European Practices

Deliverable 1.2 - Report on study of best European practices in teaching engineering disciplines and teacher competence enhancement

March 2019

Co-funded by the Erasmus+ Programme of the European Union

Project Acronym	EXTEND
Project full title	Excellence in Engineering Education through Teacher Training and New Pedagogic Approaches in Russia and Tajikistan
Project No.	586060-EPP-1-2017-1-RO-EPPKA2-CBHE-JP
Funding Scheme	Erasmus + KA2 - Capacity Building in the field of Higher Education
Work Package	Work package 1 – WP1
Task Title	Task 1.3 Desk and field study of EU best practice in teaching engineering disciplines and teacher enhancement approaches. Inventory of the best European teaching methodologies of engineering disciplines
Task Coordination	Mordovia State University, Saransk / University of Minho, Portugal
Outcome ref.nr.	Deliverable 1.2
Status	Final
Dissemination Level	National

Revision Sheet

Version	Date	Author (Partner/Person)	The revision reason
1	18.02.2019	Tatiana Salimova, Elena Soldatova	First version. Draft version – WP1_T1.3_D1.2 Sent for UMinho team feedback
2	11.03.2019	Rui M. Lima, Diana Mesquita	Second version. Draft version – WP1_T1.3_D1.2 To present and discuss at Riga Meeting
3	14.03.2019	Tatiana Salimova, Elena Soldatova, Atoev Shohrukh, Rui M. Lima, Diana Mesquita	Third version. Final version – WP1_T1.3_D1.2 Including inputs from all partners.
4	15.03.2019	Tatiana Salimova, Elena Soldatova, Atoev Shohrukh, Rui M. Lima, Diana Mesquita	Fourth version. Final version – WP1_T1.3_D1.2 after approval of the consortium with minor changes.

Table of Contents

List of Tables

Lists of Figures

1 WP1 – Task 1.3 – Outcome 1.2

WP1 is aimed to provide comparative analysis of the best European practices in teaching engineering disciplines and teacher competence enhancement. Inventory of tools, methods and approaches utilized by European universities for teaching engineering disciplines in higher education institutions is presented. The study covered the following advanced technologies and teaching methods of European education: academic mobility system, European Credit Transfer System (ECTS); project-based learning, practice oriented approach, student-centred approach, personalization, active and interactive learning (computer simulations, business and role play, case study, brainstorming etc.); blended and e-learning. Another issue presented in the report is the study of the European experience in teacher competence enhancement with the focus on teachers in engineering disciplines.

The current report presents an analysis of the 35 best European practices in teaching engineering disciplines, including 19 organizational approaches for teacher competence enhancement, being part of the WP1 progress tasks. Thus, this report starts with a context background regarding to the current state about implementation of teaching and learning methods and engineering education and background for the selected methodological approach. This methodological approach draws on a qualitative analysis of teaching and learning best practices selected by the EU project participants. These set of best practices were analysed and the discussion of the results. A set of recommendations are also presented as guidelines to take into account for the development of EXTEND centres.

2 Context Background

In the context of the project, task 1.3 intends to provide a comprehensive analysis of the EU best practices in teaching engineering disciplines and teacher enhancement approaches. The Bologna declaration and further the Budapest-Vienna Declaration (2010) encouraged strategies that enable student and staff mobility, improve teaching and learning in higher education institutions, enhance graduate employability and provide quality higher education for all. At the same time, the quality of education and student-centered learning are key landmarks in development of Universities (Salimova, 2014, Salimova & Vatolkina, 2010, Salimova & Vatolkina & Makolova, 2014). In the EU, the modernisation of higher education has been acknowledged as a core condition for the success of the Lisbon Strategy (2000) and more recently the Europe 2020 strategy and ET 2020. The European Union has been preoccupied with harmonizing their higher education systems (which of course include engineering education as well),while also trying to preserve each country's identity.

The changes started from matching the regulatory framework and the structure of education programs. The processes of globalization, digitalization of society, cross-border flow of capital, goods, services, people and ideas, together with rapid technological developments, transforms occupations and the skills needed in the labour market. It creates pressure on Higher Education systems to respond quickly to changing skill needs and to renew their qualification requirements, training programmes and curricula.

Fourth Industrial Revolution is the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres. The speed of current breakthroughs has no historical precedent. When compared with previous industrial revolutions, the Fourth is evolving at an exponential rather than a linear pace. Moreover, it is disrupting almost every industry in every country. Digital fabrication technologies, meanwhile, are interacting with the biological world on a daily basis. Engineers, designers, and architects are combining computational design, additive manufacturing, materials engineering, and synthetic biology to pioneer a symbiosis between microorganisms, our bodies, the products we consume, and even the buildings we inhabit. And the breadth and depth of these changes herald the transformation of entire systems of production, management, governance and education (Schwab, 2016)**.** Overall, the inexorable shift from simple digitization (the Third Industrial Revolution) to innovation based on combinations of technologies (the Fourth Industrial Revolution) is forcing High Education Institutions to reexamine the way they train.

Engineering Education can be seen as a set of teaching and learning processes for the development of engineering competences at all levels of training: initial, postgraduate and continuing. It is related to the teaching processes of concepts, techniques, competences, attitudes and values related to the professional practice of engineering. In other words, it is related to the development of the capacity to mobilize all these resources in real contexts, to solve problems, using several areas of science and different technologies to support the society (Lim, 2015; UNESCO, 2010).

The engineer of next generation will need to learn much new technical information and techniques and be conversant with and embrace a whole realm of new technologies. Similarly, one must consider the several elements of the engineering education system, to include: the teaching, learning, and assessment processes that move a student from one state of knowledge and professional preparation to another state; students and teachers/faculty as the primary actors within the learning process; curricula, laboratories, instructional technologies, and other tools for teaching and learning; the goals and objectives of teachers/faculty, departments, colleges, accreditors, employers, and other stakeholders of engineering education; the external environment that shapes the overall demand for engineering education (e.g., the business cycle and technological progress); and a process for revising goals and objectives as technological advances and other changes occur (National Academy of Engineering, 2005). Engineering education integrates research and practice to accelerate innovation and improve the quality and diversity of engineering graduates entering the professional world of engineering (Lim, 2015). This field of knowledge is transversally related to all areas of engineering and have been gaining an exponentially increased interest in the last decade (Lima, de Graaff, Mesquita, & Aquere, 2018).

But despite obvious increase in attractiveness for young people engineering education is still facing many challenges in different countries. Post-socialist countries are witnessessing dramatic changes in higher education caused by the transition toward a market-driven economy. Universities have had to adjust to a new life. They have needed to search for new sources of funding and involve teachers / researchers into entrepreneurial activities. The HE system of Russia has gone through a series of structural reforms in the past 20 years, notably moving within a still largely centralized system towards a greater university autonomy in the 1990s, and then through a reestablishment of federal control by means of new forms of state management. In 2003, Russia joined the Bologna process and went through a complex and radical structural transformation, replacing traditional diploma training (for engineers it took 5–6 yearsof training) with the two-tier system (Dobryakova & Froumin, 2010).

Obviously, these system-wide changes influenced Russian engineering education. It had big difficulties adjusting to the Bologna process but gradually many universities introduced two-tier programs in engineering. Moreover, they struggled with the lack of funding for new equipment and found creative ways to raise money through tuition and partnerships with business. There are a number of studies of the changes in the governance, structure and funding of engineering education (Dezhina & Froumin, 2004, Mesyats & Pokholkov, 2003). These studies demonstrate that almost all Russian engineering schools have adjusted their organizational structures to the new rules of the game. They have increased the intake of students in the market relevant areas and built partnerships with local, national and multinational companies. In 2006 about 22% of Russian students (more than 1.6 million) are enrolled in engineering and technical fields; this share has declined over the last decade (from 33% in 1995) (Education in Russia, 2007). Drop-out rate among students majoring in engineering is almost 25%, employment rates for bachelor graduates decreases due to unwillingness of industry to employ engineers with 4 years of education, teaching staff is ageing (average age – 52 years in RF and 56 years in TJK) and universities fail to create an effective system to retain young PhD graduates in engineering disciplines to perform teaching and research. One of the major unsolved problems behind these challenges is the deterioration of teacher training system in the universities and irrelevance of teaching methods employed for engineering disciplines. However, despite the problems and challenges engineering education faces in Russia in recent years, it begins to gain interest again. Thus, in 2015, 28.8% (153.3 thousands of people) of the total student enrollement in higher education were majoring in engineering (bachelor's, master's and PhD programs) in Russia (Education in numbers, 2018).

