 2014 Labour Market Survey and Professional Development Survey concerning reselection of engineering studies. The paper presents the reselection rate of TEK members by gender and age group, explores certain factors impacting reselection, and discusses implications for engineering education.

1 Academic Engineers and Architects in Finland – TEK (2014): Survey on Professional Development 2014, Academic Engineers and Architects in Finland – TEK, Helsinki
2 Academic Engineers and Architects in Finland – TEK (2015): Labour Market Survey 2015, Academic Engineers and Architects in Finland – TEK, Helsinki

CHAPTER 15

Curriculum Development

Project-based Learning as an Effective Developer of Young Engineers' Curriculum

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1

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According to the Job Outlook 2015, employers are looking for graduates who possess the ability to work effectively in a team, adapt to the work culture and successfully transmit ideas [1]. However, the traditional university curriculum is not succeeding in the development of such competences [2]. Board of European Students of Technology (BEST) organised surveys and Events on Education (EoE) to better understand the stakeholders' perspective on curricular development of European Engineering Education (EEE).

Students indicated that it is important for an engineer to develop soft skills and to be open minded in order to fulfill the European market requirements [3]. Moreover, university representatives deemed that the most important skills for a student to develop were teamwork, communication and project management [4]. Interestingly, students have identified Projectbased Learning (PBL) as a more effective teaching method at developing those soft skills [5].

PBL improves both long-term retention and the attitude that students and teachers have towards learning and teaching [6] so its acknowledgement as an effective method might bring a brighter future to the curricular development in the mindset of the modern job market.

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Adoption of a New Project-Based Curriculum in Information Technology

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This paper presents early findings of the curriculum reform in engineering education in the Metropolia UAS. Alarge-scale reform in curricula was launched in August 2014, in order to address low retention in engineering studies. The aim wasto enhance education by applying collaborative project based learning models through the whole university[1,2]. In the information technology degree programme, first year studies were integrated into four thematic 15 ECTS modules ofeight study weeks. This paper focuses on the first experiences of the curriculum change, in particular retention rate, as well as student and teacher satisfaction evaluated through online questionnaires.

Information technology students were divided into groups of approximately 30 individuals, altogether 10 groups in two campus locations. Each group studied together in the same classroom throughout the period and was instructed by a team of lecturers representing different professional disciplines such as communication skills, mathematics, physics, programming and electronics. The themes were called Objects, Games, Robots and Networks, rotating through the study year. Each instructor team had a considerable degree of freedom when planning the implementation, which resulted in a variety of ways to integrate subjects. Some implementations actually consisted of quite separate parts, whereas others had a larger unified project assignment.
All classrooms had flexible furniture arrangements, small tables and white boards that could be moved around. There were some fixed computer workstations in addition to student laptops.

According to first findings, the outcomes were actually less varied between different implementations than anticipated. The change from large study groups, lectures, and laboratories into smaller, tightly knit groups seemed to have been a decisive factor in improving the results. Belonging into a group and working in teams was a simple way to increase commitment to studies and overall feeling of belonging, for students from diverse backgrounds in particular. Early conclusions of the reform are very satisfactory, though the results and data from feedback surveys calls for more analysis.Certain positive outcomes are obvious, such as almost no dropouts and high student satisfaction. Comparison of results of different implementations will yield more detailed information of how to best continue the integration of study subjects.

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An ontology to understandcurriculum change: a case study of comparing 3 course programme overhaulsat withinthe Dutch 3TU coalition.

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The 3TU coalition consists of the three universities of technology in the Netherlands: Delft, Eindhoven and Twente, which are all all-round engineering universities. The universities decided to strengthen engineering research and education in the Netherlands by collaborating and learning from each other in the Centre for Engineering Education (CEE). In the CEE, the three universities work on joint research and development projects with a special focus on studying and enhancing engineering education in a structured way.

The project reported in this paper is set up within the framework of the 3TU CEE and pertains to curriculum change in the three participating technical universities. . In recent years the three universities overhauled their bachelor programmes to improve the learning experiences of the students and, ultimately, improve graduation rates and diminish time to graduation. Such curriculum changes are usually not documented in such a way that the process and outcomes can be easily understood and that limits the capacity of an organisation to learn from them. In this CEE research project, the overhaul processes are mapped, evaluated and compared ex post facto. The goal of this effort is to collect and share experiences and ideas on course programme development and implementation and to isolate effective practices.

To achieve this, an ontology of factors influencing a curriculum change process needed to be developed, to allow comparison across the research sites. This ontology was designed to help map and evaluate effective practices for design and implementation of changes in course programmes, but also to help understand what interventions are effective in terms of improving student success.

The special focus in this project is the uniqueness of developing engineering course programmes. Engineering is an interdisciplinary field where scientific knowledge is applied knowledge to design solutions to solve complex problems in an engineering kind of way (see e.g. Godfrey & Parker, 2010; Graham, 2012). This creates many challenges for those who design course programmes, but also for those who implement such a programme.
In this paper we describe the elements of the ontology and the scientific basis for inclusion. We also describe how the ontology fits in with the research methodology of the project.

Combining online and face-to-face tutoring to enhance learning physics Concepts

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Abstract

Optimizing learningconcepts in physics coursesand motivating students to attend instructions are the two main goals in the pilot conducted in the first-year Physics course *Applied Natural Sciences* (ANS) [1]. This pilot has been conducted both at the AppliedPhysics (AP) and the Electrical Engineering (EE) departments. The rationale to optimize the educational approach is two-fold: first of all, the low percentage of students' attendance to the instructions at the physics department;secondly, the low pass rates at the electrical engineering department in the past three years.

To meet the educational challenges set by the two main goals of the pilot, the pedagogy to teach physics was modified. Firstly,the Mastering Physics (MP) e-learning platform was replaced by Oncourse, an in-house developed e-learning environment. The two main reasons for this change are 1. MP seems to be less appropriate to give feedback on students' answers [2], and 2. it is sensitive to fraud. Moreover, Oncourse fits better the outcomes of the course as it is requested by the students to work with symbols instead of with numeric values [3]. Secondly, we introduced tutor groups with up to 10 students per group. The tutor groups are to replace the independent learning group approach in which students, up to 30 to 40, work independently on solving exercises while the teacher walks around and answers punctual questions.

To analyse this pilot we collected both students' and teachers' opinions on Oncourse and tutor groups. We also analyse the students' pass rates of both AP and EE departments and compare these with the results of two consecutive generations 2013/2014 & 2014/2015. Although the results are promising regarding the online feedback system en the tutorial approach there are still some areas to improve in order to raise pass rates.

In this paper we will present the results of the use of an online platform and tutor groups to enhance students' learning.

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Concept Mapping as an Innovative Tool for Curriculum Development

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In the last decennium learning outcomes became a key factor in quality assurance in higher education in Europe causing an increased interest in methodologies for specifying learning outcomes of a study programme. At the Faculty of Engineering Science, KU Leuven, the ACQA (Academic Competence and Quality Assurance) framework [1] was adopted and implemented. Competence profiles based on ACQA criteria were compiled for all engineering programmes and actively used in accreditation procedures, quality assurance and curriculum development [2].

Despite the proven value of the use of learning outcomes and competence profiles in curriculum development, education developers at the Faculty of Engineering Science felt a need for additional tools to analyse the curriculum with the feeling of ownership as an important additional scope. The use of concepts to analyse the curriculum felt to be very approachable and open to large groups of lecturers. In general, concept mapping is a visual representation of ideas designed to illustrate the relationships between ideas. Previous experiences with concept mapping as a tool for course design proved to be inspiring to elaborate these principles to a curriculum level.

In this paper, we will describe the use of concepts and concept mapping as an innovative tool for curriculum development. The use of diverse formats of concept mapping at the Faculty of Engineering Science will be described and discussed in the context of qualitative support in curriculum development.

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Co-creation beyond the expected:
Generating new knowledge through interdisciplinary learning

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ABSTRACT

Background: Co-creation is a term that has been used to emphasize collaborative learning in design education. Allowing students to develop both hard and soft skills has been demonstrated important to facilitate effective learning [1]. Mixing disciplines with each other is an important catalyzer to gain new insights and also grow applicability on societal challenges and innovation. This paper proposes a curricula design that matches student interdisciplinary learning, design challenges and societal benefit. With an aims to create innovation in the meeting between e.g., medicine, social sciences and engineers it is a process that involves empathy and capability to define, ideate, prototype and test. Creation allows prototypes to be made, which are by default presented and interpreted differently by people according to their understanding and frame of reference[2].

Purpose: The purpose of this study is to present the curriculum for a master level course that emphasis and support the creations performed by problem-solving interdisciplinary teams. The subsequent purpose is to position the course design in relation existing best practices that has presented similar challenges of merging the specific methods presented, e.g. Scrum and Design thinking.

Design/Methodology: Observational notes and more than 100 student reflections, notes and remarks from more than 30 peer-to-peer faculty internal meetings, international workshops and faculty-student 'review screenings' sessions have been used to evaluate the pros and cons of the presented curriculum.

Findings: Open lab has arisen as a new course offering targeting societal challenges and an unique opportunity for students to take part in. To allow divergent and radical thought patterns to arise design thinking and scrum are put together as key elements to support a dynamic learning environment already from start. Moreover, initial team building and checkpoints, pre-checks and cultural differences have been reported to be affected in a positive way resulting deepen student project understanding and appreciation.

Conclusions: From initial course design and analysis the learning environment provides a catalyzer for learning to be appreciated and acted upon. The design of activities should build on a shared perspective from faculty and motivate students and convincing them to deepen their need for interdisciplinary design. By working interdisciplinary and collaborative it has been possible for students to co-create new knowledge beyond the expected from the stakeholders' perspective.

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Integrated Mechatronic Design with Project Base Learning

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One of the main issues as regards as regards education and especially engineering education is to arbitrate between adding interesting new skills and consolidate existing ones. Indeed, many students have difficulties to transform their academic knowledge into professional know-how. Many different ways have been proposed to make the students succeed in this this task: internships, trainings, projects… That complement the traditional courses. This is all the more the case for mechatronic engineers because they have to deal with complex systems that need interdisciplinarity, which requires further more than academic expertise in one or more scientific and technical fields. Topics are indeed too much separated in education but are so close in a real system. In addition, within the classical projects activities, students often have to organize and drive for the first time their own project. Last but not least, engineers have more and more to work with foreigners in international teams and have to deal with different cultures and habits. That’s why the educational team of Polytech Orleans that is involved in the final year of Mechatronic and Systems Design has proposed another organization for the skill acquisition within a specific course which is called: Integrated Mechatronic Design. The goal of this paper is to present this concept and the results after 5 years of experience and improvement.

The principle is based on a guided industrial mechatronic project activity for which the students are gathered in multinational teams of 6-7 people. Each team is driven by a project leader chosen among the students via a typical recruitment process with a CV and a cover letter. The composition of the teams is made with dedicated human resources software « PAPI »to obtain well balanced skilled teams. The overall aim is explain how their knowledge can be used to solve a real industrial problem and to experience human resources management which is a key point in real life industrial project activities. Back to the introduction, this course tries to answer the issue of transforming their academic knowledge into professional know-how. It promotes actives learning processes based on issue learning process. However, knew concepts are taught to the students but only according to what is needed to solve the problem asked by the project, respecting the project progress.
Students are supervised by the pedagogical team who plays the role of experts. Well adapted to “y generation” that are often associated to the following key words: connecting people, Immediate knowledge, Role games, attractiveness of community , teams , actions , pragmatic tasks, real skills with software ; the course gets a high level of satisfaction of the students and industrials who come for their evaluation at the end of the course and employ our students.

Motivation blockers of first year Mechanical Engineering students at the Fontys University of Applied Sciences

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Before the start and during the first weeks of their first year, it has been observed by teachers that engineering students start with a high level of motivation, which often seems to decrease during the course of the first semesters. Such a decrease in motivation can be a main driver for students dropping out of University early. A qualitative research will be carried out to answer the main questions that have been raised within the engineering department of the Fontys University of Applied sciences: to what extent does a decrease in the motivation of first-year students exists, exactly when during the course of the first year does this decrease occur and what are the underlying reasons causing this decline in motivation? Gaining more insight in the motivation drop of students could result in modifications to the curriculum. The final objectives are reducing the dropout level of students in the first year and increasing the quality level of young propaedeutics. In [1] and [2] studies are carried out to measure student's motivation constructs, which have been carried out for first year Engineering students. The authors describe a certain level of motivation drop for first year students at an Engineering University. In Geraedts 2010 [3] it is defined that Maslow rules for students can be seen as an element of a student's perception onto his or hers education. Often it can be observed that in most cases undergraduates start their education as an unconscious insufficient competent student having a very limited view on the work arena and complexity of the engineering discipline. Quickly after the start of the education year this view develops into a more defined perception of what the content and complexity of the future work field is and what is expected of the student during his or hers education. It is hypothesized that this gain in insights of the student into the work field and the related expectations is a significant contributor to the decline of intrinsic motivation. In this paper the investigated hypothesis and possible other aspects that influence the motivation of students will be presented. Based on results, potential corrective and preventive measures will be defined and discussed. Corrective and predictive measures depend on the results of this study and could be aimed for instance at: 1) making adjustments to the content and/or structure of the first semester curriculum, 2) improving the support of students in making adaptations into a better learning strategy and 3) improve the information on-which students decide to start a mechanical engineering education. This paper will focus on the first year mechanical engineering students of the Fontys University of Applied Sciences. About 100 first year students will be questioned using predefined questionnaires and additionally 20 of them will be interviewed for validation.

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CHAPTER 16

Education concepts specific for Engineering Education

buildING│bridges - Integration of gender and diversity perspectives in engineering education

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ABSTRACT
The research project buildING│bridges@teaching aims at the integration of gender and diversity aspects in different teaching formats in engineering.
Methodically a gender- and diversity-oriented teaching evaluation and modern, media supported blended learning approaches are used in order to achieve the intended goals.
Starting with a status quo and literature analysis of best practice examples the implementation of gender and diversity aspects will be integrated in selected teaching formats at the faculty of civil engineering at RWTH Aachen University.

Within the project a participant observation as well as an analysis of material of different engineering subjects was carried out by researchers from multiple disciplines in order to generate an interdisciplinary view on existing teaching formats.
First research results were already implemented and tested in new designed teaching approaches for example within the redevelopment of the multidisciplinary introductory lecture of civil engineering at RWTH Aachen University. Gender and diversity aspects were integrated into different engineering subjects and joined with blended learning techniques in order to create an innovative approach for the introductory lecture.
Another approach developed within the framework of the project is to bring together (future) engineers with stakeholder as well as diverse users of buildings, products or technology with their individual needs and requirements with the aim of sensitizing all participants for a variety of perspectives and connected challenges.
Based on these, research-based and transferable approaches for gender- and diversityequitable educational contents the project aims to integrate its findings into a variety of teaching formats in engineering.

Within the framework of the project the research group "Gender and Diversity in Engineering" cooperates with the Academic and Research Department Engineering Hydrology at RWTH Aachen University.

Tutor Training Using Role Play and Video Analysis for the LearnING Center, a Study Room at TUHH

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To support student self-study and facilitate learning in groups, Hamburg University of Technology (TUHH) started the "LearnING Center" in April 2013. The LearnING Center is a room where all students can study on their own or in groups. For 28 hours per week, student tutors are present in the room, assisting students in their learning process.

While there are similar projects at many universities, especially in the US, most of these are associated to one department. Contrary to those, the LearnING Center at TUHH is open for students from all departments, including mathematics, civil engineering, mechanical engineering and electrical engineering. Thus, tutors may be asked questions about any of theses subjects.

To prepare tutors for their work in the LearnING Center, we designed a training program that includes role-play elements and video analysis. In this, tutors are shown how to help students by asking them questions and thus entering a Socratic dialog. This approach allows them to help students even with only limited content knowledge about the subject in question.

We are very pleased to observe an increasing number of students using the opportunity to study in the LearnING Center and also an increasing number of questions asked. The aim of this paper is to present our training approach and illustrate the concept of the LearnING Center to promote its implementation at other institutions. We will report on the lessons learned during the first two years and make suggestions for similar projects.

Engineering Opportunities for Engineers

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It is not enough to provide future engineers with technical skills. They must also learn how to work in interdisciplinary teams, how to develop designs rapidly, how to manufacture sustainably, how to combine art and engineering, and how to address global markets. To provide future professionals an opportunity in the work market has become now part of university formation as a way to assure also the future of university. As long as the dialogue with enterprises are not yet effective in many places, it is up to the schools and universities to have the initiative to enhance their programs to assure the proper formation for future professionals that can perform in this mutant work environment of 21st Century. In according to the National Academy of Engineering, USA report “The Engineer of 2020” paints a picture of a dynamically changing and evolving world: “The successful future engineer will need strong analytical skills, practical ingenuity, creativity, good communication skills, business and management knowledge, leadership, high ethical standards, professionalism, dynamism, agility, resilience, flexibility, and the pursuit of lifelong learning”, the report says [1].

This paper contains the description of a course designed by COPEC – Science and Education Research Council education research team, for engineering students what is called “Working with Communities Course”, which provides the students of engineering in 3rd year the chance to work with consultancy for the entrepreneurial community, in the region. It is for an Engineering School of a private university and the goal is provide the needed resources to enable interdisciplinary efforts to prepare engineering students to tackle real-world challenges in engineering, entrepreneurship and new business ventures as professionals [2].

The idea is to offer a space that has been named after “Innovative Office” where local entrepreneurs go with a problem or project to discuss and to find sustainable solutions under the consultancy of young engineers. The engineering students then work using their creativity to design and present solutions within the constraints of ethical practice grounded in science and engineering methods and standards. This approach is not the ultimate one however, it has some components that fits to the present moment that the country economy is living and comes to add efforts for the betterment of engineering programs and as one of the consequences the rise of attractiveness to the engineering career. So far the program has been working well and is opening doors for young engineers. May be the best outcomes of the project are the skills that the students develop along the process in the “Innovative Office”, along the perception that they have to take risks and turn today’s failures into the seeds of tomorrow’s successes.

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K12 Enhancement Program: Engineering the Future of an Entire Young Population

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The K12 students are growing under new and mutant paradigms of education once this is the century of big and challenging paradigm breaking standards. This is due to the enhancement of science and technology that is changing people's life and consequently the education field.
Schools have been trying to keep up with these new education paradigms, in every level and it demands in most cases, a completely adoption of new teaching method. Proficiency in sciences is now a requirement for young people once governments have recognized that it is necessary a critical mass of scientists, researchers in engineering and mathematics among others in order to foster nations development.

Based on a research conducted by the Education Research Team of COPEC – Science and Education Research Council [1] for a City Hall K12 Schools Reform Plan the challenge is to provide better and effective knowledge for young students even for those who will not enter University. The goal is to provide K12 students of public schools of a city the necessary knowledge about science and research methodology in a way that will remain as a life practice. The mission of the course is to impart research skills to the young students and help improve the ability of using the natural curiosity to foster their knowledge as a day-by-day life practice in order to enhance the quality of life [2]. The main idea is to present the engineering as a possible career choice for both boys and girls as a way to ensure a better future. Basically the course is offered to students of last year of K12 as reinforcement for acquisition of knowledge to overcome some lacks in the basic formation of young population of the city public schools. It is part of a bigger project of the City Hall and that implies in some strategies. The course main characteristics is the approaches to provide the students the ability to develop scientific mind set to develop concepts and theories to solve and understand scientific and nonscientific problems and to find solutions to scientific, nonscientific problems [3]. It is part time course delivered in two different times, in the morning and in the afternoon always after school period.

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Activity Based Learning: Overcoming problems in implementing OBE in Engineering Education during transition phase.

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National Board of Accreditation, India has become the signatories of the Washington Accord adopting outcome based education guidelines in order to impart the quality education in engineering institutes **[1].** Albeit OBE requires thorough assessment and evaluation of the students individually, with special focus on the overall development of the students. OBE is based more on student centric learning and less on the role of a faculty or the content part (taught) which requires modifications at grass root level in the University teaching learning scheme. It demands a transition of a lecturer in to a facilitator. It also requires a paradigm shift in teaching learning process in engineering education system as OBE focuses more on development of all three learning domains, contradictory to traditional teaching learning process which is more focused on development of the cognitive domain and psychomotor domain only.

According to the World Bank Report, the modern volatile and complex world demands from an engineer the core employability skills like integrity, collaboration skill, communication skill, self-esteem, self-discipline, accountability etc. To champion the importance and value of 21st century education, the skills like critical thinking, problem solving, creativity and innovation, collaboration skill, communication skill must be developed and honed during the course tenure so that they could become competent global engineers **[2] [3]**.

This paper brings forth the out of box thinking and implementation concept of the OBE for UG program, through activity based students' engagement, specially designed activity to achieve PEOs, POs and CLOs. It intends to solve the problem of large classes though the implementation of the FLIP classroom model. A six month activity based teaching learning process has been adopted for different streams, involving more than 1500 engineering students. The outcome/s achieved by each activity has been termed as Activity Outcome (AO). This paper discusses the problems encountered during the implementation of OBE frame work for large class **[4]** in context with Indian Environment and also strives to provide some methods to implement activity based learning to achieve desirable outcomes.

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Three step development model used for active learning in electrical engineering

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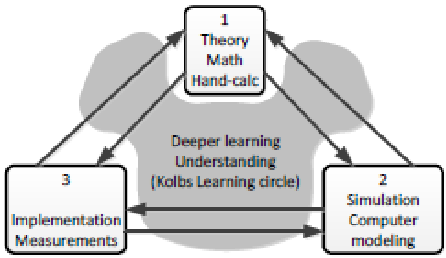
Over the last decade more and more attention has been put into moving the engineering from traditional large class room teaching towards bringing more practical aspects into the teaching.

This trend has also been formulated in the CDIO-concept (Conceive-Design-Implement-Operate) [1] for teaching. In this paper a 3-level model used for courses in synthesis of integrated electronics is presented and it is discussed how it is used to teach the student the different development phases in engineering work. At the same time the model – combined with coaching – is used to ensure deeper learning for the students and also assesses the learning outcome of the students.



In electrical engineering development is practically always done in 3 (this is probably also true for many other engineering disciplines) phases as illustrated in the figure. The first phase is mainly described by the theory and mathematical modeling the students learn about electronics. At all universities the students spend a great deal of their study analyzing various problems using the theory they are taught. This is the very foundation to become a good engineer. The second phase is mainly described by computer modeling of electronic circuits. Many software tools exist in the market for this and it is an essential part of the skills of an engineer to be able to handle these tools. The last phase is naturally the physical implementation of electronics. For engineers to be skilled in electronics they need to be able to operate seemingly between the different phases in order to successfully synthesize electronics. It is also during synthesis that the students are required to handle more and more higher level learning objectives (SOLO (Structure of Observed Learning Outcomes) and Bloom's taxonomy
[2, 3]). Based on this, the model is introduced to the students to make them aware of the need to interlink the experiences and knowledge from the 3 phase in order to become skilled engineers.

In the paper it is described how the model is used in the teaching in integrated electronics at theTechnical University of Denmark and how it brings awareness to the students about the workflow of professional with in the field. It is also described how the model is actively used when the teacher and student have contact hours. The paper describe how coaching and a problem solving methodology is used to help the student interconnecting the phases (the grey area) which again helps the students elaborate on their design and make their own conclusions on how to progress. By doing this the students undergo learning which can be described using
Kolb's learning cycle [4]. Based on observations in one of the phases they draw on the experience in the other phases and thereby achieve deeper learning. The models are shown to the student and actively used during the teaching which is described in more detail in the paper.

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Making way for the intercultural in engineering education: new spaces for embracing the tensions

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To date, there is not yet a consensus on how best to address the development of intercultural competencies in engineering education. Both theory and practice often reveal different or opposing views on the purposes, curriculum, and principal stakeholders in this process [1-5].

This presentation will highlight some of the basic tensions behind the prevailing views and will consider different ways in which these tensions can be managed [6]. First, it will be shown how engineering educators have traditionally attempted to resolve these tensions by choosing one option above the other. The authors will then present an alternative approach that embraces these tensions by coping with seemingly contradictory options and engaging with multiple narratives. This approach requires a special place, which has been referred to as a 'liminal space' [7], a 'creative platform' [8], or an 'interpretive space' [9], where students (and teachers) learn to cope with ambiguity, in itself a well-documented requirement of intercultural competence.

Finally, the authors will detail how they have implemented this approach in their teaching practice with reference to two compulsory undergraduate engineering courses at their institution: 'Intercultural communication' and 'Beyond engineering: pursuing sustainability'.

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Development and Validation of Module Presentation of Selected Topics in Physics for Architecture Students

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The study aimed to develop a module on identified topics which students find difficult, validate the material and field tests effectiveness in enhancing the achievements of Architecture students in Qassim University. It had three phases namely: Phase 1-Developing module on selected topics in Physics 1, Phase 2-Testing the readability of the module, and Phase 3- Testing the effectiveness of the module in improving the achievement of the students exposed to the material for two months.

From students identified as slow learners by the architecture department, 90 were randomly assigned into two classes: 45 students to the control group who were taught with the conventional approach and 45 students to the experimental group who were taught using the module as instructional materials.

The results showed that the group with module materials performed better in the achievement test, quizzes, midterm examinations and final examination than the group which may not taught with the module materials. The former group also showed more favorable attitudes toward physics, after using the material.

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‘Where there is no Engineer’ – The use of community based projects to develop graduate attributes in first year students.

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This paper investigates the use of a PBL project in a community setting to assess how effectively this teaching pedagogy can develop graduate attributes in first year students. Engineers without Borders Ireland launched a nationwide competition entitled ‘Where there is no Engineer - Designing for Community Resilience’ in October 2014 [1]. It aims to encourage engineering students to design sustainable infrastructural projects for developing countries. The competition formed the basis of this project which was to design a pedestrian bridge to span 6m across a river.
Nairobi was chosen as the locality for the project and the research and design needed to take cognisance of the local conditions, materials and labour available in that area.

Eighty first year engineering students were given six weeks to research, design, analyse and present a bridge design solution. The winning group built a full scale bridge for testing across a pond as evidenced in Fig.1. Tutors witnessed a high level of engagement from the students during the project. The fact that their bridge design could be used in a real life project in Africa was an influential factor in their engagement.

Students were asked to indicate their perceived increase in competency of particular skills, as a result of involvement in the project. The findings from the study are presented in a radar diagram as shown in Fig. 2 which highlights areas where the project was effective. The data and feedback gained from this study will be used to provide a framework for the design of further PBL projects to develop graduate attributes in the first year of study.

Fig.1: Testing of the full scale bridge

Fig. 2: Percentage increase in competency

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Multi-concept use of low-cost hardware for engineering education

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While solid theoretical foundations are strictly necessary for any kind of engineering and scientific education, students benefit greatly from applications and practical examples to supplement their learning. Especially in engineering education, problem-based learning and laboratories are a centerpiece of higher education curricula [1] [2] [3]. Creating laboratories involves a lot of work for the educator as well as considerable investments in hardware.

One of the possible solutions for this problem is the creation of remote laboratories where students can access a lab setup over computer networks. Thus, a single setup can be used by several lab groups as well as across different classes. However, this usually means that students have no physical access to the hardware and the setup adds little when compared to a simulation. Another solution to reduce hardware cost is low-cost mass market hardware [4].

In this paper, we propose that a single laboratory setup can often be used to demonstrate more than one concept. Thus, a mass market low-cost hardware setup can be leveraged across different classes, labs, and disciplines. This solution offers both a reduction in hardware costs due to the use of inexpensive hardware as well as a reduction in development time over individual setups for concept. In addition individual students or groups can have access to their own hardware to gain hands-on experience.

As an example we present an embedded system that automatically tracks a ball with a camera. The setup shown in figure 1 consists of an Arduino Uno to control the motor that turns the camera and a Raspberry Pi which handles imaging and image analysis. The example can be used as a laboratory exercise for image acquisition and processing, controls, parameter tuning, system identification, testing, and deployment on embedded platforms.

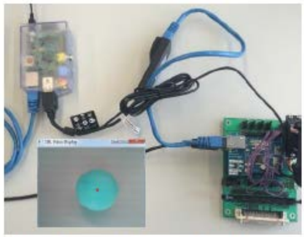

Figure 1: Exemplary demo setup using Arduino and Raspberry Pi

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Pedagogic experiences in problem-based learning environment focused on human-centred design

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The Faculty of Engineering Science at University College London (UCL) has recently undergone a reform of the undergraduate curriculum, which resulted in the creation of a distinctive programme that connected curriculums from across seven engineering disciplines.
The Integrated Engineering Programme is extensive, taking in nearly 700 students in its inaugural year at the start of the autumn 2014 term. Its most significant contributions are the experiential and authentic learning opportunities it provides students to apply their technical knowledge and develop their professional skills in engineering design modules year on year. The first opportunity for every student is within the cornerstone Integrated Engineering Design module. This paper seeks to share theapperception and evaluation of pedagogical experiences carried out during the first of two 5-week 'Challenges' that make up this year 1,term 1,multi-disciplinary problem/project-based learning (PBL/PjBL)[1] module, which focuses onhuman-centred design [2].

The main purpose of this research was to investigate the strategies, dynamics and results of efforts to support a key learning outcome for the module – engaging students with the process of engineering design [3]. This article presents a set of pedagogic experiences observed and analysed: contextual and enquiry–based learning with cultural partners and external advisors, formative assessment 'Design Review' meetings, and collaborative writing and documentation. The methods of conducting the research include the analysis of reflective writings by each student throughout the 5-week Challenge. This data is also supplemented with feedback provided by students and academics, which has been provided during follow up interviews and focus groups. Also included is statistical data generated from two student surveys, completed before classes commenced, taking place during their year 1 induction week, and after the completion of the module.