According to the research conducted in the National Development Strategy of the Republic of Tajikistan untill 2030, higher education, including the engineering discipline, is poorly integrated with scientific activities which adversely affects the quality of training and at the same time reduces the potential of preparing qualified specialists.

The EU universities have a large experience in the creation and implementation of modern teaching methods including project-based learning, practice-oriented approach, e-learning, student-centered approach and many others. It is very important in the context of new challenges to analyse the best European practices in teaching engineering disciplines and teacher competence enhancement and find out the solutions for transformation Russian`s Engineering Education. This purpose is crucial in order to prepare future engineers to face the challenges of their practice. In fact, the professional practice requires the combination of different competences and, for that reason, they must be included in the curriculum. However, the curriculum and the pedagogical practice are not always aligned with this purpose (Jackson, 2012; Markes, 2006; Nair, Patil, & Mertova, 2009; Stiwne & Jungert, 2010; Tymon, 2013). In short, for an understanding about the curriculum it is essential to understand it as a project that includes the teaching and learning experiences, the process of its development - design, development and evaluation - and the following key elements - objectives, content, resources, assessment and teaching and learning strategies (Barnett & Coate, 2005; Biggs, 1996; Zabalza, 2009).

The research in Engineering Education is strongly linked to the engineering fields (Bernhard, 2015) and to the improvement of education of engineers and the research interest is being even higher when referring to Active Learning in Engineering Education (Lima, Andersson, & Saalman, 2017). Active learning is related to all learning environments and approaches that create meaningful learning experiences. These learning experiences should be based on relevant experiences related to the professional practice, using adequate learning environments that give context to learning, and in that way create energy and motivation for the engagement of students. Finally, real deep learning will happen when students are able to critically analyse their own learning (Bonwell & Eison, 1991; Christie & de Graaff, 2017; Felder & Brent, 2003; Prince & Felder, 2006). The increased interest in Active Learning is related to fact that strong evidences support the effectiveness of the application of these principles, when supporting learning processes and competences development (Freeman et al., 2014; Prince, 2004).

Recently, the New Engineering Education Transformation (NEET) initiative from the Massachusetts Institute of Technology (MIT) developed a report about the global state of the art in engineering education (Graham, 2018). This report studied the current organization leaders, the emergent leaders and the future direction for the engineering education field. This is a report based on interviews with representing key-persons from those institutions. This approach returned some notable results related to the need to evolve towards "socially-relevant and outward-facing engineering curricula", emphasizing student choice, multidisciplinary learning and societal impact (Lima & Mesquita, 2018).

3 Methodological Approach

Particularly this report will focus on task 1.3. The output of the task will contribute to tasks 1.4 and 1.5. In the scope of this project, the diversity of approaches in teaching engineers to be analysed implies a definition of multiple sources and methods, as recommended by Wolf et al. (2006). With this in mind, the team of the project used a methodological framework called Deming cycle (PDCA circle). The argument for choosing this methodological pattern is that Deming cycle is widely used in different areas in its original or modified form. Besides being an effective process improvement guide, it offers a systematic improvement method. The Deming cycle informs future improvement by providing feedback and maintains order during strategic planning, decision making and problem solving (Divjak & Ređep, 2015).

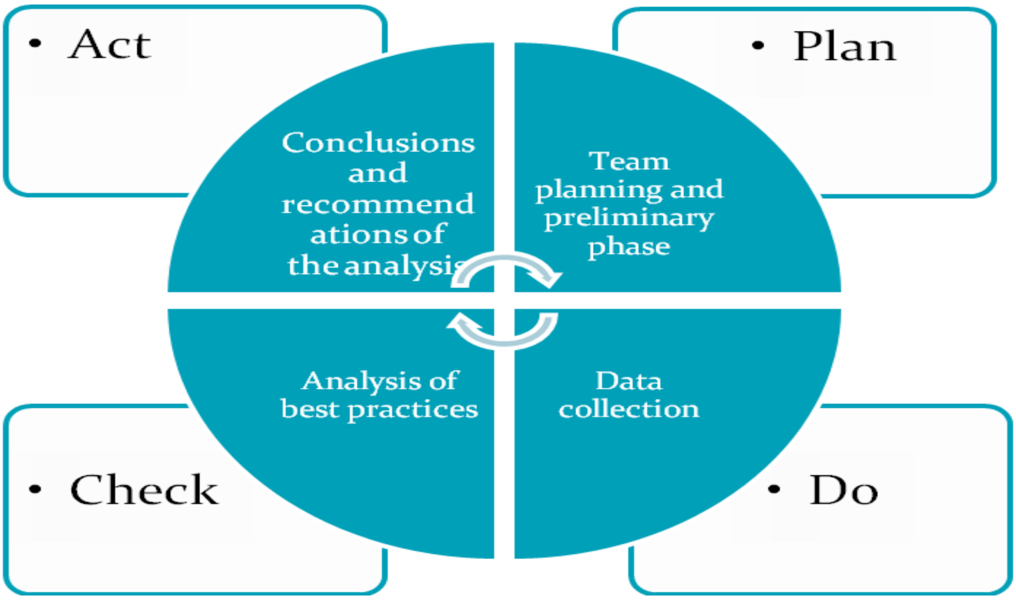


Figure 1. Deming cycle

As planned in this task, there is the need to collect European best practices information, including teacher development approaches and teaching methods used in training of engineers. In the first phase (Plan) the WP1 team developed (Figure 2) instruments for collecting information.

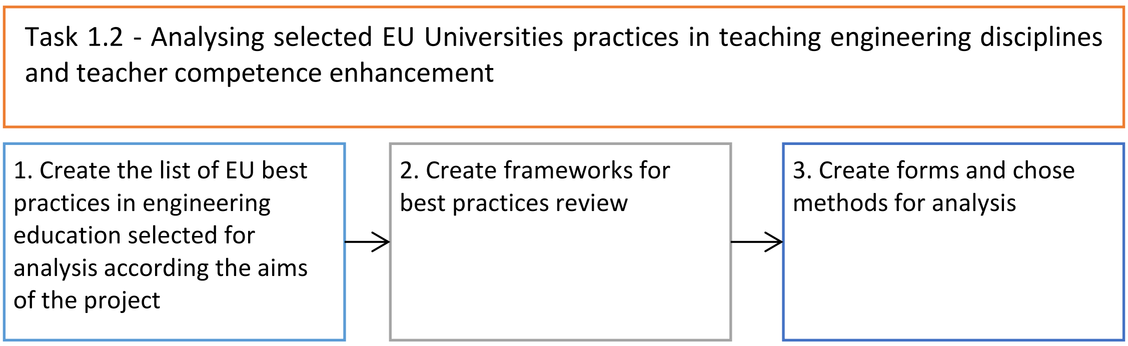


Figure 2. Preliminary phase for data collection (Phase Plan)

To achieve the objectives of task 1.2, the first step would be to establish a definition of best practices, secondly to define quality criteria that categorize the various practices. Thirdly, a methodology to evaluate practices collected against those quality criteria will be developed. For the aims of the project "a best practice" is defined as a relevant teaching and/or learning tool/method/approach/structure implemented in a real life setting in education of bachelor, master or PhD degree students majoring in engineering at one or several EU universities and which has been favourable assessed in terms of adequacy (ethics and evidence), effectiveness and efficiency related to process and outcomes. Other criteria are important for a successful transferability of the practice such as a clear definition of the context, sustainability, intersectorality and participation of stakeholders (Criteria to select best practices, 2017). The best practices described in the chapters below meet also the follow requirements: a multidisciplinary approach, a breadth of education, leadership on the national level. Identification and selection of best practices were based on expert opinion of EU and PC Universities project team members following the criteria's mentioned above. The list of 28 best practices provided by the EU Universities partners was created for further analysis. It is important to highlight that excellence in engineering education depends on structural and context issues. According to the approach, it was decided to consider examples of successful approaches of teaching professional development and of teaching methods in engineering education in EU. Two frameworks (templates) were defined for best practices review (depending on the methods/tools/approaches used in teaching engineering disciplines and teacher competence enhancement). Next step in carrying out the report is creating forms and choosing methods for analysis.