Analysis of the data collected shows that the pedagogic experiences embedded into the 5-week Challenge work to initiate student learning of how to conduct research, whilst compelling their active participation and independent critical investigation of the design process. The authenticity, level of detail and cultural diversity associated with the context surrounding the human-centred problems given to the students as a design 'Challenge' are thought to be, in many ways, the main catalysts to the students' level of engagement.

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Effectiveness of Arabic as Medium of Instruction in Enhancing the Performance of Students in Architecture Studio Courses

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This action research was conducted to assess the effectiveness of Arabic as a medium of instruction in enhancing the performance in Architecture Studio course of architecture students in Qassim University.

Comparability of the two study groups was first established according to architecture studio course average grades and results of their knowledge in studio. A pretest was first administered to determine their entry knowledge. The lessons, one in Arabic and the other in English, were conducted for four months to two groups. After this, a posttest was administered to determine differences in performance in studio course between the two groups.

The study showed that the class taught in Arabic obtained a significantly higher mean achievement posttest score than the class where English was the medium of instruction.

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Generic model for international assembly instructions for special machinery assembly

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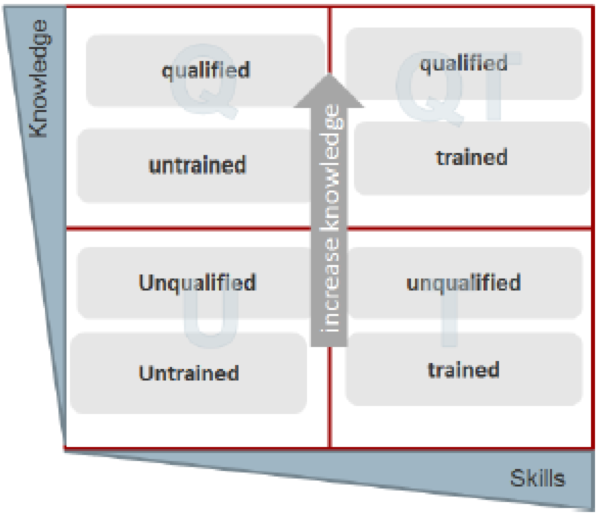

Figure: Knowledge-Skill Framework [1]

Knowledge transfer is a tremendous task for the assembly of complex products while increasing the production share at a new location, because no or little experience about the new product's assembly processes is available at the new site. Companies are facing high costs for exchanging trained and qualified workers to the new facilities in order to increase the knowledge and skill level of the partners of the abroad location (see fig.). Increasing the knowledge level means in this context increasing the theoretical understanding of the assembly and increasing the skill level means in this context increasing the proficiencies in assembling a special product developed through training through the already skilled workers.Taking cultural and organizational issues like mental models, different languages and software availability into consideration, the task of knowledge transfer gets complex.

A generic structure for documenting respective assembly with the purpose of knowledge transfer is presented in the paper. The structure is validated and evaluated in a study conducted for large scaled compressors, at which the local production share worldwide and especially in the BRIC states shall be increased. The arrow in the figure shows, how the knowledge level of the workers is increased first with the help of the assembly instruction to create a basis on which in a further step the skills of the workers for the assembly of a certain product are increased in a more efficient way through training. The feedbackabout the created instruction of the workers of one of the local sitesisevaluated.

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Integrating Research into a New Common First Year Engineering Design Programme

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We represent a group of lecturers working together to teach design modules that are part of a new common first year engineering programme. In this paper, we present the basic rationale and format of the programme that is now required for all students entering the honours Bachelor of Engineering major at our institution. We explain how we integrated research by Crismond and Adams [1] in our first year of teaching this design-oriented programme and what we observed in doing so.

The programme, first delivered in the 2014-5 academic year, is intended to prepare students to select and enter the second year of any engineering programme offered by our institution. The new School of Multidisciplinary Technologies coordinates the programme, which is delivered by a group of engineers, mathematicians and scientists. The School itself was created to improve collaboration among various parts of the college. The programme includes three group-based design projects that span the academic year. In the process students:

- Achieve a foundation in physics, chemistry, mechanics, computing, and mathematics
- Gain experience identifying, formulating and solving engineering problems
- Begin to understand engineering design process as a system
- Experience new ways of analyzing and interpreting data
- Develop a sense of professional responsibility, socially and environmentally, and an appreciation of professional ethics
- Work effectively as individuals and teams
- Develop communication skills of use in engineering and across society

The Engineering Design Projects module represents 1/6 of the credits students complete in their first year of engineering. It meets for four hours weekly, and each successful student earns ten ECTS credits. Each takes part in one-semester of robot construction and programming, a half-semester of bridge design and construction, and a half-semester developing and constructing an “energy cube” that deals with energy and light transfer.

To help enhance our teaching team’s efforts in modeling and explaining effective design process, a self-selected group of lecturers read Crismond and Adam’s article “The Informed Design Teaching and Learning Matrix” [1]. We analyzed its two-page matrix and discussed how to use the chart to structure class activities and to explain design. In the module, we presented an early version of the matrix [2] as a way to help students differentiate characteristics of “novice” and “informed” designers. This paper discusses overlaps we found between the matrix and the module. We see it as a way of popularizing the matrix and helping make the matrix more accessible for engineering educators to use.

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A Project/Design approach in an Electrical Engineering Course

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This paper talks about the implementation of a Project/design approach in an electrical engineering course. The School of Engineering at Deakin Universityadopted a new project/design approach in which students learn through design activities driven by a project with a defined deliverable to deliver the skills and knowledge students require to understand and solve design problems, a key requirement for employability of the modern day engineer. The new approach following the principles of project/design-based learning used a design project to teach students about the fundamentals of electronic signals and systems. The students worked in teams of five to six members and each team was given a design problem, which encompassed the learning outcomes for that particular unit. The staff member played the role of a facilitator, facilitating the student centred learning process. This paper presents the implementation process of the project/design approach across the trimester; the project and design problem and the processes is set for student and staff interaction. This paper also focuses on presenting the views of the students on this new approach.

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Integrating foreign studies within the constraints of European Harmonisation: a BIM e-learning course

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Working on international projects with project partners from all over the world is common practice in almost all engineering disciplines nowadays. To prepare students for this part of their professional life a study period abroad is probably the most effective way. Spending several months in a foreign country will teach future engineers not only the necessary language skills but will also lead to an understanding of cultural differences which can be crucial for their professional success when collaborating within multinational engineering projects.

At the University of Kaiserslautern we developed a curriculum for a M.Sc. program for Facility Management at the faculty of civil engineering, starting in fall 2015. To address the requirements of future workplaces, we decided to integrate international studies into the third semester of a two years program.

Integrating foreign studies as mandatory part of the curriculum following the stipulations of European Harmonisation is not as easy as the inventors of the European Credit Transfer System (ECTS) intended. We found two main barriers to the implementation of a study period abroad: 1. A full semester of studies at a foreign university requires partner universities, which offer 30 ECTS in courses that fit into the overall program at the home university. 2. Foreign institutions of higher education often require high tuition fees. Grants and other funding options are often not accessible to foreign students. In Germany, education is usually tax-financed and free of tuition fees.

For the new M.Sc. Facility Management we decided to use a mixed strategy to integrate foreign studies, project oriented teamwork and globalisation into our education concept. Beside 12 ECTS credit points that have to be obtained from international studies we offer several e-learning courses that students should take during this period and which explicitly reinforce the learning goals of project oriented teamwork in a globalized environment.

The Building Information Modelling (BIM) e-learning course is a sound example of how these soft skills can be combined with teaching an innovative, technology-oriented approach that will play an important role in future civil engineering practice.

With BIM, future buildings are represented as digital models, which can be shared and exchanged among project participants, between different software applications and across the entire building lifecycle. Due to the improved exchange of information using digital means, the construction domain can seize the benefits of global networked cooperation.

By teaching the BIM method in the context of a specific project, the learning effect is twofold: Students can embed the theoretical foundations of BIM into practical application, and they are introduced to the complexity of cross-project workflows with various different stakeholders – a fragmentation which is characteristic of construction projects. Finally, from a pragmatic point of view the BIM method enables the students to work together in teams across time zones and to stay connected during the period abroad.

Role-playing games for the simulation of a professional experience combining scientific and management learning

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In the context of the education program of the department "Technologies for Energy, Aerospace and Engine" of the school of engineering "Polytech Orléans" (France), a role playing game is organized at the end of the 1st year of master level.
According to the employment statistics of our students at the end of the present education program, it was confirmed that most of them obtain a position in industrial Research and Development departments in big companies as R&D engineers, or in smaller structures as consulting and audit agencies as business engineers. Consequently, a specific program was developed to train students for both types of position and the present paper describes the one dedicated to the position of business engineer.

It is expected from this simulation of professional experience combining scientific and management learning that the students can develop some personal qualities that are essential for an engineer, but rarely evaluated, as:

- ability to find and prioritize information, ability to analyze and synthesize,
- autonomy and organization,
- active listening, using arguments, assertiveness, persuasiveness and self-confidence.

During one full-time month of education, the students are immersed in a role-playing game as engineers in a consulting company, that have to perform all the processes related to a technical service provision dealing with the employment sectors of the department (aerodynamic expertise, wind tunnel testing, internal combustion test bench, air conditioning design, etc.).
The teaching staff, accompanied by industrial partners, build three calls for tenders and play the clients (a company) during the whole project duration. A pair of students, who plays the supplier, must respond to one of these bids. It is intended that the clients do not know exactly what they are expecting from this service provision. That means that the first step of the project is dedicated to interviews of the clients by the student teams in order to better identify the client expectations (technical specifications). Based on this information, the student teams build technical and financial proposals to answer the bid. After a second interview, the clients select the best proposal from all student teams and the effective realization of the service provision is based on the selected proposal. In order to achieve this first stage of the project (two weeks), some practical lectures are given to the students on the methodology to respond to a bid, to write technical specifications, to assess a financial proposal and to negotiate a contract, right at the moment when they need it to carry out the project.
The second part of the project (two weeks) is dedicated to the effective completion of the provision of service. To do so, student teams make use of the technical and scientifically skills that they have acquired during their previous education program.
The project period ends on a third interview with the clients, where student teams have to present their results and prove that they have fulfilled the requirements of the negotiated provision of service Some concrete examples will be developed within the full paper.

An experience of the use of Project-Based Learning to simulate a business environment in a discipline of chemical engineering course

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The engineering courses in the XXI century are facing a double challenge; they must deal with the high velocity of technological changes and, at the same time, they must produce professionals with skills that some years ago were acquired from the professional experience, such as capacities of team work, leadership, communication and expression. Such abilities have been called as transversal skills [1].

Problem-based Learning (PBL) appears as a tool to meet the expectations for a more dynamic and efficient course [2]. In this work, the author shows how an experience, based on PBL principals, was used to simulate a business environment to the students of a discipline called
Industrial Chemical Processes aiming at the same time promote the learning of matters related to the discipline and the acquisition of transversal skills needed to engineering professionals.

The students enrolled in the course were randomly divided in twelve groups of five or six members. Each group should simulate a startup company that had as main objective to attract investment from a group of investors formed by the rest of the class.

The six main issues of the discipline syllabus were distributed to the groups, so that each two groups should work on the same subject.

The tasks of the groups were executed in the form of two projects, the first should address general aspects of the topic and the second should present a problem related to the theme and an innovative proposal for its solution.

The teacher showed the students the rules of the course, with the schedule of presentations and how evaluations received by the class for each presentation would be converted into "investment" that eventually became grade for each student.

Each week two groups presented their projects and competed with each other for a fictitious investment. The competitive environment served to stimulate creativity, to enhance the seriousness with which the students worked and to develop the transversal skills.

At the end of the semester, students responded to a survey on the course, which showed that they were very motivated by the PBL approach; they preferred this new model to the traditional and considered to have learned as much or more than the traditional way of class.

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On Using Test-Driven Development to Tutor Novice Engineering Students using Self-Assessment

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When educating new engineering students into software programming, the first problem they face is understanding what should be accomplished. This is normally thought in more advanced courses on requirements engineering within software design, which is a difficult discipline for novice programmers to grasp. In this paper we present a technique where we provide the requirements as software tests. This way students are not only able to read what their expected software should accomplish, moreover they can test themselves if their implementation is right.

This technique is part of Test-Driven Development (TDD), where requirements provided by uses cases, formal specifications, notes… are transformed into executable tests before the requested software is written. This way, programmers focus on the item's interface and observable behavior.

One of the key advantages of TDD is quality of source code. Currently, there are only a few methodologies that succeed in improving source code quality. One such approach is TDD, which is a recent methodology that fosters the development of error-free, well developed and maintainable code. This paper aims to explain the core principle of Test Driven Development for use in engineering education, treating topics such as: What is the red/green bar mantra? What are the benefits and liabilities of TDD? Why should tests be automated?

By using TDD to learn engineering students how to program, focus is shifted from writing software that output results to screen towards pragmatically designing and verifying programming code where the functionality can be automatically tested. Gradually students are motivated to start writing the software tests themselves, before implementing the item under test. So they are writing applications that can be automatically tested. Furthermore, as during the programming course new programming concepts are learned, they can implement this by rewriting the existing code, so-called *refactoring*, and still be able to verify the correctness of this code.

Students appreciate this technique of first receiving the software tests and later writing the software tests, because this allows them to monitor their progress themselves. The instructor has to put some effort in designing all necessary software tests and writing them so they are easily readable by students, but as these tests also deliver feedback to the programmer/student, time spent on correcting and delivering feedback is reduced during lab exercises. In this way, the instructor gets more freedom to focus on programming concepts, rather than basic issues that students can solve themselves.

CHAPTER 17

Continuing of lifelong learning Engineering Education

Work Based Learning – in Industrial Engineering

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The development of employees' skills and competences has become the key driver of economic growth in the developed world. It is widely recognised that it is mainly through enhancing people's skill and competences that future competitive advantage willemerge. Consequently companies need to be able to identify precise areas where they have, orcan build, distinctive Competences that will enable them to compete effectively. However skill and competence development aimed at especially post-graduate employees is still an area of great potential of progress. Nowadays with the European Qualification Framework (EQF) the tool to accredit such skills and competences is available - even if they (the skills and competences) have been achieve through in-formal or non-formal learning.
A partnership of seven industrial engineering institutes from Ireland, Netherlands, Germany, Denmark, Sweden and Finland have set out to develop and test a model for skills and competence development for employees within a company context.
Inspired by the concept of Work-based learning (Boud, 2001) and a facilitating approach to learning (Kolmos et al., 2004)),the partnership will develop a Work-based learning model aiming at industrial engineering – a WBL-IE model, which will be pilot tested in the seven partner countries and the learning out-come will be matched against the EQF. The intention with the research is to bring new knowledge and models to the field on continuing education primarily within an industrial engineering context.
The research approach is inspired by action research, which is defined by a participatory process concerned with developing practical knowledge in an attempt of improving e.g. life of human beings (Lewin, 1946; Reason et al., 2003) and a case studies methodology (Flyvbjerg, 2006, 2011).
This paper will provide insight into the results of the pilot cases; how the competence need are recognised; how the learning objectives are identified; how the learning program is designed and how the learning out-comes are assessed and matched to the EQF.

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Research-Based Computer Games to Train Civil Engineering Students to be Lifelong Learners

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Abstract

In spite of vast efforts to adopt available information technology in higher education teaching and learning, the truth is that most of university students and academic staff make only limited use of communication technology. Selwyne [1] concluded that there is a growing need for the education community to account for the distinct 'digital disconnect' between the enthusiastic rhetoric and rather more mundane reality of university information and communication technology use. Recent advances in computer science and multimedia as well as optimistic effects of multifaceted modes of education on student learning, have encouraged teachers to look at adopting the new technology to improve students' learning experience. Chang et al. [2] have suggested that digital games can be powerful informal learning environments encouraging active and critical learning, supplementing traditional teaching methods.

It is well accepted that well designed discipline based computer games can help with student learning process and experience in higher education. In this study, a computer game called "Back to Bedrock" has been developed for soil Behaviour subject at undergraduate level and students' learning process has been monitored and evaluated. It was aimed to help Civil Engineering students with information collection methods, creative thinking, problem solving, and lifelong learning abilities, through a research-based computer game. The results of this project indicate that implementing innovative methods such as computer game based assignments can provide enjoyable competitive and cooperative learning environment enhancing students' learning motivation, and critical thinking abilities, improving the overall performance of students in the subject.

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Team-based Professional Development in Higher Education: A Review Study

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The University of Twente is currently redesigning its engineering education to better prepare its engineering students for the future. To implement this curriculum innovation successfully, professional development of teachers is needed. Teacher professional development in higher education has gained more and more attention during the last decennia. Research has been published on various kinds of professional development programs like courses, workshops, (online) trainings or peer observations [1]. Most review studies in this area focus on professional development of individual teachers, whereas team-based professional development programs have been neglected. Although research has shown that professional development in teams can be very effective [2], there has never been a review study focusing on these team-based interventions in higher education. To provide an overview about research on this topic, we carried out a systematic review study specifically focused on team-based professional development. The method for this study is based on Petticrew and Roberts' [3] method for executing systematic reviews in the social sciences. A systematic literature search was conducted using four scientific databases, which resulted in 533 publications. Based on our exclusion criteria, about 20 publication were found to be suitable for this review. With this study we try to answer the question: What are the benefits of team-based professional development in higher education, and under which conditions are they most successful. The results reveal that in comparison to individual professional development interventions only a small number of research studies about team-based professional development interventions have been published. Most articles focus on team-based professional development as such, some describe team activities part of a larger professional development program. Several conditions for successful team-based professional development are described in these articles, for instance a faculty or university culture supporting professional development, trust between team members, supportive leadership, and leader and management commitment. Regarding the benefits of team-based professional development several articles report an effect on teacher attitudes, for instance teachers state that they value the collaboration with their colleagues and see team-based professional development as a good opportunity to learn. However, most articles which focus solely on team-based professional development do not measure the effect of these interventions on teacher learning, only a few quantitative methods were used. In comparison, articles which study team-based professional development as part of a larger professional development program often specifically highlight the benefits of these programs in the form of knowledge gained.

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Interdisciplinary E-learning: an Engineering Perspective

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As economic constraints leave fewer resources available for professional development, researchers and practitioners have become increasingly interested in the interplay between learning, community and technology. In particular, they are examining the potentials of community based E-learning. Novel technologies are developed to improve the teaching and learning experiences of an entire (research) community. Into this perspective, E-learning research is not focusing on understanding the world as it exists, 'it instead seeks to change the world as it exists' [1]. In order to 'change the world as it exists', our European FP7 training network, iCARE aims at investigating Interdisciplinary E-learning (IEL) in a community of people involved in improving the auditory rehabilitation of children with hearing impairment.

Interdisciplinary in this context refers to combining and exploring the interconnections between new and different approaches in different research fields and specializations [1]. And, IEL means that we are supporting learning activities and professional development opportunities with the benefits of E-learning technology, like connectivity, flexibility and interactivity [2] between members with different perspectives and levels of expertise in a wide variety of contexts. iCARE does not focus on one single and authoritative perspective or knowledge form but instead on a combination of not always consistent points of view that represent a range of disciplinary and methodological possibilities. Indeed, it is generally required nowadays that the researcher is conversant with more than one disciplinary body of knowledge and research method [1].

In iCARE we aim to design, develop and implement an "Interdisciplinary E-learning Educational model" to create a new generation of researchers capable of exploiting the synergies between different disciplines. We expect as a result that this new generation of researchers will be able to share and combine research outcomes across disciplines to develop novel methods, skills and procedures for improving auditory rehabilitation. Several junior and senior researchers, with different fields of expertise, i.e. engineering, psychology, neuroscience, acoustics, cognition, audiology, speech language… will follow a three years' IEL training in auditory rehabilitation from fifteen proficient academic and industrial partners across Europe. In this respect our research contributes to develop more diversity in engineering and engineering education.

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Design and Implementation of a first-year engineering design subject

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Being able to produce engineering graduates with a thoroughly developed set of desired competencies is a challenging task and consequently the focus of much research in engineering education. However, the focus of typical engineering subject curricula largely remains the development of technical skills, with so-called “generic skills” often assumed to be learned during the course of study without adequate instruction, assessment or feedback. In the first year of engineering study, it is particularly important to make students aware of how much these generic skills are valued by industry in graduate engineers, to inspire them as engineering students and to prepare the base of their learning for the years ahead.

This paper will focus on the development, design, implementation and evaluation of a new large first-year engineering systems design subject as a means to develop particular “generic skills” types of graduate attributes, to broaden a students’ knowledge of engineering and to encourage further study in engineering. The first-year subject curriculum was designed according to a specifically chosen set of Engineers Australia graduate competencies functioning as the intended learning outcomes. Teaching and learning activities were designed around these intended learning outcomes; the focus being a semester-long team design project with multiple dependent modules, each employing different disciplines of engineering. It is argued that such a purpose-built first year systems design subject exposes students to the importance of a range of graduate competencies, particularly generic skills, builds understanding of how such skills are developed and assessed, gives a taste of engineering from multiple disciplines, and forms a sense of community amongst the student cohort.

Data was collected measuring academic performance, attendance and submission rates, peer ratings, feedback given and student perceptions of the subject, which was then analysed in order to assess if the intended learning outcomes were being met. From this it can be determined that students improved specific graduate competencies such as communication and teamwork skills, and became inspired to continue on with their study of engineering through engagement with the assessment tasks such as regular reflection, feedback and selfassessment.

CHAPTER 18

Attractiveness of Engineering Education

Writing Learning Objectives that Engage Future Engineers:

Hands-on & Minds-on Learning Activities

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One of the first steps in planning engaging, integrated Science, Technology, Engineering, Mathematics (STEM) instruction for primary grade children is to determine the learning objectives for the young learners. From clearly developed objectives, educators can select appropriate materials and activities to stimulate student interest, and to develop assessments to document the impact on student learning. Engaging students in interesting engineering learning experiences early is critical for motivating them to pursue engineering careers and to eventually serve as mentors to other future engineers. The impact data are critical for providing evidence of teacher effectiveness and of student achievement, information that can serve to motivate teachers and students to continue their engineering education. Two types of learning objectives will be discussed in this paper. The first type includes objectives for student skill development. These objectives are typically skills that are directly observable (e.g., the student will build, the student will create). The second type is what one can refer to as thinking objectives and are more hands-on &minds-on and less easily observed (e.g., the student will compare, the student will explain). For each kind of objective, teachers need to develop behavior indicators. These indicators can include language, such as specific scientific or mathematical vocabulary, that they expect students to use while engaged with particular materials, or behaviors that teachers expect to see, such as collaborating to accomplish a task or sharing materials.

Assessments of STEM activities are unlike assessments in a specific content area where the teacher is looking for the student to demonstrate mastery in a math skill such as one-to-one correspondence. STEM activities, by their very nature, integrate many skills and learning objectives across the disciplines. The objectives and outcomes are not always clearly mapped to one of the four STEM disciplines, science, technology, engineering, and math, but are often cross-curricular in nature, addressing content, practices, and skills from not only the STEM disciplines, but also from others such as language arts and social studies.

Curriculum planners and teachers using the standards from the various disciplines are presented with rich opportunities for observing student achievement during STEM activities. Examination of crosscutting concepts [1] reveals that ideas and practices of technology (system models, mechanisms and prediction) and engineering (structure and function), are integral to STEM education. Decisions on what goals and objectives to assess should be based not only on standards, but also on data that teachers have from diagnostic assessment results that provide information regarding what students are ready to learn and what students are interested in learning. This paper describes a process of developing meaningful, hands-on &minds-on objectives that willstimulate student interest in engineering, and support planning, instruction, and assessment of STEM learning experience in the primary classroom.

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Enhancing the programming skill in high school engineering education via flipped classroom and peer assessment

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The new generation of engineering students has grown up within the new technologies which provide opportunities like internet, smart phone environment and applications on such environment which also affects how they learn. We are starting to re-think how to teach students in this new generation, how students gain knowledge through videos before class, and how instructors guide students to clarify and apply that knowledge during class in a flipped classroom.

Recently, many events aimed to promote computer programming education for K-12 students worldwide. For example, President Barack Obama stated in the video for the 2013 Computer

Science Education Week annual event: "Don't just buy a new video game - make one. Don't just download the latest app - help design it. Don't just play on your phone - program it." A popular tool for teaching K-12 students computer programming is Scratch. Scratch, a visual programming environment, allows students to create their own personally meaningful interactive content (interactive stories, games, music and art).

This study explored the effects of on-line self-learning and the validity of on-line peer assessment in high schools and to analyze effects of various types of peer feedback on students. Participants were 111 senior high school students enrolled in a Scratch programing course. Following procedure was performed during the class for 18 weeks: the students watched the on-line video materials, gave feedbacks, and formed 33 groups of three or four to create Scratch game projects, viewed other groups' work, and performed assessment on the Web-based learning and assessment system.

The peer assessment activity consisted of three rounds. Pearson's correlation analysis was conducted and the results indicated: 1) students significantly improved their projects as involving the peer assessment activities; 2) the peer-assessment results and teacher assessment results were without significant differences, indicating that peer assessment in high school could be perceived as a valid assessment method; 3) the on-line video materials feedback and end-of-project final score were highly consistent. This study also examined the relationships between the types of peer feedbacks in which students obtained from peer assessment and the subsequent performance of their projects. Corrective peer feedback was useful in helping students' development of better projects.

Supporting K-12 STEM reform through K-12 STEM Learning Workshops at Singapore University of Technology and Design

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As our world is facing major technological, economic and social challenges, many governments around the globe have identified deficiencies in STEM education, while on the same time they are considering STEM fields to be the drivers of future technological and economical advancement [1-2]. "As reported through the international literature, countries have developed strategies that propose solutions to these STEM education deficiencies. Strategies have included different specialized programs for the primary, high school, and university education levels"[3].

In 2010, the Massachusetts Institute of Technology (MIT) began collaborating with the Singapore Ministry of Education to create the Singapore University of Technology and Design (SUTD). The goal of this collaboration was the development "of a new engineering-oriented university that will reach the Engineer of 2020 vision, while in parallel addressing the timely formation of an institutional identity and culture that borrows from those of MIT"[4]. Development of SUTD complements Singapore's efforts to reform STEM education both at the pre-collegiate and at the university level. This paper describes why and how MIT has supported K-12 STEM Learning Initiatives at SUTD during the first 3 years of SUTD's life. The workshops presented target K-12 teachers and students.Participant evaluations are also discussed.

Acknowledgements

The authors would like to acknowledge the support and contributions of all MIT-SUTD Collaboration staff members, the SUTD and Design Opportunity Program administrators, as well as MIT and SUTD faculty and staff for assisting in organizing all K-12 STEM Learning Workshops.

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“Creativity & Construction” as part of the orientation program MINTgrün

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Since 2012 the Technische Universität Berlin offers a special one year orientation program called MINTgrün (in English: STEMgreen). It is designed for young people, who just left school and don't know which direction to choose now. The target of MINTgrün is to show them, particularly young women, the countless possibilities of a future in sciences, technology, engineering and mathematics. The students have the advantage to try a lot of subjects, so they can figure out what these topics are actually about. This is important, because a lot of students can't decide about their future, due to the fact that they just have blurry ideas of the exact fields of work. This is also why we offer courses where students can talk to different people working in economics or academics. Additionally we perform alternative ways of teaching by hands-on experience in labs with terms like robotic, construction, environmental research, programming and mathematics. Thereby we expect the students to get a better insight in different academic jobs. [1]

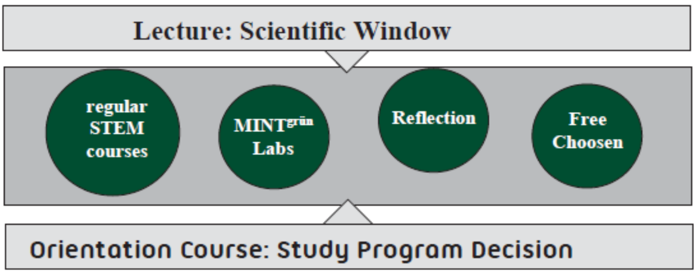

Fig. 1: Structure of the orientation program MINTgrün

In the course “Creativity & Construction” (C&C) the students have to create mechanical machines. After collecting ideas, what machines could be possible the student decides for one to build it in groups. The specialness of C&C is, that the students learn the facts and subject matters while they need it to complete their machines. In this way it is more interesting for them and easier to understand, because it refers to their projects. Also its more fun to create something by your own hands than always to listen to dry facts. Learning-by-doing is also a good way to convince people, who are in doubt about an academic future, because they're afraid of lacking mathematical talents.

The number of students is growing from 77 in the first year, to 177 in the second year and up to 325 in the actual third year. The amount of women grows from 22% up to 34% in the same time. In the last two years we could help a lot of students to choose their future mostly in STEM (up to 75%) or other academic (about 20%) environment but also somewhere else. That's what the challenge of MINTgrün is about.