3.1 Methodology steps

Figure 3 presents a simple process model followed by the team, during the execution, analysis and development phases.

In Step 1 the team collected qualitative information about EU best practices in teaching engineering disciplines and teacher competence enhancement using the frameworks previously defined. It is important to highlight the fact that the best practices collected by the EU project partners were divided in two groups. The first group includes the EU Universities experience regarding organizational approaches to teacher professional development like setting up centres, platforms, networks and activities aimed at governance, research and development, Life Long Learning, internationalization and mobility, curriculum development and delivery, University Business cooperation. The second group combines best practices focused on using a wide variety of active learning strategies, which were classified and defined according to a predefined glossary (Table 1). The active learning is an approach to learning in which teaching is prepared in order to engage students in the learning process, by creating meaningful learning contexts. These learning contexts allow students to understand the relevance of *what* they learn and *what for*. An Active learning environment includes enthusiasm, energy, engagement and action. Critical thinking about learning is also a key-issue (Bonwell & Eison, 1991; Christie & de Graaff, 2017; Prince, 2004; Prince & Felder, 2006). Different methods and principles can be used as referred by (Lima, Andersson, et al., 2017).

Step 2 is analysing best practices collected using two forms (according the frameworks) and content analysis. The forms allowed to collect qualitative data based on experts' opinion. This data was then analysed using content analysis strategies. For data analysis, a content analysis (Miles & Huberman, 1994) was carried out to identify recurring topics as well as contrasting patterns amongst teacher development approaches and teaching methods. Step 3 included identification of the gaps between the EU Universities best practices and Russian and Tajikistan realities in training engineers and development of recommendations for adaptation and possible dissemination of the identified European approaches in the practice of the Russian project partner universities. This step assumed the using of the maturity grid as an assessment tool. The concepts of process or capability maturity are increasingly being applied to many aspects of product/process/organization/structure/ development, both as a means of assessment and as part of a framework for improvement. Maturity models have been proposed for a range of activities including quality management, software development, supplier relationships, product development, innovation, product design, collaboration and education. The principal idea of the maturity grid is that it describes in a few phrases, the typical behaviour exhibited by an organization at a number of levels of 'maturity', for each of several aspects of the area under study. This provides the opportunity to codify what might be regarded as good practice (and bad practice), along with some intermediate or transitional stages. (Fraser & Moultrie & Gregory, 2002). According to the aims of report the most common maturity grid - Quality Management Maturity Grid is used. This maturity grid was developed by Ph. Crosby (Crosby, 1979) It describes, in a few phases, the typical behaviour exhibited by an organization at five levels of 'maturity', for each of estimated object. The Crosby Maturity Grid had a strong evolutionary theme, suggesting that organizations were likely to evolve through five phases - Uncertainty, Awakening, Enlightenment, Wisdom, and Certainty – in their ascent to the excellence. The using of this tool allowed to identify the gaps between the European and Russian practices and approaches in training engineers.

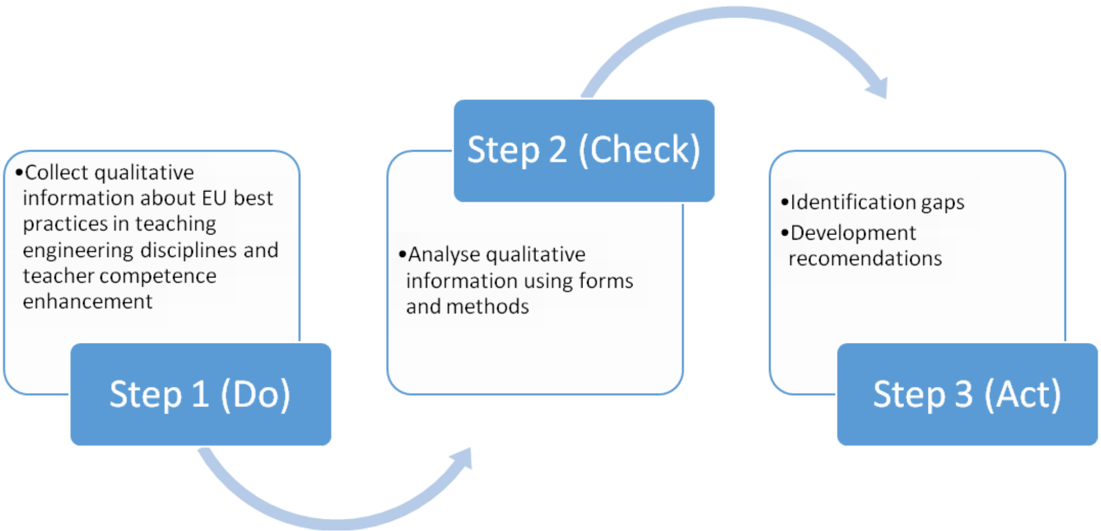


Figure 3. Execution, analysis and development phases (Phases Do, Check, Act)

Table 1 presents active learning strategies classified and defined as: Problem-Based Learning (PBL); Project-Based Learning (PBL); Gamification; Team Based Learning; Work Based Learning; Research Based Learning. This list represents some of the most common active learning approaches but some other approaches can be considered during the analysis phase.

Table 1. Glossary of Active learning strategies

CONCEPT	DESCRIPTION
Problem-Based Learning (PBL)	Is an educational approach whereby the problem is the central point of the learning process (Graaff & Kolmos, 2003). The type of problem is dependent on the specific learning environment, but are usually presented as a case, based on a real life issue or a realistic approach. The problems are selected and edited to meet educational objectives and criteria. It is crucial that the problem serves as the basis for the learning process, because this determines the direction of the learning process and places emphasis on the formulation of a question rather than on the answer. This also allows the learning content to be related to the context, which promotes student motivation and comprehension. It is essential that the directing force is consistent with the way the assessment drives the educational method.
Project-Based Learning (PBL)	Is a Problem-Based Learning approach, in which teams of students must develop a solution for a problem. Thus, this also an approach based on real life issues, where the problem is ill defined and the students must be able to define the problem before developing the project solution. Dealing with an open problem, teams of students can develop several different solutions that may not even be expected by the teachers (Edström & Kolmos, 2014; Lima, Da Silva, Van Hattum-Janssen, Monteiro, & De Souza, 2012; Powell & Weenk, 2003). Teachers act as coaches, mentors or supervisors, depending on the phase of the project and the specific learning environment. In most situations, a Project-Based Learning approach is developed during a period of time longer (e.g. semester) than Problem-Based Learning (e.g. 4 weeks) (Graaff & Kolmos, 2003).
Gamification	Gamification is the use of game design elements characteristic for games in non-game contexts, in order to o increase user experience and engagement. This is not the same as serious games because the learning activities may not include simulation nor competition (Zichermann & Linder, 2013).
Team Based Learning	Team-Based Learning is an evidence based collaborative learning teaching strategy designed around units of instruction, known as “modules,” that are taught in a three-step cycle: preparation, in-class readiness assurance testing, and application-focused exercise. A class typically includes one module (Haidet, McCormack, & Kubitz, 2014). TBL combines small and large group learning by incorporating multiple small groups into a large-group setting (TBLC, 2018).
Work Based Learning	Is the term being used to describe a class of university programmes that bring together universities and work organizations to create new learning opportunities in workplace. Typically, this may include the following types of activities: visits to professional places, networking interaction opportunities, and project-based learning approaches in interaction with external organizations (Boud & Solomon, 2001).
Research Based Learning	Curriculum is designed around inquiry-based activities in order to create and develop new knowledge. The focus of learning through inquiry; the teacher-student division minimised and students are engaged in research practice (Healey & Jenkins, 2009; Healey, Jenkins, & Lea, 2014).

Finally, an integrated discussion and recommendations was developed and presented in the last section of the report.

3.2 Data Collection Summary

The following tables summarise the data collected and analysed in this report. Table 2 refers to the data of 35 cases of best practices that were proved by EU partners and analyse in this report.