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The Validity of High School Performance as a Predictor of Undergraduate Engineering Performance

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A critical issue for most undergraduate University programs is the process by which students are selected for admission. Whilst moderated by broader objectives, such as encouraging diversity and recognising previous socio-economic disadvantages, ideally any selection process ought to be able to identify those students who are most likely to be successful in, and suited to, their studies. In previous work [1] two of the authors studied this issue, with a particular focus on correlation between students' performance and their responses to a range of broader questions regarding their motivation and aptitude prior to commencing their
University studies. Nevertheless, the question of the relevance of high school academic performance to university admission remains a subject of active debate (see, for example, chapter 3 of [2]). This paper therefore extends this earlier work, exploring in greater detail the correlation between undergraduate engineering course performance of students and a range of secondary school academic measures, including performance in particular subjects as well as the students' overall ATAR (Australian Tertiary Admissions Rank). The study is based on 5444 students who studied Engineering at the University of Sydney between 2006 and 2014.

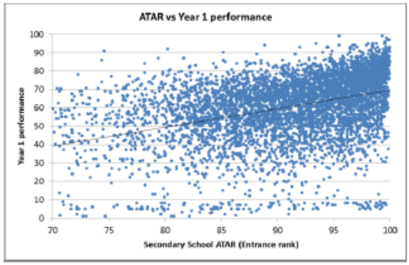

Figure 1: Individual student performance in year 1

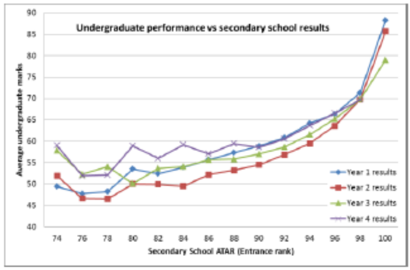

Figure 2: Average student performance in each year

The results suggest that there is a range of performances for students with similar ATAR results (see, for example, Figure 1). Despite this variation there is a significant correlation between ATAR and first year performance (r=0.39) that, as shown in Figure 2, remains relatively consistent throughout the later years of the degree program. Whilst it is important to acknowledge that correlation does not imply causality, this does indicate the value of the ATAR as an indicator of likely undergraduate success. In the paper these issues are explored comprehensively and the implications for student admissions are considered – especially in terms of the evidence for including within the (University) admissions criteria students' choice of, and performance in, particular high school subjects.

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CHAPTER 19

Accreditation quality assurance and globalization of Engineering Education

Developing the Unified Accreditation System for Engineering and Technology Programmes in Russia

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Programme accreditation is considered to be an important aspect of quality assurance of engineering education and is defined as "recognition given to a program as meeting applicable criteria as a result of an evaluation process" [1]. According to the Federal Law "On Education in Russian Federation" professional accreditation of educational programmes should be understood as recognition of quality and level of graduate competencies as meeting the requirements of professional standards and the labor market [2]. Since 2002, the national system for professional accreditation of engineering programmes offered in Russian HEIs has been successfully developing by the Association for Engineering Education of Russia (AEER) that represents the Russian Federation in the European Network for Accreditation of Engineering Education (ENAEE) and is a signatory of the Washington Accord (IEA). In 2013 the AEER accreditation criteria and procedure were updated and elaborated resulting in the development of the unified accreditation system for engineering and technology programmes [3].

The aim of the current paper is to describe the methodology for developing the unified accreditation system in Russian engineering and technology education and to present a review of AEER accreditation system.

The article discusses the current requirements for Russian engineering and technology education and analyzes correspondingly the advantages and disadvantages of the former issue of AEER criteria and procedure. On the basis of this discussion, it underlines the importance of applying the updated AEER accreditation criteria and procedure for quality assurance in Russian engineering and technology education [4]. The developed unified accreditation system provides a common approach to accreditation of educational pogrammes at various levels, which stimulates the coherence of educational programmes for the providing of a single engineering education area in Russia that meets international practice.

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Departmental Refinement Measures for
Engineering Education Accreditation

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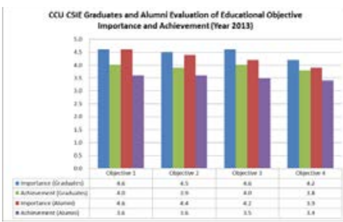
This abstract presents the refinement measures that were successfully enacted in the department of computer science and information engineering, National Chung Cheng University (CCU), Taiwan such that several key point indicators of engineering education were improved by a significant margin. To achieve continuous improvement and to resolve several departmental issues, the following measures were applied for the past decade from 2005 to 2014:

- At least 5 courses should correspond to each educational objective so that no objective is left inadequately covered by the curriculum.
- When a course covers a student outcome, students must be given clear pointers as to how to perform self-evaluations, including the criteria for each level of self-grading so that not only consistency can be achieved in the whole class, but also across the program.
- Student outcome coverage must be consistent across different classes of the same course, given by different lecturers, so that the program can be consistently evaluated.
- Mid-term comments are collected from students so as to allow lecturers to modify teaching techniques and thus perform improvisations on student outcomes.
- Each course lecturer needs to perform self-evaluation after the course ends such that continuous improvement can be followed up. It includes reviews on the student outcome evaluation and teaching method evaluation.
- A course design/study platform is developed by CCU for integration of not only course materials and lecturing information, but also accreditation evaluations, including student outcome selection, criteria specifications, and assessment in each course, and lecturer self-evaluation. Statistics on departmental evaluations are also performed for each semester.

Application of the above measures has resulted in marked improvements in several areas, including the levels of importance given to each educational objective and the levels of achievement for each educational objective. The survey results were performed for each semester by graduating students, as well as, alumni who have graduated for 3 to 5 years. As shown in the following figure, there are significant improvements between two consecutive years, namely 2012 and 2013. As far as graduating students are concerned, the average importance for objectives 2, 3, and 4 increased from 4.2, 4.2, 3.9 to 4.5, 4.6, and 4.2 (out of 5.0), respectively, which is around 7% to 10% improvement. The average achievement by graduating students for the objectives increased by as much as 19% (for objective 4). As far as alumni are concerned, the average achievement increased as much as 13.3%.



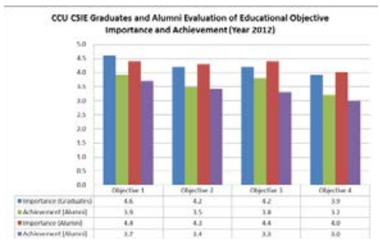


Figure 1. Comparison of CCU CSIE Educational Objective Evaluations

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The introduction of a EUR-ACE based system for Quality assurance and accreditation of Engineering Education in Central Asia: outcomes and lessons learnt

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The introduction and the implementation of easy comparable practices for the accreditation of programmes in the Engineering/Technology field is a mandatory request of the growing worldwide globalization and of the concomitant globalization of the engineering curricula. In this respect the Tempus QUEECA project (Quality of Engineering Education in Central Asia) is presently aimed at setting up and implementing a system of Quality Assurance (QA) ofEngineering Education (EE) in Central Asia (CA) countries (and more precisely Kazakhstan, Kyrgyzstan, Uzbekistan and Tajikistan), finalized to the pre-professional accreditation of engineering programmes (i.e. accreditation of educational programmes as entry route to the engineering profession).

The self-sustainability, and consequently the success, of this strategy has been assured, within the project, thanks to a massive involvement of the relevant actors in all the consortium members' countries. In particular partner countries' Ministries for Higher Education are actively involved in the project in order to comply with legislation obligations as far as Higher Education (HE) system changes are concerned. The involvement of academics and students, at large scale, is ensured, given the project structure, through the active participation of the European partner associations (among which ENAEE and SEFI). These associations can in fact be listed among the main actors in the field of EE with a direct involvement in the accreditation issues.

With specific reference to one of the main priority (governance reform) of the QUEECA project at the present-day it is to report about the substantial correspondence between the project activities and the actual needs and priorities of the partner HE institutions. The creation of national, self-sustainable EE societies and strictly connected accreditation centres in charge with quality assurance and accreditation issues appeared to be a very ambitious goal of the project impacting directly the local university management and governance. The autonomy and the self-sustainability of such bodies will be among the most ambitious goals of the project (as the QUEECA project has to solely transfer know how and encourage capacity building in the concerned countries).

The paper presents the main outcomes and added value of the whole QUEECA project, reporting also about the shortcomings encountered during the project development including the difficulties related to the introduction of a EUR-ACE based system in geographical area subject to several challenges, from the political to the social ones.

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Coaching stakeholders involved in external program evaluations

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Even for higher education institutions (HEIs) experienced with accreditation evaluations, they remain a key moment with high stakes. In Flanders, accreditation is based on periodic program evaluations by an external body. A positive advice by a commission of external experts, appointed by a government organization, is a necessary condition for further accreditation.

Evaluation commissions heavily depend on interviews with stakeholder groups to determine whether applicable standards are met. Time for interviews, however, is exceedingly limited.
Getting the intended impression across can be difficult, especially if the stakeholders are not skilled speakers. Moreover, stakeholders' perceptions may be misinformed. Coaching stakeholders to communicate efficiently has accordingly become crucial for HEIs to receive an accurate evaluation.

This paper describes an approach to coaching based on scientific insights from the fields of social psychology and communication. The approach was adopted for an engineering program located at six campuses, to be visited within the time constraints of four days, including fourteen group interviews with a total of 150 individuals. The subsequent steps in the coaching process are described with reference to supporting scientific theories.

Acknowledgments

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Assessing the role of mechatronics engineering, based on it graduate profile by knowledge areas

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The graduate profile of Mechatronics Engineering students at the Instituto Tecnologico de Estudios Superiores de la Region Carbonifera (ITESRC) marks a clear objective: seeks to train professionals in the creative Mechatronics Engineering.

When they graduate, must have analytical and critical capabilities that enable them to design, project, build, innovate and manage computers and mechatronic systems, in the social and productive sector.

Also they must be able to integrate, operate and maintain equipment, always with an ethical commitment to quality and a framework of sustainable development[1].

All mentioned requirements, were placed on paper when the career began.

Meanwhile, companies are hiring graduates of the specialty, with a desirable professional profile requesting the number of previous skills and some added values, according to their operational needs.

This paper sets out explicitly the extent to which it meets the demands of the labor sector, effecting a qualitative research, supported by the focus group techniques and cross-sectional study.

The impact of the study is to carry out the necessary adjustments on the graduate profile of Mechatronic Engineer, to achieve a comprehensive training consistent with society needs.

What is not measured, it's not controlled, and the ITESRC wants to keep all in control to give a good education service and the best students for society.

[1] **ITESRC.** INSTITUTO TECNOLÓGICO DE ESTUDIOS SUPERIORES DE LA
REGIÓN CARBONÍFERA "Dr. Rogelio Montemayor Seguy". [On line] March 20th 2013. [Cited: March 21st 2013.] http://itesrc.edu.mx/nuevoingreso/meca.htm.

CHAPTER 20

University – Business

Collaborative PhD projects: together towards innovation

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The Delft Infrastructures & Mobility Initiative (DIMI) and Delft Energy Initiative (DEI) of the TU Delft are starting a pilot for PhD students which are not employed at the university, but at a company or a governmental organisation that is interested in the same research themes. These collaborative industry-university PhD projects strengthens the cooperation between the university and industry and this interaction increases the potential for innovation. The ambition to increase Europe's competitiveness by innovating faster based on sound research could become a reality. An important condition, however, is that these collaborative PhD projects with high potential candidates from industry run smoothly. The question is therefore: What does doctoral engineering education for collaborative university-industry projects look like?

I have studied the problems that PhD students already working encounter from the start of their PhD study to the end. The needs of the PhD candidates varies significantly. Some of these problems can be solved easily; others are less easy to solve, since they arise from differences in the domain of practice and the domain of scientific research. Interviews are also held with supervisors at the university and companies in order to recognise the specific needs of each party and be able to (co-)design a tailor-made PhD doctoral engineering programme.
Furthermore, I have looked into the part time PhD programs offered by universities in the Netherlands. I have made a comparison and they turn out to be very diverse.

This paper presents the design criteria of collaborative PhD projects for DIMI and DEI, using the existing literature. Collaborative PhD projects will become an interesting learning process for all parties involved.

Tools and inspiration for engineering education development through stakeholder cooperation

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Conference Topic: University – business: cooperation and inspiration
Keywords: stakeholder cooperation, industry cooperation, inspiration, engineering education

ABSTRACT

This practice-based paper presents the motivation, model and results of national level stakeholder collaboration for the development of engineering education. In addition, it presents how the results have been utilized in a case university. Stakeholder collaboration has been successfully used in the development of engineering education in Finland. University management, teachers, education developers, students as well as partners outside the universities such as industry representatives and policy makers all share an interest and a role in the development of engineering education. The Academic Engineers and Architects in Finland TEK has been active in facilitating the collaboration between key stakeholders, creating networks and forums of cooperation as well as ways of distributing the know-how and best practices of education development.

One of the recent large scale stakeholder forums for was organized together by TEK and The Federation of Finnish Technology Industries in December 2014. The bi-annual two-day event attracted almost 90 representatives of university management, teachers, education developers, students, industry, research centers and policy makers. It is considered as one of the main networking and development forums in the field of engineering education. In addition to the strategic development of universities, the focus was on the future working life competencies; *namely what they are and how can university education produce the skills and competencies needed*. The aim of the event was to create tools and share best practices supporting competencies especially for the following multidisciplinary areas: career planning, sustainable development, innovation and entrepreneurship as well as sales and customer service.

The key findings of the stakeholder workshop indicate that more emphasis should be put on the development of students self-esteem and confidence, communication and networking skills and in general the “Yes, I can!”-attitude. Inspiring and systematic cooperation with industry and other stakeholders, such as visiting lecturers, traineeships, project work and case studies, as well as multidisciplinary team work and utilization of modern teaching technologies and learning facilities are some of the tools to be implemented in engineering education.

In order for the tools to have an effect on education, they need to be put into practice. This paper examines, how a case university, in this case the School of Electrical Engineering in Aalto University, has been implementing new ideas and best practices gathered through collaboration with other universities and stakeholders.

Using common Learning Resources between Academia and Industry: from Practice to Theory

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The current paper is part of a general research work started in 2011. The research project is aiming to make explicit the assumptions and decisions for the design of digital learning resources that would support blended learning in both academia and industry. In particular, we try to understand the influence of human, organizational and didactical aspects on the design of common learning resources for academia and industry.

Using design based research methodology, we have engineered an e-learning module in geostatistics, in real world settings and in collaboration with instructors from industry and faculty members from university. The learning resource, a self-paced tutorial, has been used for blended learning in several institutions: one Higher Education Institution (HEI), three companies and one public research institute so far. The study represents ten blended courses, five at HEI and five professional trainings. In total, 126 students and 31 employees were given the opportunity to use the module. It represents around 120 hours of online learning. The investigation involved mixed research methods, both quantitative and qualitative, to gather and analyze data: interviews, questionnaires and also web analytics to understand how the learners used the online resource.