Table 2. Summary of the EU best practices analysed in this report

COUNTRY/UNIVERSITY	TEACHER PROFESSIONAL DEVELOPMENT APPROACHES	ACTIVE LEARNING STRATEGIES
Latvia/RTU	6	
Latvia/RTU, University of Latvia, Switzerland	1	
Nordic countries/Technical Universities	1	
Germany/TUD	2	
Germany/KIT	1	
Global/Oracle	1	
Romania/UPB	3	
Sweden/ITU	1	
Portugal/ UMinho		4
Poland/CUT		1
Netherlands/DUT		1
Denmark/AAU		1
UK/UCL		1
France/IPG		1
Denmark/DTU		1
Finland/TU		1
Netherlands/MU		1
United Kingdom/UW	3	4
Total	19	16

The 35 best practices analysed in this report are from the following EU universities:

- Teacher professional development approaches: RTU–Riga Technical University, UPB – University Politehnica of Bucharest, TUD -Technical University Darmstadt, KIT – Karlsruhe Institute of Technology, UW – University of Warwick.
- Teaching (and learning) methods: UMinho - University of Minho, CUT - Częstochowa University of Technology, DUT- Delft University of Technology, AAU- Aalborg University, UCL - University College of London, IPG – Institut Polytechnique de Grenoble, DTU – Technical University of Denmark, TU- Tampere University, MU- Maastricht University, UW – University of Warwick.

Table 3 summarizes the data of the European best practices based on organizational approaches to teacher professional development, considering the main features of each approach (centres, platforms, networks or activities).

Table 3. Summary of the European best practices in Teacher Professional Development Approaches analysed in this report

UNIVERSITY/BEST PRACTICES	CENTRES	PLATFORMS	NETWORKS	ACTIVITIES
RTU/EngineeringHighSchool	Governance LLL			
RTU/*Design* Factory	R&D CDD UBC			
RTU/UseScience		R&D CDD Governance		
RTU, University of Latvia /Center of High Energy Physics and Accelerator Technologies	R&D CDD I&M			
Nordtek Network			Governance I&M	
RTU/Latvenergo Creative Laboratory	Governance LLL UBC			
RTU/Alumni Association			Governance	
RTU/International Week				LLL I&M
TUD/INGENIUM - International Career Researchers	R&D I&M			
TUD/Center of Educational Development and Technology	Governance LLL I&M			
KIT/From Graduation to professorship	R&D LLL I&M UBC			
Oracle academy		R&D CDD LLL I&M UBC		
UPB/Summer Schools				R&D UBC
UPB/Entrepreneurship Centre, UPBIZZ	CDD I&M UBC			
ITU			LLL I&M	
UPB/Campus UPB	R&D UBC			
UW/Higher Education Academy Recognition	R & E			
UW/ Warwick International Higher Education Academy & Warwick Award for Teaching Excellence	R & E			
UW/ Education innovation Group	Governance CDD			
	12	2	3	2

R&D - Research & Development. UBC – University Business Cooperation. CDD - Curriculum development and delivery. I&M - Internationalization and Mobility. LLL - Lifelong Learning, R & E – Recognition and Engagement

Table 4 summarizes the data of the European best practices based on institutional environment to teacher development approaches, considering the main features of each approach (centres, platforms, networks or activities).

Table 4. Summary of the European best practices in using Active learning strategies analysed in this report

University/ Best practices	Problem Based Learning	ProjectBased Learning	Gamification / Serious Games	Team Based Learning	Work Based Learning	Research Based Learning	Various approaches
UMinho/Industrial Engineering and Management Integrated Master (4^{th} Year, 1^{st} semester)		V					
UMinho/: Industrial Engineering and Management Integrated Master (1^{th} Year, 1^{st} semester)		V					
UMinho/Several engineering programs		V					
UMinho/Several courses related to Lean Manufacturing concepts			V				
CUT/Master in Management and Production Engineering			V				
DUT/Faculties in engineering, applied science and design							V
AAU/Educational programs adopted a purely Problem-Based Learning (PBL) approach.	V	V					
UCL/Integrated Engineering Program		V					
IPG/Master in Industrial Engineering – Sustainable Industrial Engineering program					V	V	
DTU/: General Engineering programme (BSc)		V				V	
TU/International Degree Programme in Science and Engineering, BSc							V
MU/: Data Science and Knowledge Engineering		V					
UW/: Engineering Degree Apprenticeship					V		
UW/: Reflective Practice & Learning Logs							V
UW/: Signature Pedagogies & Design Thinking							V
UW/: Self-Assessment							V
Total	1	7	2		2	2	5

4 Results – best practices analysis

In this section the results from EU best practices analysis in teaching engineering disciplines and teacher competence enhancement will be presented. The analysis focuses on the information collected (as mentioned in the methodological approach) and is organized considering the categories defined based on the scope of EXTEND project. Thus, the description includes the identification of teacher development approaches, active learning strategies, an overview of the organisational and teaching context and key-dimensions regarding to how it works in practice (e.g. activities developed, teacher role).

4.1 Best Practices analysis – Institutional Environment for teacher competence enhancement

A total of 19 best EU practices represent structural approaches. In 12 of them, it is possible to identify that centres are key structure for training engineers and teacher development. On the base of the centres all kinds of activities are performed: Research & Development, Governance, Curriculum development and delivery, Lifelong Learning, Internationalization and Mobility, University Enterprise Cooperation, Recognition and Engagement. Usually centers are structural units of the Universities. The RTU Best Practices 1, 2, 4 and The WU Best Practice 30 (see appendix) present experiences for setting up centers connected with different fields in engineering aimed to teacher competence enhancement and support the design/ re-design of new/revamped courses and innovations. For example, the Best Practice 1 is aimed at carrying out core pedagogical skills by teaching young high school children. In RTU Best Practice 2 the ability to apply teacher's theoretical knowledge to practical tasks, prototyping, testing new designs, working with advanced hardware and software solutions is showed. The Best Practices 4 and 6 are focused on Research & Development activity and the University Enterprise Cooperation as key drivers for boosting the next generation of technologies. Regarding to the TUD Best Practices (see appendix practices 9 and 10) it is important to highlight that both cases deal with methodological upgrading that covers the provision of such services as: e-learning tools and methods, evaluation and counselling, interdisciplinary projects in the entry phase of studies, qualification for studies and careers via tutor qualification and key competence strategies. KIT Best Practice (11 in appendix) is an example of the academic and research institution that focuses on research oriented teaching, strong science-industry relations and an internationalization edge. These targets are underpinned by consistent policy making likely to promote life-long learning, comprehensive advanced training, unrestricted exchange of know-how, and a sustainable innovation culture. It provides young scientists different kinds of support aimed at competence enhancement in all career phases, from graduation to professorship, by customizing offers to individual scientists with focus of interdisciplinary approach. UPB Best Practices 14 and 16 serves as an educational and research centres for students, teachers and scientists. They provide great opportunities for research and development activities based on multi – and inter- disciplinary technologies and collaboration between University and companies. Best Practices 3 (RTU UseScience) and 12 (Oracle Academy) refer to the resource facilities with open access to a variety of services, hardware and software to be used in engineering education. They are an excellent examples of collaboration between research personnel, scientific institutions and enterprises with the aim to develop the existing and create new competitive products and technologies with high added value. The Best Practices 5 and 15 (see appendix) is focused on the development of an international collaborative environment (network) for research, innovation and education within interdisciplinary areas providing clustering and knowledge exchange between technical universities, high tech industries and the local community in different development projects. Finally regarding to the Best Practices 7, 8 (RTU) and 13 (UPB) – see appendix – it is interesting to identify the examples of extra-curricular activities based on the developing contacts, knowledge and support. These activities facilitate cooperation among different stakeholders –students, teachers, alumni, Universities units, employees aimed at obtaining and reinforcing experience based knowledge. The WU Best Practices 31 and 35 (see appendix) are aimed at recognition of the teachers who have made outstanding contributions to learning and teaching and spread effective learning and teaching behaviours around the university.