The paper is divided into two parts. In the first one, we account for the noticeable differences in the observations made within the academic and corporate contexts. To begin, we recall some descriptive statistics concerning the instructors and the learners: their satisfaction level, their preferences and how they used the e-tutorial, including their scores from two embedded quizzes. Besides, we run more advanced statistical analysis, as non-parametric and parametric tests, to understand if statistically significant differences can be found between the groups. When significant differences are found, we use the available qualitative data to further refine the analysis and guide us through an Exploratory Factor Analysis (EFA).

In the second part of the paper, we discuss possible interpretations of these differences and link them to learning theories and principles. We refer to the Knowles' principles for adult learning, to situated cognition and to multimedia learning. All three theoretical frameworks have been found relevant in order to explain some observed differences between the academic and corporate populations of learners and instructors. To finish, we conclude with the possible impact the differences can imply on the Instructional Design (ID) of common resources for blended learning between HEI and industry.

The Main Mode Analysis of University-Enterprise Cooperation on Engineering Education

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Abstract
University-enterprise cooperation to carry out the engineering education is the key to successfully cultivate engineering talents, the design and selection of university-enterprise cooperation mode are directly related to the effectively cooperation of university-enterprise. Based on the author's in-depth analysis and research of university-enterprise cooperation practice, this paper induces the eight types of university-enterprise cooperation mode: systematic and comprehensive cooperation mode; modular cooperation mode; project-based cooperation mode; ordering cooperation mode; cooperation mode of substitution internship; cooperation mode of learning and working alternation; multi major joint cooperation mode; and course replacement cooperation mode.
For each of above modes, the paper gives the clearly definition, specific analysis and evaluation of the features and application condition, including advantages and disadvantages, etc. and points out the problems needed attention when adopting a mode, in order to provide the useful suggestions and reference for higher education institutions to carry out university-enterprise cooperation.

Keywords
Engineering education; university-enterprise cooperation; cooperation mode

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A flow based approach to authentic learning in social oriented teaching

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Flow is a mental state characterised by an experience of peak performance and total concentration when engaged in a task. Studies imply that flow occurs when we perceive clear goals, get immediate feedback in right time and when we experience a balance between the level of the challenge we are exposed to and the level of the skills we posses to meet this challenge. Working in flow creates through concentration and motivation a sense of value and balance, which is essentially worthwhile for the individual [1].
The mental traits described to create flow match well with theories about what facilitates efficient and deep learning. The results from a study made in a fifth-year course in a mining engineering program where the concept of flow is actively used as a strategy in teaching and pared with authentic learning to increase creativity in an open-ended challenge project, indicates that authentic learning under the right conditions create a state of flow within the individual student [2].
In this course the open-ended project is fully developed during a one-week immersion in an actual mining site. That kind of setting implies a high challenge for students who must show different kind of knowledge and skills in order to achieve intended deliverables. The process is highly social and exploits concepts from the communities of practice theory and much of the work is done in groups of students [3]. In a course setting like this it's crucial to understand how, and if, flow also works in groups [4]. Social relations and social processes consume a lot of mental energy during different stages in a group development process and have a server impact on intellectual performance and its quality.
Thus, it has an impact also on learning, creativity, problem solving etc. [5]. In this paper we will continue to discuss how those aspects of teaching can be used actively, and how students react to different attempts from the teacher to create a learning environment, which also take into account the emotional aspects of learning and meta-cognitive processes in order to enhance student motivation and learning outcome. Empirical data from an investigation among the students in the course that pose the case in this paper will be presented, analysed and discussed.

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CHAPTER 21

Integration of research in Engineering Education

Application of Research-Inspired Assessment to Enhance Students Learning in Civil Engineering

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Abstract

The relationship between teaching and research has become a highly challenging issue due to evidence of synergy between them and complexity of integrating them. As reported by Locke [1], the separation of research and teaching could be the result of policy and operational decisions to distinguish the way these activities are funded, managed, assessed and rewarded. However, this would not necessarily excuse higher education institutions from a commitment to optimise the beneficial relations between teaching and research. For example, research conducted by Posch and Steiner [2] at the Swiss Federal Institute of Technology (ETH) in Zurich on innovation for sustainability, concludes that appropriate integration of research and teaching activities leads to mutual benefits for both higher education institutions and students.

In this study an approach introducing research activities in Civil Engineering subjects to enable students to develop skills within critical and creative thinking and being lifelong learners has been developed and evaluated. Research based activities/assessments in two major Civil Engineering subjects at undergraduate level have been introduced, and students' learning process has been monitored and evaluated. The results of this project indicate that by incorporating research components in subjects, research-based learning culture among Civil Engineering students were developed. This clearly gave more satisfaction to the students about the learning experience. Statistical analysis of results indicated that students with better performance in mini-projects performed better in the final exam, which was a totally independent assessment task. In addition, the averaged final exam mark of students with good quality projects was higher than the one for other students.

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The teaching-research nexus in engineering education

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In the academic community there is commonly a belief that there is a strong link between teaching and research that is mutually reinforcing [1, 2]. Empirical studies have however failed to establish any relationship between research productivity and teaching quality [3, 4], but can instead show an evident division of labour among the ranks of faculty [5]. In engineering education there have been evidence of an 'academic drift' implying a shift of focus from industrial practice to esoteric bodies of knowledge [6]. However, concerns have also been raised about a 'curriculum creep' where industrial needs are taking priority over the research links in teaching [7]. Needless to say, engineering education is contended and the teaching-research nexus is being challenged from several directions. But how is this tension perceived and handled by faculty? What incentives are there to promote and to thwart the teaching-research nexus? And which of these are effective in influencing the behaviour of faculty? These are some of the questions we pose in our study.

The study will be conducted on a more general level as how time and responsibilities are managed by faculty but also closer to the practice of teaching and researching, as in how these duties are carried out. The novelty of the approach is to study the connection of the beliefs and opinions of faculty with their actions. We will build our analytical model on developed taxonomies [1, 2, 8] and conduct a case study in two selected environments. The objective is to map different stances and approaches to the teaching-research nexus among faculty and explain the occurrence of these. Our object of study will be a large technical university with a variety of institutional arrangements among the departments for financing and promotion and also varying academic cultures, but within a common organizational umbrella guaranteeing a similar institutional framework.

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A tool to see with or just something to manipulate?
- Investigating engineering students' use of oscilloscopes in the laboratory

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BACKGROUND: The production of knowledge in science and engineering in modern society is technologically embodied. A central characteristics of learners' and professionals' experience of our world in engineering and in most sciences is that experience should not be seen as a direct experience *human – world*, but as an experience shaped by the use of physical and symbolic tools, *human – mediating tools (artefacts) – world*. However, it is common in research regarding students' learning in the laboratory to see instruments and experimental devices as something is just manipulated [1, 2] with no cognitive value [3]. On the contrary I have argued that the technology used in labs, indeed, can be used as tools for making sense [4] and that this can constructively be used in the design of labs [5]. However, in reference [4] I noted that first year engineering students, when using an oscilloscope, mainly were manipulating it with little connection to the real circuit investigated.

PURPOSE: To investigate the differences between novices and more advanced students in the use of the oscilloscope as a tool for measurement and as a (cognitive) tool for understanding.

METHOD: First and third year electrical engineering students courses of action while using oscilloscopes in two different labs were recorded on video and transcribed verbatim. The videos and the transcripts were analysed using methodologies from ethnomethodology and conversation analysis, i.e. focus was on students' practical, contingent and embodied inquiry-

RESULTS: There were a remarkable difference between the first and the third year students. Not only were the more senior students more able and fluent in handling, i.e. manipulating, the oscilloscope but they also (contrary to the case with the first year students) used it as a tool to "see" with, i.e. as a cognitive tool, used to investigate and make sense of circuit behaviour.

CONCLUSIONS: The results further underlines that the active role of instruments and experimental devices [cf. 4, 5] for student learning and discourse can not be neglected and that a materialdiscursive- analysis of learning is indeed needed. To enable improvements and re-design of, for example, labs and teaching materials we need to further investigate the cognitive role of technologies to gain a better understanding. Furthermore, the results points to the danger of drawing wrong or limited conclusions, such as neglecting the cognitive value of technologies, if only novices and younger students are investigated.

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CHAPTER 22

Ethics in Engineering Education

Formal and Hidden Curricula of Ethics in Engineering Education

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In recent years, a commitment to professional ethics and professional responsibility has been included among the learning outcomes required of engineering education programmes in many counties [1, 2].
So, how should engineering ethics be taught? There is evidence - both within engineering education and more widely - that discussing dilemmas in formal education does lead to increases in measured moral reasoning ability [3, 4, 1]. It has also been argued that ethical issues should not be taught as if they are only the individual responsibility of a particular engineer, but should rather be understood as embedded in a broader social and political context within which engineering decisions are taken. This may require more than the introduction of ethics courses; instead, it may require rethinking engineering education [5].

The 'hidden curriculum' concept may be useful in this context. It suggests that, alongside the 'formal curriculum', students also learn some things implicitly through the social and organizational nature of their studies. Hence, discussion of dilemmas that do not have a single clear resolution can seem to students to be out of synch with the culture of engineering education which is often focused on narrowly technical solutions [6]. Similarly, if assessment is highly competitive and individualistic, students may, implicitly, become more self-serving in their decision making. In such contexts, courses addressing ethical issues may be swimming against the cultural tide of the programme as a whole.

This paper explores the role of the hidden curriculum in engineering education, drawing on quantitative data from a very large study of moral reasoning among engineering students (almost 1,000 participants with longitudinal test data at two time periods). The study also uses an innovative measure of moral reasoning (the Engineering and Science Issues Test) [7], which was translated and used in a French language context for the first time.

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E-learning of ethics, awareness, hacking and research by information security majors

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Some earlier courses were reorganized in 2013 to construct a syllabus for the information security major at Tampere University of Technology, a 30 ECTS credit unit package in the 300-cu master's degree. As their other subjects the students may have for instance communications or software engineering, or information management.

This paper describes how the compulsory courses introduce four important but not very technical engineering skills using mainly an e-learning approach. The reasons for such an approach is to save resources in the very beginning – because of the large number of students heading for other majors – and after that to offer flexibility in scheduling to serve the elective courses, as well as the studies of other disciplines – those that provide a need for security.

The four topic areas are *ethics* of individuals and organizations, personal *awareness* of security issues, *hacking*, i.e. offensive way of thinking, and The described introductory stage of exposing the students' minds to these matters does not forget innovativeness, but that remains more in the background before the students start working with cases and hands-on experiments later.

The description covers four separate courses, forming a prerequisite chain. The first and last one are lecture-based and it takes at least two years to pass them; 3–4 years is more normal. The academic units are not essential here. Instead, one of the main points is the repeated exposure to the various ways of thinking. In the following summary of the succession the numbers 1–4 refer to the courses, but they can be just thought of as time-separated occasions:

Ethics: 1. Laws 2. Laws 3. Ethical questions in one's own environment – technology-related ethical questions for individuals – ethical questions for organizations. 4. Interview a security professional, ethical point of view included.
Awareness: 1 & 2. Policies, guidelines and web-sites of security information. 3. Daily observations (own or from news) and actions regarding information security, 4. Campaigns etc.
Hacking: 1. By-pass authentication by changing the source code of a web page. 2. -- 3. Carry out and report an exercise found at one of listed sites, 4. Laboratory exercises in hacking.
Research: 1. Fill in a questionnaire resembling the one from 3rd stage. 2. -- 3. A questionnaire to five acquaintances, completed by interviewing them; deal with the results. 4. Read research papers, interview a security professional trying to generalize together with peers.
The paper explains the rationale of these exposures and how they are delivered. It must be noted that *not* everything is compulsory for passing the courses. The paper reports observations concerning the student choices and feedback. The course #3 appears in its earlier form in
[1].The current version was updated to be two times larger and more professionally oriented.

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Teaching & Learning Ethics in BEng programmes at the Technical University of Denmark

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Since 2008, all BEng programmes at The Technical University of Denmark have been based on the principles for engineering education defined by the international CDIO (Conceive-Design-Implement-Operate) initiative [1]. One of the standards encompasses an extensive "syllabus" that specifies relevant engineering competencies organized in four categories: (1) disciplinary fundamentals, (2) personal, (3) interpersonal and (4) system building skills. While the general aim for the DTU BEng programmes is a full implementation of all CDIO standards, there are still "blind spots" in individual programmes and also across most/all programmes. One issue that has been identified as a generally weak point by the coordinators of the 18-20 BEng programmes is the lack of a structured approach to address ethics (ref. CDIO Syllabus section 2.5[2][3]). A main barrier seems to be faculty members' lack of systematic and profound knowledge about ethics.

Based on these recognized difficulties, a programme coordinators and other faculty members have been involved in a process leading to these conclusions:
(a) Ethics should be acknowledged as a specific academic field of study
(b) By its nature this field of study differs very much from traditional engineering disciplines, and therefore it represents a special challenge for engineering students (and their teachers)
(c) Faculty need support from experts to design and implement teaching activities in ethics
(d) Working with cases is probably the best way of learning to apply ethical reasoning, and the cases should be specific for the individual study programme.
Based on these conclusions, a pilot project has started, involving 4 BEng programmes with the aim of the project of establishing a model for teaching ethics that can be tested, refined and applied to the rest of DTU's BEng programmes. The pilot project runs in the winter/spring 2014-15. It includes two half day seminars for faculty including introductions to ethical concepts, theories and reasoning, discussions of the challenges of teaching ethics [4], and resulting in the development of programme-specific cases. These cases will be imbedded in a one day student seminar for each programme, starting March 2015. Experiences from the pilot project will be reported in the final paper for the CDIO conference 2014, including: learning objectives for students and teachers, programme-specific case descriptions and questions, and evaluation of the first project phases.

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CHAPTER 23

Open and distance learning – MOOCS

Experience of the design of a MOOC in Engineering for the learning of microcontrollers

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In this paper we undertake the problematic of designing a MOOC (Massive Open Online Course) in Engineering and in the learning process of the microcontrollers as element for the control systems. Nowadays the presence of microcontrollers is massive, as well as the number of manufacturers and the existing variety. All this justifies the efforts in the design of an Engineering MOOC about this topic

Recently MOOCs follows in debate, and lately in a growing number. The list of MOOC depending on the main platforms has been studied and it has been observed unfortunately that Engineering is not as present as desired. The difficulty that involves the transmission of knowledge, and mainly the accomplishment of practical aspects using hardware elements, as well as the evaluation of the acquired competences, causes that the MOOC in engineering have not advanced so quickly in comparison with another type of courses. In addition the variety to existing platforms, every time in greater number, commercial and private, adds the necessity of election of one of them for the accomplishment of a MOOC.

One of the main participants in a MOOC is the addressees of the same, the students. In this experience of the design of a MOOC on microcontrollers, students of engineering in diverse aspects participate to consider their point of view. One of them is the measurement of the times of learning.

The problematic of the evaluation of the competences to acquire on developed, always considering the opinion of the students. Also on treats the accomplishment of practices or works of practical, essential in the type of matter that is handled in this MOOC, how in many others of engineering.

In conclusion a summary of the found problems will be realised in the development of the design of the MOOC and possible solutions will be contributed to take to end the accomplishment of a MOOC in Engineering applied to microcontrollers.

Students’ Experiences on Modern Fully Online Introductory Mechanics Physics Course

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A new blended method to study physics was presented by authors in SEFI 2013 – conference [1].
The key points of the method are:

1. The continuous assessment using week exams and group measurement assignments
2. The use of the active engagement learning methods in the lectures
3. The use of video material to push the routine tasks in the web environment

The implementation plan for fully online course applying the method was presented in SEFI 2014 conference [2]. The challenge of the implementation was to convert the active engagement, interaction among students, measurement assignments and week exams into web environment. The first pilot implementation was carried out in the course “Mechanics” – 3 ects, on autumn 2014. The students’ experience on the course and the course’s activities was studied using a questionnaire at the end of the course. The paper presents the main outcomes of the study and conclusions for the further development of interactive online learning.

The pilot course was carried out in Tampere University of Applied Sciences, in its open university. The course was carried out in the time period of 8 weeks. 53 students enrolled the course. 21 students answered the online questionnaire at the end of the course. 14 of the 21 answerers were never studied online before.

The main results could be summarized as following. 19 of the 21 answered students would recommend the course to others, but still 11 students would rather take traditionally face-to-face delivered course. Overall the course exceeded students’ expectations. The students’ opinion about the usefulness of different online activities in the course varied a lot. The activities consisting videos were found the most useful. The great majority of the students found the system of continuous assessment better than the single traditional final exam. The interaction among students and formation of co-working student groups was found the major difficulty in the course. Only a few active groups were formed. Still the majority of the students answered that students should form the groups themselves instead the teacher.

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The Value of Engineering MOOCs from a Learner's Perspective.

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Conference Theme : Open and online education in HEE
Sub Theme: Engineering education as a vector for social advancement
Topics: New education tools for engineering educationOpen and online education, Engineering education research, Continuing and lifelong learning
Keywords: Open and online education, MOOCs, Learner's perspective, Learning analytics

The number of MOOCs offered and the number of universities offering them doubled in 2014 reaching 2,400 courses and 400 universities with millions of students [1].
Also in 2014 there was a strong development of the MOOC ecosystem with better business models, the emergence of alternative credentials, course sequences, and credit for MOOCs. MOOCs can handle things like project based learning and handson science experiments. In this emerging development of Open and Online Education it is crucial to get to know the learner better to be able to improve the design of the MOOC and lower the threshold for the learner to be successful [2].
So who are these tens of thousands of individuals who sign up for free, online courses and what is the perceived value of their participation in such a course?

The focus of this paper is on the perceived value for the learner as experienced in five engineering MOOC courses(2013-2014). To answer this question we applied learning analytics on the collected user data, including qualitative data retrieved from a preand post-survey of in total 139.000 registered students of which 5.070 completed their courses [3].
Thereby we looked at figures concerning the demography and retention, but concentrate on the issues that help to develop a better understanding of the value of the course for the student. These comprise questions on confidence in handling the course, determination to finish, the use of the online forum, social interaction, the relevance of the course for job or other purposes, the challenges like time investment, their expectations and experiences, and if such a course inspired them to continue learning. The paper discusses the outcome and set some conclusions.

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Anytime, Anywhere – The development of an online course in Research Methodologies

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Students when approaching their thesis work are becoming increasingly mobile, planning to their thesis in industry or research institutes abroad. Combined with the freedom in planning that many students at the Faculty of Aerospace Engineering enjoy, students are starting their thesis at any time during the year. As a result there is an increasing demand from students for increased flexibility in the preparatory course Research Methodologies which is mandatory for all Master students at Aerospace Engineering.

To meet these needs an online version of the course was developed to allow for the desired flexibility. This paper will discuss the set up of the online course, details the lecturer's experiences so far and share some of the evaluation outcomes with an aim to inspire other lecturers in setting up online courses to allow for increased student flexibility.

MOOC and Serious Game: a Pedagogy based on Transfer and Action

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The past years have seen the exponential growth of the number of Massive Open Online Courses (MOOCs). Many universities made the move to predominantly address positioning and students' selection concerns. Nonetheless, the components used in a MOOC are still pretty much the same as the ones used in online education: lecture, videos, forums and quizzes.

As an application school in engineering for the energy and transportation sectors, IFP School launched its first MOOC on November 2014. In this paper, we describe how the school challenged the current practices with the design and implementation of a Serious Game over a period of three weeks of the online course. This pedagogical innovation facilitates knowledge transfer through situational learning. Indeed, the Serious Game allows the learners to put their knowledge into practice and to face situations they would face in the industry in their future careers.

The paper is organized in two parts. First, we review the main steps of the project: the educational objectives, the instructional design, the content development, the Serious Game usage and the learners' qualitative feedback. For its first edition, the MOOC has a 31% retention rate on the total number of registered people, a high score considering that the average completion rate for a MOOC is around 10%. According to the MOOC survey, the majority of users considers the Serious Game to be the main positive asset of the course. In addition, partly due to the Serious Game implementation, 49% of the registered people are students under 25 years old, when the average for other MOOCs in France is between 15 and 19%. In a second part, we discuss the characteristics of the Serious Game as it has been implemented in the IFP School MOOC. In particular, we use typological studies on gamification and also multimedia learning to understand if all or part of the components are exclusively related Serious Games theories and principles. Finally, we conclude with the interest of gamification in an application school like IFP School.

CHAPTER 24

Employability of engineering graduates

Employability of engineering graduates – Case: Results of Finnish Engineering Graduate Feedback Survey

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Conference Topic: Employability of engineering graduates
Keywords: employability, career, graduate, feedback, survey

ABSTRACT

This practice-based paper presents the results of a national scale Graduate Feedback Survey on engineering graduates from Finnish universities of technology. The paper focuses on the employability themes; employment situation at time of graduation, employment channels, types of work contracts and assignments and how well the current job corresponds to the area and level of education. The paper also explores how well the university education has provided the necessary professional competencies. The abstract refers to the data collected from the graduates of 2013, but the newest results of 2014 graduates will also be available for the Full Paper. As a result of extensive and longlasting collaboration of key stakeholders within the field of engineering education in Finland, the universities of technology nowadays have a common graduate feedback survey coordinated by Academic Engineers and Architects in Finland TEK. It is worth noticing that all the universities of technology participate in the feedback survey, making it a very extensive research. Answering rate of graduates to the survey has been about 60 %.

According to the 2013 graduate feedback data, 59 % of graduates were employed at the time of graduation. This is 10 % less than the year before and corresponds to the development of the general economic situation. The employment challenge commonly first hits the new graduates. The results of the study reveal that gaining relevant work experience and networks prior to graduation clearly increases the employability. Of the graduates employed at the tie of graduation, almost 80 % had been recruited to the company in which they had made the final Master Thesis or to a company they had otherwise been working for during their studies.
Only less than 20 % of the employed graduates had no prior contact to their present employer.

The growing demands of working life create challenges for engineering education. According to the feedback study, especially communication and interaction skills, creativity and entrepreneurial mindset should be emphasized much more in university education. In addition, working life is undergoing vast structural changes. Even highly educated engineers cannot rely on steady career development or secure employment in the future. Graduates have to be prepared to actively work on their career development and professional competence.
The feedback survey shows that self-esteem, self confidence and other career skills are not enough developed within the current engineering education. A growing amount of engineering jobs will be created in the small and medium sized companies. Their competence and recruitment needs should be taken into consideration much better within the engineering education. This will in the end benefit the individual, industry, economy and society as a whole.

Managing the Multiplicities of Graduate Level Education! Are Master's Students' Expectations Matched by their Experiences?

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With rapid increases in student fees reflecting moves towards a QUASI Market model of Higher Education in the UK and across much of the Western World[1], many universities find themselves having to meet progressively higher levels of student expectations[2]. This is particularly the case at undergraduate level, where increases in fees over the past decade have far exceeded inflation. Yet with so much attention on 'consumer savvy' undergraduates, the question of whether Master's level students' expectations are matched by their experiences is one which remains largely unanswered. Grounded in an empirically grounded approach to learning and teaching developed by the paper authors [3], this paper sets out to being to answer this question. In doing so it makes a distinctive contribution to debates about graduate level engineering education and concludes with a number of recommendations.

Discussion: The 'MSc: Managing Expectations' Project analyses the expectations and experiences of Graduate level Engineering Management Students over a two year period. Focusing on the 'student experience', three main concepts are identified as being particular relevant to enhancing learning [3]: *Relationships: Variety: Synergy*.

Relationships: Based on empirical research, the significance of *Relationships* within the academic environment is discussed with particular attention being paid to the value of students' social and academic support networks, including academic tutoring.

Variety: Grounded in a statistical analysis of 'engagement data' together with survey and interview findings, the concept of *variety* critically examines students' perspectives and experiences of different approaches to learning and teaching.

Synergy: Possibly the most important concept discussed within this paper, the need for constructively aligned curriculum is extended to reflect the students' *apriori* knowledge and experience as well as employer and societal demands and expectations.

The conclusion brings the different concepts within the discussion together, providing a set of practical recommendations for colleagues working both at graduate and undergraduate level.

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Development of a broad and approachable format for didactic professionalization in a multicampus context

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During the last decade the need for didactic professionalization at universities has increased.
Since the early 2000s, an increasing number of workshops, seminars and conventions were organized to enhance the teaching skills of lecturers and faculty members of the faculties of
Bioscience-engineering, Engineering Science and Science. These professionalization activities consisted of different formats, and were supported by both university broad and discipline specific educational services within the university.

Soon the three abovementioned faculties started to collaborate, as a fair amount of professionalization demands were identical within the different faculties. However, a need for a more tailored and approachable format was felt. This need was urged by the establishment of two new faculties, Architecture and Engineering Technology, also causing a geographical expansion from one to seven campuses.

This paper elaborates on the development and benefits of an alternative peer-to-peer format, including the implementation of video-conferencing technology and adjustments to anticipate new trends in educational development or organizational preconditions. A SWOT-analysis of the current format is conducted, taking into account participation rates, opinions and findings of participants. Finally possible improvements and future plans are discussed.

Higher Education Institutions as Key Actors in the Global Competition for Engineering Talent – Germany in International Comparison

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In order to prevent the forecasted shortage of highly qualified labour in technical professions,
Germany and other industrialized nations show increasing interest in strategies of controlled immigration, one being the recruitment of foreign students: Many European countries are seizing the opportunity to attract international students to enter their workforces after graduating from their universities [1]. Those students are assumed by employers to have gained knowledge about culture and language of their host country. Therefore, the above mentioned strategy appears to be valuable for OECD countries in general [2].

In Germany, the legal conditions for working in the country as foreigners have become more relaxed during the last decade. This is especially true for workers in engineering professions from the new EU-member states. In case of third country international students, the law is generally in favour of those who have obtained a degree in Germany [3]. In fact, according to OECD reports, the largest share of highly qualified immigrants who come to Germany nowadays is due to academic migration and the implementation of international study programs [4]. Since the General Agreement on Trade in Services (GATS) and the introduction of Bachelor and Master degrees throughout the European Union via the Bologna Process, the recognition of foreign degrees has become much easier. Due to the good reputation of its academic system and no or rather low tuition fees, Germany's higher education institutions already belong to the most attractive worldwide for foreign students [5]. By offering international study programs in technical subjects and natural sciences, German universities are trying to attract international students who have already obtained a bachelor's degree in their home country and who might decide to stay in Germany after graduating.

This paper describes the political and economic influence on the higher education system and legal developments regarding foreign students in Germany. With a special focus on academic migration in engineering education and the STEM fields, it aims to analyse the position of Germany within the global movements of educational mobility. It deals with the implementation of international study programs in technical disciplines and considers the perspectives of international students who are enrolled in such programs in Germany.

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CHAPTER 25

Poster session

Industry collaboration in a Master degree

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The education of future engineers requires of knowledge and abilities to be updated and adapted to the industry where they access with technical responsibilities. This education needs the industry's cooperation in the teaching activities in a direct and continues way, especially in a Master degree, whereby students will achieve specialization.
The Master in Maintenance Engineering of the School of Design Engineering since its beginning in 2006, has been practicing this industry collaboration in the education of its students and in paper we show its best practices/internships that have caused it to be awarded as "Best Master of the Polytechnic University of Valencia" during 2013/14.
Within this master students perform internships at several companies, as is the case of vehicle inspection facilities and buses of the Municipal Transport Company of Valencia. Likewise, for all courses, two seminars are being organized, one dedicated to the Energy and the other to the Maintenance, in which the most relevant industry professionals and Spanish public administration participate. They expose the latest technological advances and the most trending topics, noteworthy is the participation of companies known as Iberdrola, Repsol, RENFE , Red Eléctrica Española, etc.
Additionally, it is made clear the importance of work experience inside companies to students as a manner of putting into practice their knowledge, acquire required skills to elaborate industrial projects and show their abilities to join the labour market. These work experiences extend from 4 to 6 months in a variety of industrial sectors: industry, agricultural cooperative, fleet of transports and etc.

“A la Modes:” The Role of Expressive Modalities in the Teaching and Learning of Design Thinking

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Over the past two decadesand in the sciences especially, there has been a growing research interest in gaining insight into how the various expressive modalities -- linguistic, visual, aural, spatial, actional -- are all used to facilitate teaching and learning. Charles Goodwin in an early and seminal article entitled “Professional Vision” suggestsat least one of the primary motivations when he states that we should see such research as contributing “to efforts by… practice theorists…to develop…informed analyses of human action and cognition as socially situated phenomena. [1] I am interested in how various modalities facilitate teaching and learning in design, specifically how they foster indeed embody design thinking. More generally, I am interested in “how humans [in this particular case, one teacher and one student use those modalities to] make meanings, represent and respond to these meanings, and rework the meanings” related to design thinking and how they co-create an experience of design [2].