4.2 Best Practices analysis – Active Learning Strategies

A total of 16 best practices were selected in Europe. For 7 of 16, PBL model is defined as dominating. At the same time a wide range of strategies such as work based/ research based / problem based learning are used. For a better understanding about the teaching and learning experiences of The European universities, some common elements were identified amongst them. First, all PBL models described presents an interdisciplinary approach. For instance, the project development in the context of Best Practice 1, 2 and 3 (UMinho), includes incorporating the knowledge and competences inherent to all courses studied by the students in the semester. For instance: "Organization of Production Systems, Information Systems for Production, Production Integrated Management, Ergonomic Study of Workplaces, Simulation and Integrated Project on Industrial Engineering and Management". The projects carried out at specific programs of University of Minho, explore an interdisciplinary approach characterized by the integration of content of different courses in the project, which implies a collaboration amongst the course teachers. It is worth mentioning that PBL is used in different years of the programs. The experience of UMinho shows an excellent example of applying the strategy for both the first semester and the final semester. The difference is in the content of the approach. What is specific for the first semester is that a teacher-centred theoretically-driven approach dominates (students are provided with «a learning project guide, which is a document prepared by the coordination team.... In this document students find information about the PBL learning methodology, the teachers' contacts, tutor information, learning outcomes of each course (including of the project), scheduled classes and project milestones, assessment model and physical resources (e.g. room project, lockers,…) and e-learning platform». The interdisciplinary approach is also maintained by incorporating students from different engineering degrees in the project teams. Applying PBL in the final semester implies more autonomy (in some cases even self-governed group work) and much more responsibly of students for the solutions resulted in the projects.

Second, most of PBL models include close collaboration with internal and external stakeholders. The coordination team usually includes teachers, tutors and educational researchers from different schools/departments maintaining a wide diversity of ideas and experiences. In some cases (Best Practice 8) special universities units provide students with teaching, learning and training support within the project development. Collaboration with companies, high schools or media partners within project development allows to open the university to "outside", providing suggestions and solutions for real problems. For that reason, collaboration is a key/element in these models, not only in terms of collaboration between team members, but also with other stakeholders.

Some cases show a great combination of active learning strategies. For instance, the experience of Aalborg University (Best Practice 7) is based on Project and Problem based learning in with project work based on authentic problems. It offers a complex environment, engaging students in real contexts and give them the opportunity participate in interdisciplinary activities and develop their professional skills in the real-word.

Serious games it is an approach implemented at UMinho (Best Practice 4) and Częstochowa University of Technology, Poland (Best Practice 5) implies to use different type of equipment, tools and materials and have a strong hand-on simulation nature. In this contexts, students can visualize, touch, reflect about the content through the experience of learning by doing. Thus, students plunge into real practice through hands-on approaches.

Best Practice 9 (Institute Polytechnique de Grenoble) and Best Practice 30 (University of Watwick) focuse on work-based learning which is quite related to the *practicum*. In this case, external stakeholders are also actively involved in tutoring and mentoring of students projects. In this case, students are encouraged to go inside of an industrial company or research institutes, during one semester, to focus on a research problem or to develop an innovative idea.

The Best Practice 10 (Tampere University) presents an Active Learning approach, in which students are challenged to work in both ways - independently focusing on their own needs, motivations and expectations and taking responsibility for their studies and in close collaboration with their fellow students communicating and working as part of a group. There is a wide range of activities that can be selected: workshops, events, conferences, social projects, etc. Finally, Best practices 33 and 34 are focused on developing student's imagination and creativity, empowerment and engagement.

5 Discussion and Recommendations

The report developed in this part of the project had the intention to find out the gaps between the EU Universities best practices and Russian and Tajik realities in training engineers and possible dissemination of the identified approaches. The contextual background allowed to identify some trends in EU engineering education. It is important to point out that there are two key components in teaching engineering disciplines and teacher competence enhancement. They are institutional environment for teacher competence enhancement (as centres, platforms, networks and activities) and active learning strategies to be implemented in the classroom (such as project and problem based learning, gamification, team-based learning, amongst others).

The results of the analysis show that EU approach to creating the environment for teacher competence enhancement is similar to Russian Universities approach. Nevertheless, the Russia University centres' activities are mostly focused on the Research and Development. Part of them implement the strategy of Internationalization and University Enterprise Cooperation carrying out research projects (Maykova & Okunev & Salimova & Soldatova, 2017). In terms of active learning strategies, all kinds of methods are used by Russian Universities but the levels of maturity in applying them are much different. The report team ranked the maturity of using the methods (Table 5).

Table 5. Active Learning Strategies Maturity Grid with regard to Russian Universities practice

METHOD	UNCERTAINTY	AWAKENING	ENLIGHTENMENT	WISDOM	CERTAINTY
Problem-Based Learning (PBL)			While going through teaching and training learn more about the method benefits. Opening gambit		
Project-Based Learning (PBL)			While going through teaching and training learn more about the method benefits. Opening gambit.		
Gamification		Recognizing that the method may be of value but not willing to use it			
Team Based Learning		Recognizing that the method may be of value but not willing to use it			
Work Based Learning			While going through teaching and training learn more about the method benefits. Opening gambit		
Research Based Learning				Implementing and deployment the method at all	

				levels of the educational programs	
Various approaches (combination of previous methods)			While going through teaching and training learn more about the method benefits		

**Uncertainty*- no comprehension of the necessity in using the method; *Certainty*- proficiency and sustainability in using and applying of the method

Table 6. Active Learning Strategies Maturity Grid with regards to Tajik Universities practice

METHOD	UNCERTAINTY	AWAKENING	ENLIGHTENMENT	WISDOM	CERTAINTY
Problem-Based Learning (PBL)			While going through teaching and training learn more about the method benefits.		
Project-Based Learning (PBL)		Recognizing that the method may be of value but insufficient competence of the teachers is an obstacle for making advances			
Gamification			While going through teaching and training learn more about the method benefits. Opening gambit		
Team Based Learning		Recognizing that the method may be of value but not willing to use it			
Work Based Learning			While going through teaching and training learn more about the		

			method benefits. Improving.		
Research Based Learning		Recognizing that the method may be of value but the technical capacity is limited to use it			
Various approaches (combination of previous methods)		Recognize that the methods are of value but limited technical base and low competences to use them.			

Ranking active learning strategies reveals that most of methods are not new for Russian and Tajik universities and tend to the levels of Awakening and Enlightenment. With this in mind, a set of recommendations will be presented.

Recommendation 1:

Develop Institutional environment potential for teacher competence enhancement in Russian Universities not only in the field of Research and Development but more actively in other fields (Governance, LLL, Internalization and mobility, Curriculum development and delivery, University Enterprise cooperation). The EXTEND centres in Russian Project Partner Universities could provide these opportunities. A comprehensive analysis of EU best practices selected for the aims of the project partially confirmed the impact of the institutional environment on the teacher competence enhancement. In 9 of 16 practices regarding to institutional environment it was possible to identify that centres are key structure for training engineers and teacher development. On the base of the centres all kinds of activities are performed - Research & Development, Governance, Curriculum development and delivery, Lifelong Learning, Internationalization and Mobility, University Enterprise Cooperation

Recommendation 2:

Develop Active Learning Strategies such as Problem-Based Learning, Project-Based Learning, Gamification, Team Based Learning, Work Based Learning and Research Based Learning in Russian Universities in a more effective way.

One of the main results of this analysis shows a strong focus of the European engineering programs on Project-Based Learning (7 out 12 examples). At the same time a wide range of strategies such as work based/ research based / problem based learning are used. PBL models described presents an interdisciplinary approach. Most of PBL models include close collaboration with internal and external stakeholders. The coordination team usually includes teachers, tutors and educational researchers from different schools/departments maintaining a wide diversity of ideas and experiences.

The Active Learning Strategies Maturity Grid with regard to Russian Universities practice shows the gap in using these methods. Most of them are at the low or medium levels is attributable mainly to the institutional reforms in Russian Higher Education in recent 15 years. But there is a great potential for applying wide diversity of active learning strategies in teaching engineering disciplines in Russia.

Recommendation 3:

Develop active learning approaches with strong University Enterprise collaboration to get closer to the needs of realities and future challenges in Industry.

Another emerging trend recognized in the conceptual background is the need to create explicit curricular links with external agents, namely with industrial companies. The European Union initiative, University-Business Cooperation (UBC) (Davey et al., 2011) describes the need to develop graduates' competences aligned with the needs of the labour market. The interaction between engineering educational programs and external agents and industrial companies can be developed by visiting industries, invite professionals or key agents of the society to deliver seminars, integrate internships and work-based learning in the curricula, or developing projects to deal with real industrial or society problems (Lima, Dinis-Carvalho, et al., 2017). Some of the best practices show interactions with industrial companies or other external stakeholders. A strong recommendation would be to boost close partnership between industrial companies and Russian Project Partner Universities.

Recommendation 4:

Higher Education Institutions should support and promote continuous professional development of teachers, for sustaining the change of teaching and learning methods in direction of more effective approaches. The great majority of higher education (HE) teachers in Russian Universities did not have pedagogical training previously to engage in their professional activity as teachers. Nevertheless, there is currently a strong trend on continuous professional development of teachers. It is important to highlight the necessity to develop institutional environment and provide sustaining continuous evolution of active learning methods in engineering education. The EXTEND centres set up within the project will contribute to strengthening mastery of active learning methods and best pedagogical practices in engineering education.

Recommendation 5:

Considering the results of the maturity grid research based learning is in early stages of development among Tajik teachers, according to Tajik academia the main barriers for making advances are weak human resource i.e. low qualified teachers and insufficient technical capacity such as laboratories, access to scientific literature, research grants, etc. Moreover, it should be noted that there is no clear system for organizing advanced training and retraining of teaching staff in engineering subjects. Therefore, creation and support of integrated scientific and educational institutions, universities and inter-university complex, scientific-educational and industrial centres is required. In addition, it is very important to develop RD centres in HEI's, integrating research and practice in order to create a real environment, both for academic staff and students. The EXTEND centres in Tajikistan Project Partner Universities could provide these opportunities. Additionally, it is expected to develop Active Learning Strategies such as Problem-Based Learning, Project-Based Learning, Gamification, Team Based Learning, Work Based Learning and Research Based Learning in Tajik Universities in a more effective way. This effort will make the curricula more attractive since the data provided by the State Agency of education quality control under the Ministry of Education and Science of the Republic of Tajikistan (MESRT) indicates that the lack of interest to Engineering areas is due to old and not attractive teaching methods. Moreover, engineering pedagogy should be prioritized as fundamental of RD with an increase in the concentration of scientific potential. Furthermore, an analysis conducted by MESRT indicates that some of the graduates from engineering fields were not successful in finding jobs due to their limited capabilities. The research indicates that there is huge demand to link engineering education to business sector through modernization of the curricula. It is needed to enhance entrepreneurship and management as additional competences among students in engineering fields. In this context, problem and project based learning and gamification are effective learning methods to develop the competences of engineering students.

This report, developed as a result of EXTEND project Task 1.3, presented and analysed a set of selected best practices in teaching engineering disciplines and teacher competence enhancement from European Universities. The analysis and the recommendations presented in this report create the basis to incorporate the practices in the reality of Russian and Tajik Universities.

6 References

Barnett, R., & Coate, K. (2005). *Engaging the Curriculum in Higher Education*. Maidenhead: Open University Press / Society for Research Into Higher Education.

Bernhard, J. (2015). *Is Engineering Education Research Engineering?* Paper presented at the 41st SEFI Conference (pp. 8), Leuven, Belgium.

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education, 32*(3), 347-364.

Bonwell, C. C., & Eison, J. A. (1991). *Active Learning: Creating Excitement in the Classroom*. Washington DC: ERIC Clearinghouse on Higher Education.

Boud, D., & Solomon, N. (2001). *Work-Based Learning: A New Higher Education?* : Taylor & Francis

Christie, M., & de Graaff, E. (2017). The philosophical and pedagogical underpinnings of Active Learning in Engineering Education. *European Journal of Engineering Education, 42*(1), 5-16. doi:10.1080/03043797.2016.1254160

Criteria to select best practices in health promotion and cronic disease prevention and management in Europe (2017). Retrived from https://ec.europa.eu/health/sites/health/files/major_chronic_diseases/docs/sgpp_bestpracticescriteria_en.pdf

Crosby, Philip B. (1979) Quality is Free, New York:McGraw-Hill

Davey, T., Baaken, T., Muros, V. G., & Meerman, A. (2011). *30 Best Case Studies of Good Practice in the Area of UBC within Europe*. In Todd Davey, T. Baaken, M. Deery, & V. G. Muros (Eds.), Retrieved from http://www.ub-cooperation.eu/index/casestudy

Dezhina, I., Froumin, I. (2004). Engineering education in Russia and its relation to innovation activities. From Knowledge to Welfare: Integration of Science and Higher Education for the Development of Russia. World Bank, Moscow, 278–318.

Divjak, B.,Ređep, N., B. (2015). Strategic Decision Making Cycle in Higher Education: case study of e-learning. International conference on E-learning

Dobryakova, M., Froumin, I. (2010). Higher Engineering Education in Russia: incentives for real change. *International Journal of Engineering Education, 26(5), 1032-1041.*

Edström, K., & Kolmos, A. (2014). PBL and CDIO: complementary models for engineering education development. *European Journal of Engineering Education, 39*(5), 539-555. doi:10.1080/03043797.2014.895703

Education in Russia. (2007). Statistical Yearbook. Moscow.

Education in numbers. (2018). Rertived from https://www.hse.ru/data/2018/06/29/1153062641/obr2018.pdf

Felder, R., & Brent, R. (2003). Designing and Teaching Courses to Satisfy the ABET Engineering Criteria. *Journal of Engineering Education, 92*(1), 7-25.

Fraser, P.,Moultrie, J., Gregory, M. (2002). The use of maturity models / grids as a tool in assessing product development capability: a review, IEEE International Engineering Management Conference, Cambridge UK, 18-20 August.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410-8415. doi:10.1073/pnas.1319030111

Graaff, E. d., & Kolmos, A. (2003). Characteristics of Problem–Based Learning. *International Journal of Engineering Education, 19*(5), 657-662.

Graham, R. (2018). *The global state of the art in engineering education*. Retrieved from Massachusetts, USA: http://neet.mit.edu/wp-content/uploads/2018/03/MIT_NEET_GlobalStateEngineeringEducation2018.pdf

Haidet, P., McCormack, W. T., & Kubitz, K. (2014). Analysis of the team-based learning literature: TBL comes of age. *Journal of Excellence in College Teaching, 25*(3/4), 303-333.

Healey, M., & Jenkins, A. (2009). *Developing undergraduate research and inquiry*. York, UK: Higher Education Academy.

Healey, M., Jenkins, A., & Lea, J. (2014). *Developing Research-Based Curricula in College-Based Higher Education*. York, UK: Higher Education Academy.

Hoffman, T. (1999). The Meanings of Competency. *Journal of European Industrial Training, 23*(6), 275-285.

Jackson, D. (2012). Testing a model of undergraduate competence in employability skills and its implications for stakeholders. *Journal of Education and Work, 27*(2), 220-242. doi:10.1080/13639080.2012.718750

Lim, H. L. (2015). Handbook of Research on Recent Developments in Materials Science and Corrosion Engineering Education: IGI Global.

Lima, R. M., Andersson, P. H., & Saalman, E. (2017). Active Learning in Engineering Education: a (re)introduction. *European Journal of Engineering Education, 42*(1), 1-4. doi:10.1080/03043797.2016.1254161

Lima, R. M., Da Silva, J. M., Van Hattum-Janssen, N., Monteiro, S. B. S., & De Souza, J. C. F. (2012). Project-based learning course design: A service design approach. *International Journal of Services and Operations Management, 11*(3), 292-313. doi:10.1504/IJSOM.2012.045660

Lima, R. M., de Graaff, E., Mesquita, D., & Aquere, A. L. (2018). *Engineering Education (Research) in Higher Education*

Institutions. Paper presented at the PAEE/ALE'2018, 10th International Symposium on Project Approaches in Engineering Education (PAEE) and 15th Active Learning in Engineering Education Workshop (ALE) (pp. 134-140), Brasília, Brazil. http://paee.dps.uminho.pt/proceedingsSCOPUS/PAEE_ALE_2018_PROCEEDINGS.pdf

Lima, R. M., Dinis-Carvalho, J., Sousa, R. M., Arezes, P. M., & Mesquita, D. (2017). Development of Competences while solving real industrial interdisciplinary problems: a successful cooperation with industry. *Production journal, 27*(spe), 1-14. doi:10.1590/0103-6513.230016

Lima, R. M., & Mesquita, D. (2018). *Engineering Education (Research) in European Countries – an overview based on publications in journals (accepted)*. Paper presented at the 3rd International Conference of the Portuguese Society for Engineering Education (CISPEE 2018), Aveiro, Portugal.