I begin my paper by introducing an emerging research methodology, multimodal (inter)action analysis, that is “squarely situated in [the study of] practice.” [3] [4] It is a methodology that has grown out of interactional sociolinguistics and a focus on “real-time interaction;” mediated discourse and nexus analysis and an “emphasis on mediated action;” and multimodality with its attention to the semiotics of the above mentioned modalities. [3] Next, I describe how a teacher and student in a one-on-one 26 minute interaction in a junior-level Industrial Design course coproduce an understanding of ***simplicity*** – a concept relevant to this particular instance of design thinking – through their multimodal (inter)action. [5] Indeed, I show that “significant pedagogic work is realized through … [the complimentary use of] a range of [different] modes.” [6]
Finally,because I hope that my research will contribute to the work of practice theorists as well, I use the co-production of the concept of simplicity to debunk the “entrenched view … that everything that needs to be conveyed [in a teaching/learning context] can be [by] using language.” [2] And, I offer an alternative view, one that highlights the “transformative action of [socially situated] individuals” and how their shaping and reshaping of the modalities necessary for developing design thinking might encourage life-long learning strategies more conducive to professional practice. [2]

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Computational Fourier Optics Simulation using a virtual laboratory

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In this work we present a virtual laboratory developed in MATLAB GUI (see figure 1) (Graphical User Interface) to be used in Photonic Devices course at the Design Engineering School (Valencia, Spain) as a computing tool which allows doing different Fourier optical computation. The Fourier analysis is widely used in theoretical systems and any optical systems can be easily described in the Fourier domain.
The program enables to create imaging simulations that include diffraction and aberrations and create an optical propagation/diffraction computer simulation. With this program the appearance of any image can be computed only convolving the initial object by the Point Spread Function (PSF) of a determined optical system. The PSF is obtained from the aberration map which is provided by commercial machines as do the interferometers and the aberrometers.
As an example, this virtual laboratory allows the students to know objectively how an optical system, such as an ophthalmic lens, provides the appearance of a determined scene or optotype. Moreover, the software allows visualizing what kind of aberrations affect more to the image quality, the interaction among them and the effect of the pupil size in the final image.

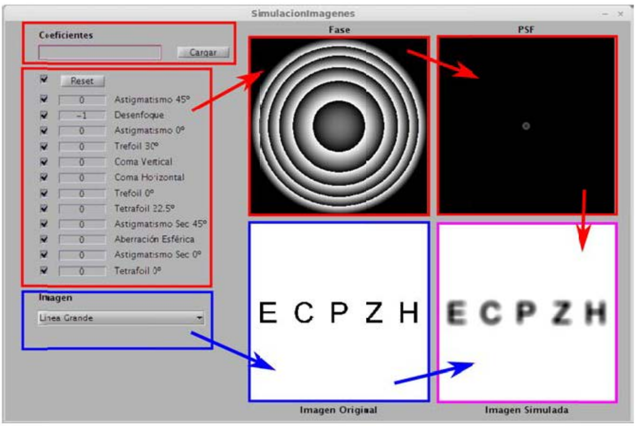

Figure 1: Graphical User Interface of the virtual laboratory

Teaching sustainability to Industrial Engineering students

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The complex issue of sustainability has increased its importance in companies' strategy. The competencies and skills required to industrial engineers have changed accordingly: industrial engineers must now address issues such as eco design, certifications, information flows streamlining, life cycle assessment and processes and products innovation. Hence, in view of a continuous renewal of teaching, the change of some essentially descriptive classes on industrial technologies has been pursued. As the crucial importance of cross-disciplinary and multidisciplinary nature of the topic, the new classes have been designed focusing on the complex issue of sustainability, especially in its environmental and socio-cultural aspect.

The content and teaching methodology have been defined assessing which skills neo engineers should have in order to successfully address the dynamic and proactive sustainability of a company. The main purpose has been highlighting both the close links between market dynamics, research and creative development and productive processes and the effects that these connections lead on business organizational models. That is to improve sensitivity to the recent need of Italian companies to contain the consumption and the costs of energy and water and deal with wastewater management.

As its great economic and social importance in Italy, the classes focus on the fashion industry (textiles, clothing and tanning / footwear). In addition, the Italian fashion industry (from processing of fibers to weaving, from finishing to the finished garment) has worked on reducing the environmental impact of its processes and on the traceability of its supply chain in order to restore its competitiveness in the global context. Such a new approach calls for new ways of relating between textile companies and fashion companies with chemical and mechanical textile to share the common goal of ensuring fashionable products with a high level of aesthetics and quality but with reduced environmental impact.

Finally, the class underlines the lack of standardization in the sustainability processes (except for some large companies) and that sustainability is an question that requires collaboration of multiple figures and constant transfer of information and data collection methods: a stimulating issue for young engineers.

On the application of e-learning in engineering education

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This paper is focused on the applications of e-learning in engineering education. The School of Engineering of the University Carlos III of Madrid has developed e-learning technologies for both distance and blended learning.

The use of e-learning technologies in engineering education has been applied for different purposes in the last few years [1]. Open Course Ware (OCW) and Massive Open Online Courses (MOOCs) provide greats opportunities for distance education. Free educational materials are available to enhance engineering learning worldwide. Universities are using OCW and MOOC courses to spread their knowledge to thousands of students around the world.

However, e-learning can be also used to improve traditional face-to-face learning [2]. Blended Learning is a learning model that combines traditional learning methods with online education materials. The face-to-face learning can be enriched with e-learning technologies to optimize classroom time and to improve learning experience [3]. Small Private Online Courses (SPOCs) can be used to organize blending learning. Online videos, evaluation tests, and simulations can be included in SPOC courses to enhance traditional teaching.

The application of blended learning to improve engineering education requires facing numerous difficulties related to students, teaching staff, and institutions [4].

Blending learning implies a student-centred teaching method. The main advantages are that students are responsible for their learning process, their motivation is encouraged, and teachers can provide a more personalized attention to students.

From the teacher point of view, blending learning requires an extra work. Teachers have to design and create online materials, to monitor students progress, and to change the teaching methodology to include the e-learning technologies in the classical classroom.

Institutions have to create new facilities to produce online materials. However, the most important role of the institutions is the motivation of their staff to collaborate in the development of these new methodologies.

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Teaching Circularity using CES EduPack

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In a world of finite resources, a new systematic perspective that replaces the concept of waste with one of restoration and reduces the use of raw materials is of great interest. One such perspective known as circular economy is restorative by intent and design. Materials use and engineering will play a key role in the transition to this concept. Hence, helping engineering students to understand circular economy and its implications is an important part of Sustainable Development and Design teaching.

Closing loops of material flows is central to Circular Economy. These loops can be analysed in terms of mass flow, if you are interested in resource issues or logistics, but also in terms of, for example, energy use, carbon emissions or cost. In this presentation, we have explored a way to use the Eco Audit tool from the widely used CES EduPack educational software as a means to analyse the latter properties based on a Bill of Materials of a given product, some basic production data and product life scenarios. This can be called a Circularity Audit. A linear Eco Audit represents the *Cradle to Grave* properties (energy, carbon footprint, and cost) of a product estimated for the: *Materials production*, *Manufacture*, *Use* and *Disposal* phases as well as total *Transports*. In order to analyse the full loop, estimated *Grave to Cradle* properties have to be considered, which is possible for the scenarios of *materials recycling* and *product re-use*.

Circular economy metrics for product design have recently been developed by the Ellen MacArthur Foundation and Granta Design in collaboration funded by Life+1. They include a Material Circularity Indicator (MCI) that allows assessment of the circularity of a product and the tracking of progress towards more circular design.

In this paper, we have prepared two examples of how to use the Eco Audit tool and MCI to analyse a closed loop and circularity properties, in order to help students learn more about product life options. Firstly, we show a comparative set of Eco properties and cost across the product lifecycle, for the four end of life scenarios. Secondly, we show the total Eco properties, cost and MCI information over a product's lifecycles starting from the first, linear life, through an evolution of lives: reuse, remanufacture, recycle. This approach is useful to introduce the circularity concept to engineering students for a number of reasons, including constrained resource awareness, Design for Sustainability and introduction to product lifecycle management concepts.

1 The Circularity Indicators Project funded by Life+, more information here:http://www.ellenmacarthurfoundation.org/business/metrics

An ontology to understand curriculum change: a case study of comparing 3 course programme overhaulsat within the Dutch 3TU coalition.

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The 3TU coalition consists of the three universities of technology in the Netherlands: Delft, Eindhoven and Twente, which are all all-round engineering universities. The universities decided to strengthen engineering research and education in the Netherlands by collaborating and learning from each other in the Centre for Engineering Education (CEE). In the CEE, the three universities work on joint research and development projects with a special focus on studying and enhancing engineering education in a structured way.

The project reported in this paper is set up within the framework of the 3TU CEE and pertains to curriculum change in the three participating technical universities. . In recent years the three universities overhauled their bachelor programmes to improve the learning experiences of the students and, ultimately, improve graduation rates and diminish time to graduation.
Such curriculum changes are usually not documented in such a way that the process and outcomes can be easily understood and that limits the capacity of an organisation to learn from them. In this CEE research project, the overhaul processes are mapped, evaluated and compared ex post facto. The goal of this effort is to collect and share experiences and ideas on course programme development and implementation and to isolate effective practices.

To achieve this, an ontology of factors influencing a curriculum change process needed to be developed, to allow comparison across the research sites. This ontology was designed to help map and evaluate effective practices for design and implementation of changes in course programmes, but also to help understand what interventions are effective in terms of improving student success.

The special focus in this project is the uniqueness of developing engineering course programmes. Engineering is an interdisciplinary field where scientific knowledge is applied knowledge to design solutions to solve complex problems in an engineering kind of way (see e.g. Godfrey & Parker, 2010; Graham, 2012). This creates many challenges for those who design course programmes, but also forthose who implement such a programme.

In this paper we describe the elements of the ontology and the scientific basis for inclusion. We also describe how the ontology fits in with the research methodology of the project.

Employability of engineering graduates – Case: Results of Finnish Engineering Graduate Feedback Survey

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ABSTRACT

This practice-based paper presents the results of a national scale Graduate Feedback Survey on engineering graduates from Finnish universities of technology. The paper focuses on the employability themes; employment situation at time of graduation, employment channels, types of work contracts and assignments and how well the current job corresponds to the area and level of education. The paper also explores how well the university education has provided the necessary professional competencies. The abstract refers to the data collected from the graduates of 2013, but the newest results of 2014 graduates will also be available for the Full Paper. As a result of extensive and longlasting collaboration of key stakeholders within the field of engineering education in Finland, the universities of technology nowadays have a common graduate feedback survey coordinated by Academic Engineers and Architects in Finland TEK. It is worth noticing that all the universities of technology participate in the feedback survey, making it a very extensive research. Answering rate of graduates to the survey has been about 60 %.

According to the 2013 graduate feedback data, 59 % of graduates were employed at the time of graduation. This is 10 % less than the year before and corresponds to the development of the general economic situation. The employment challenge commonly first hits the new graduates. The results of the study reveal that gaining relevant work experience and networks prior to graduation clearly increases the employability. Of the graduates employed at the time of graduation, almost 80 % had been recruited to the company in which they had made the final Master Thesis or to a company they had otherwise been working for during their studies.
Only less than 20 % of the employed graduates had no prior contact to their present employer.

The growing demands of working life create challenges for engineering education. According to the feedback study, especially communication and interaction skills, creativity and entrepreneurial mindset should be emphasized much more in university education. In addition, working life is undergoing vast structural changes. Even highly educated engineers cannot rely on steady career development or secure employment in the future. Graduates have to be prepared to actively work on their career development and professional competence. The feedback survey shows that self-esteem, self-confidence and other career skills are not enough developed within the current engineering education. A growing amount of engineering jobs will be created in the small and medium sized companies. Their competence and recruitment needs should be taken into consideration much better within the engineering education. This will in the end benefit the individual, industry, economy and society as a whole.

Using common Learning Resources between Academia and Industry: from Practice to Theory

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The current paper is part of a general research work started in 2011. The research project is aiming to make explicit the assumptions and decisions for the design of digital learning resources that would support blended learning in both academia and industry. In particular, we try to understand the influence of human, organizational and didactical aspects on the design of common learning resources for academia and industry.

Using design based research methodology, we have engineered an e-learning module in geostatistics, in real world settings and in collaboration with instructors from industry and faculty members from university. The learning resource, a self-paced tutorial, has been used for blended learning in several institutions: one Higher Education Institution (HEI), three companies and one public research institute so far. The study represents ten blended courses, five at HEI and five professional trainings. In total, 126 students and 31 employees were given the opportunity to use the module. It represents around 120 hours of online learning. The investigation involved mixed research methods, both quantitative and qualitative, to gather and analyze data: interviews, questionnaires and also web analytics to understand how the learners used the online resource.

The paper is divided into two parts. In the first one, we account for the noticeable differences in the observations made within the academic and corporate contexts. To begin, we recall some descriptive statistics concerning the instructors and the learners: their satisfaction level, their preferences and how they used the e-tutorial, including their scores from two embedded quizzes. Besides, we run more advanced statistical analysis, as non-parametric and parametric tests, to understand if statistically significant differences can be found between the groups. When significant differences are found, we use the available qualitative data to further refine the analysis and guide us through an Exploratory Factor Analysis (EFA).

In the second part of the paper, we discuss possible interpretations of these differences and link them to learning theories and principles. We refer to the Knowles' principles for adult learning, to situated cognition and to multimedia learning. All three theoretical frameworks have been found relevant in order to explain some observed differences between the academic and corporate populations of learners and instructors. To finish, we conclude with the possible impact the differences can imply on the Instructional Design (ID) of common resources for blended learning between HEI and industry.

Integrating foreign studies within the constraints of European Harmonisation: a BIM e-learning course

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Working on international projects with project partners from all over the world is common practice in almost all engineering disciplines nowadays. To prepare students for this part of their professional life a study period abroad is probably the most effective way. Spending several months in a foreign country will teach future engineers not only the necessary language skills but will also lead to an understanding of cultural differences which can be crucial for their professional success when collaborating within multinational engineering projects.

At the University of Kaiserslautern we developed a curriculum for a M.Sc. program for Facility Management at the faculty of civil engineering, starting in fall 2015. To address the requirements of future workplaces, we decided to integrate international studies into the third semester of a two years program.

Integrating foreign studies as mandatory part of the curriculum following the stipulations of European Harmonization is not as easy as the inventors of the European Credit Transfer System (ECTS) intended. We found two main barriers to the implementation of a study period abroad: 1. A full semester of studies at a foreign university requires partner universities, which offer 30 ECTS in courses that fit into the overall program at the home university. 2. Foreign institutions of higher education often require high tuition fees. Grants and other funding options are often not accessible to foreign students. In Germany, education is usually tax-financed and free of tuition fees.

For the new M.Sc. Facility Management we decided to use a mixed strategy to integrate foreign studies, project oriented teamwork and globalization into our education concept. Beside 12 ECTS credit points that have to be obtained from international studies we offer several e-learning courses that students should take during this period and which explicitly reinforce the learning goals of project oriented teamwork in a globalized environment.

The Building Information Modelling (BIM) e-learning course is a sound example of how these soft skills can be combined with teaching an innovative, technology-oriented approach that will play an important role in future civil engineering practice.

With BIM, future buildings are represented as digital models, which can be shared and exchanged among project participants, between different software applications and across the entire building lifecycle. Due to the improved exchange of information using digital means, the construction domain can seize the benefits of global networked cooperation.

By teaching the BIM method in the context of a specific project, the learning effect is twofold:
Students can embed the theoretical foundations of BIM into practical application, and they are introduced to the complexity of cross-project workflows with various different stakeholders – a fragmentation which is characteristic of construction projects. Finally, from a pragmatic point of view the BIM method enables the students to work together in teams across time zones and to stay connected during the period abroad

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