Markes, I. (2006). A review of literature on employability skill needs in engineering. *European Journal of Engineering Education, 31*(6), 637-650.

Maykova, S., Okunev, D., Salimova, T., Soldatova E. (2017). Modeling Organisational Management Structure of the United University. *Integration of Education.* 21(3), 421-440. DOI: 10.15507/1991-9468.088.021.201703.421-440.

Mesquita, D. (2015). O Currículo da Formação em Engenharia no âmbito do Processo de Bolonha: Desenvolvimento de Competências, Perfil Profissional e Empregabilidade na Perspetiva dos Docentes, dos Estudantes e dos Empregadores. (Doutoramento em Ciências da Educação, Especialidade em Desenvolvimento Curricular), Universidade do Minho, Braga, Portugal.

Mesquita, D., Flores, M. A., & Lima, R. M. (2018). Desenvolvimento do currículo no ensino superior: desafios para a docência universitária (Curriculum development in higher education: challenges for university teaching). *Revista Iberoamericana de Educación Superior, 9*(25), 42-61. doi:https://dx.doi.org/10.22201/iisue.20072872e.2019.25.338

Mesyats, G., Pokholkov, Y. (2003). Russian engineering education: problems and ways of transformation. *Engineering Education*, **1**, 4–10.

Nair, C., Patil, A., & Mertova, P. (2009). Re-engineering graduate skills – a case study. *European Journal of Engineering Education, 34*(2), 131-139.

National Academy of Engineering. InEducating the Engineer of 2020: Adapting Engineering Education to the New Century, 2005 (National Academy of Engineering: Washington, DC)

Powell, P. C., & Weenk, W. (2003). *Project-Led Engineering Education*. Utrecht: Lemma.

Prince, M. (2004). Does Active Learning Work? A review of the Research. *Journal of Engineering Education, 93*(3), 223-231.

Prince, M., & Felder, R. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *Journal of Engineering Education, 95*(2), 123-138.

Schwab, K. (2016). The Fourth Industrial Revolution.World Economic Forum.

Salimova, T. (2014). *Quality Management.* Moscow. Omega-L.

Salimova, T., Vatolkina N. (2010). The comparative study of the higher educational institution customers. *University Management: Practice and Analysis, 65 (1), 71-77.*

Salimova, T., Vatolkina N., Makolov V. (2014). Strategic partnership: potential for ensuring the university sustainable development. *Quality. Innovation. Prosperity, 18 (1), 107-124.*

Stiwne, E., & Jungert, T. (2010). Engineering students' experiences of transition from study to work. *Journal of Education and Work, 23*(5), 417-437.

TBLC. (2018). Team-Based Learning Collaborative website. Retrieved on 2018/04/02 from www.teambasedlearning.org

Tymon, A. (2013). The student perspective on employability. *Studies in Higher Education, 38*(6), 841-856. doi:10.1080/03075079.2011.604408

UNESCO. (2010). *Engineering: Issues, Challenges and Opportunities for Development*. In Retrieved from http://unesdoc.unesco.org/images/0018/001897/189753e.pdf

Wolf, P., Hill, A., & Evers, F. (2006). *A Handbook for Curriculum Assessment*. Guelph, Ont.: University of Guelph Publications.

Zabalza, M. (2009). *Diseño y Desarrollo Curricular* (11ª ed.). Madrid: Narcea.

Zichermann, G., & Linder, J. (2013). *The Gamification Revolution*: McGraw-Hill.

Appendix – Best Practices

In this appendix it is possible to find the whole set of best practices documents collected by the EXTEND participants. These documents were the main part of data collected for analysis, as a step for characterization the best European practices in teaching engineering disciplines and teacher competence enhancement. This set of cases cannot be interpreted as a complete set of best practices for the referred universities, but as a perspective constructed by experts of the project.

EXTEND - EUR BEST PRACTICE 1 – RTU

#1 Engineering High School

☐ Research & Development
☐ Curriculum development and delivery
☒ Governance
☒ Lifelong Learning
☐ Internationalization and Mobility
☐ University Enterprise Cooperation

I Quick Facts

EU country: Latvia

WEB page: http://www.izv.lv/

Competence enhancement: University teaching staff need to possess the ability to explain complicated topics in a simple manner; therefore, by teaching young high school children, they can carry out self-assessment of their core pedagogical skills.

Relation to engineering: STEM subjects presented in a more detailed yet simple way to high school children.

II Summary

Engineering High School (EHS) of Riga Technical University (RTU) is the first general secondary education establishment in Latvia that has been founded within a university. It is a place where the most talented Latvian pupils are able to acquire in-depth knowledge in exact and natural sciences at an advanced level and prepare for higher education in the field of engineering. At EHS, special emphasis is put on the integration of engineering studies and scientific research activities into the study process.

Mission of EHS:

- to provide gifted and competent youth from all across Latvia with the opportunity to acquire competitive general secondary education with a special focus on exact and natural sciences;
- to support talented Latvian pupils, giving them the opportunity to acquire knowledge that cannot be obtained at other general secondary education establishments in Latvia;
- to create a modern study environment and ensure that only professional academic personnel is involved in the study process;
- to foster advanced scientific research skills;
- to ensure a wide range of extracurricular activities to advance professional competence;
- to promote engineering sciences among schoolchildren.

Link between High School and University:

- RTU EHS students have the opportunity to complete particular RTU study courses. In case EHS graduates opt to study at RTU, they will be able to receive a Bachelor degree in a shorter period of time.

- Academic personnel of RTU and leading researchers in different fields meet EHS students in class and brief them on current research topicalities.
- In addition to preparing the students for a centralized exam in a foreign language and research activities to be conducted in a foreign language, teachers also help students prepare for an IELTS test.
- In summer, students have the opportunity to learn more about their dream profession by doing an internship at one of RTU's partner enterprises.
- Students acquire skills in developing scientific research papers and presenting the results; they also have the opportunity to develop their research projects at RTU laboratories equipped with state-of-the-art facilities.
- In order to integrate modern technologies into the study process, teachers and students participate in developing video study courses or MOOCs.
- Together with RTU students, EHS students are able to work at RTU Electronics and Robotics Clubs, as well as gain skills and competences at RTU Design Factory.

III Checklist of Prerequisites to Success

University teachers willing to teach STEM subjects + additional teachers for general subjects thought in the high school

1-3 years, depending on the local legislation, regulators' approval and establishment of the infrastructure

Infrastructure (classrooms and labs), staff (administrative + academic) and smart planning

EXTEND - EUR BEST PRACTICE 2 - RTU

#2 Design Factory

☒ Research & Development
☒ Curriculum development and delivery
☐ Governance
☐ Lifelong Learning
☐ Internationalization and Mobility
☒ University Enterprise Cooperation

1862
RIGA TECHNICAL UNIVERSITY

I Quick Facts

EU country: Latvia

WEB page: http://rtudf.rtu.lv/

Competence enhancement: University teachers and students need to have an ability to apply theoretical knowledge to practical tasks, prototyping, testing new designs, working with advanced hardware and software solutions.

Relation to engineering: Practical support to the study process as well as an open laboratory for bringing engineering ideas to life.

II Summary

RTU Design Factory is a lively place that brings together research, education and the industry, creating a new hands-on learning culture and opportunities for radical innovation. It is positioned under the office of RTU's Vice-Rector for Science and is open to all faculties of the university. It provides access for researchers and students to facilities, tools and services for prototyping that allow creating new and complex solutions. Technologies offered range from laser cutting and engraving, 3D printing and scanning to high-speed CNC machining and post-processing.

RTU Design Factory works with interdisciplinary student and researcher teams to solve real-life challenges in various fields. It also develops scientific equipment, demonstration models or fully functional prototypes to support scientists and staff of RTU. The team speaks 10 different languages and combines a variety of skills in mechanical engineering, robotics, creative thinking and methodologies, electronics, product development, design and business. It is also a part of the Design Factory Global Network along with partners from Switzerland, Chile, Korea, China and, of course, the very first Design Factory in Aalto University, Finland. Design Factory works on a wide variety of projects, some of the recent ones including a hockey puck shooter that uses artificial intelligence, a new type of water treatment system, a training device for brass instruments and customized equipment for researchers testing composite materials.


Tools


Skills


Space

3d printing laboratory


Activities

3d printing	Mechanical Engineering	Molding laboratory	Summer school
Laser cutting	Robotics	Dirty prototyping	Study course
CNC milling	Modeling	Meeting room	Workshop
CNC lathe	Start-up support	Hot desk	Events
Silicone molding	Interdisciplinarity		Projects
Electronics	Practical learning		

RTU Design Factory also incorporates an IdeaLAB to support the process of innovation. IdeaLAB is an open laboratory for RTU students, staff and partners of RTU Design Factory where they can:

- use and learn to use 3D printers, laser cutting and engraving machine, soldering station, vinyl cutter, large format printer or come to drill or fix something;
- come to create, to do stuff and to get inspired;
- meet likeminded people and start a project together;
- turn their ideas into reality.

III Checklist of Prerequisites to Success

Scientists, Teachers and Students interested in the applied side of the engineering

1 year to set up the facilities and organize the first team

Hardware and Software solutions (starting from simple hand tools and all the way up to CNC machines)

EXTEND - EUR BEST PRACTICE 3 - RTU

#3 UseScience

☒ Research & Development
☐ Curriculum development and delivery
☒ Governance
☐ Lifelong Learning
☐ Internationalization and Mobility
☐ University Enterprise Cooperation

1862
RIGA TECHNICAL UNIVERSITY

I Quick Facts

EU country: Latvia

WEB page: https://scientificservices.eu/

Competence enhancement: University teachers and students can access state-of-the-art equipment to enhance practical knowledge, perform lab experiments and explore different solutions for research problems.

Relation to engineering: Open access to a variety of services, hardware and software to be used in engineering education.

II Summary

UseScience is an online scientific registry and platform providing researchers, students and industry representatives with information about research equipment, software, and services available at RTU and UseScience partner institutions in Latvia and abroad. The information is updated regularly.

UseScience users can contact the holder (scientific institution or its structural unit) of the necessary research equipment to book the equipment or apply for a service. The equipment holder organizes and provides the necessary service (e.g. measurement, analysis).

UseScience promotes collaboration between research personnel, scientific institutions and enterprises with the aim to develop the existing and create new competitive products and technologies with high added value.

UseScience system was developed with the aim to catalogue, record and locate their kit effectively. UseScience contains laboratory equipment, ICT and specialist tools. Each item includes its specification, custodian, location, access requirements, usage data and photos. By using UseScience organizations are able to work towards improved efficiency, utilizing the assets already in existence and lessening the need for duplication of material assets to become a more sustainable campus.

Benefits include:

- Reduces the need to occupy additional space within buildings for duplicated equipment.
- Avoids unnecessary purchasing, manufacturing and shipping of products.
- Maximizes opportunity for re-use of specialist equipment locally by HEIs, industry and Small to Medium Enterprises (SME).

UseScience system is based on KIT-CATALOGUE - the open source PHP/MySQL system, based on the existing online laboratory equipment database, developed by the Centre for Engineering and Design Education at Loughborough University.

III Checklist of Prerequisites to Success

Scientists willing to share equipment of their Lab's

0.5 to 1 year to setup the database and instruct the users

WEB page development and maintenance

EXTEND - EUR BEST PRACTICE 4 – RTU

#4 Center of High Energy Physics and Accelerator Technologies

☒ Research & Development
☒ Curriculum development and delivery
☐ Governance
☐ Lifelong Learning
☒ Internationalization and Mobility
☐ University Enterprise Cooperation

I Quick Facts

EU country: Latvia, Switzerland

WEB page: https://www.rtu.lv/en/hep/high-energy-physics

Competence enhancement: Scientists working together with university and high school students on complicated engineering problems.

Relation to engineering: Next generation technologies.

II Summary

Scientific activities

The Center's goal is to develop interdisciplinary fundamental research in the field of high-energy particle physics and accelerator technology, involving scientific and academic staff as well as students in research projects in the field of nuclear research.

The action is mainly by the application of particle physics in various industries, beginning with a wide range of emerging applications in medicine and ending with new applications, such as the cleaning of ships' exhaust gases. In particular, emphasis is put on the broad future possibilities of accelerator technology for medical applications for treatment. However, the range of potential applications is much wider. The second line of action is related to accelerator development and manufacturing technologies - they need to become more powerful, more compact, and more reliable.

RTU High Energy Particle Physics and Accelerator Technology Centre's scientific activities at the field of high-energy particle physics are:

- top quark physics - study of color flow in top quark pair decays;
- additive manufacturing;
- human detection.

Study programs

RTU decided to create a study program to that offers the opportunity to master high-energy particle physics. The program will be designed to acquire knowledge in particle physics in parallel with accelerator technology.

The graduates of the program will have the opportunity to link the fundamentals of particle physics with direct know-how of particle accelerators. This would create a link between particle physicists and engineers who are developing and seeking new applications for accelerator technology. The theme of the program will be relevant not only in the Baltic region, but all over Europe. The study program is planned to be implemented at Master and Doctoral level. Other

Baltic universities will be invited for co-operation. Already, work on the development of the program is underway and RTU has been recruiting foreign visiting professors for the program. A guest lecture program is also being implemented, which provides an insight into the discipline of particle physics for a larger student community.

Study program at high-energy particle physics

- International – all three Baltic states will jointly create the program;
- Multidisciplinary – linking particle physics and accelerator technology;
- Masters and Doctoral level;
- CERN Baltic group is an instrument to establish this study program.

Compact Muon Solenoid Experiment

On December 2017 Consortium of two universities - RTU and University of Latvia joined the CMS experiment.

III Checklist of Prerequisites to success

Field specific scientists

Up to 2 years to get accredited for being part of the network

Field trips and scientific work expenses

EXTEND - EUR BEST PRACTICE 5– NORDTEK

#5 Nordtek Network

- ☐ Research & Development
- ☐ Curriculum development and delivery
- ☒ Governance
- ☐ Lifelong Learning
- ☒ Internationalization and Mobility
- ☐ University Enterprise Cooperation

1862
RIGA TECHNICAL UNIVERSITY

I Quick Facts

EU country: Nordic countries

WEB page: http://nordtek.net/

Competence enhancement: Teachers can develop their professional skills by collaborating with partners from neighboring countries and students can experience international study mobility during their studies as well as placements for internships.

Relation to engineering: Clustering and knowledge exchange between technical universities.

II Summary

Nordtekwas founded as a network of Rectors and Deans of Technical Universities in five Nordic countries – Norway, Denmark, Sweden, Finland and Iceland – and has now expanded by adding the Baltic countries to the consortium. Membership requirements include a background in advanced engineering up to Master PhD level studies in a technical research field. The members represent 27 universities, more than 120,000 students, teachers and researchers.

III Checklist of Prerequisites to success

Senior management time and dedication	1 year to establish the consortium and host the 1st meeting	Travel expenses, dissemination expenses, institutional expenses of student and staff exchange

EXTEND - EUR BEST PRACTICE 6– RTU

#6 Latvenergo Creative Laboratory

☐ Research & Development
☐ Curriculum development and delivery
☒ Governance
☒ Lifelong Learning
☐ Internationalization and Mobility
☒ University Enterprise Cooperation

1862
RIGA TECHNICAL UNIVERSITY

I Quick Facts

EU country: Latvia

WEB page: https://www.rtu.lv/lv/studijas/arpusstudijas/latvenergo-radosa-laboratorija

Competence enhancement: A laboratory that is supported and set-up by a partner representing the industry helps to create a better connection to real life situations that students will face when they enter the labor market.

Relation to engineering: An engineering enterprise that provides support to future engineers.

II Summary

Support for science and education on behalf of the industry - Latvenergo Group (Latvenergo Group is the largest power supplier in the Baltics. It operates in electricity and thermal energy generation and trade, electricity distribution services, and the leasing of transmission system assets) annually implements projects contributing to the development of science and education in energy, promotes engineering and technology professions, and facilitates training of qualified specialists.

Latvenergo AS has supported the Engineering High School of Riga Technical University for three consecutive years, as well as contributed to the enhancement of the technical equipment of Latvenergo Creative Laboratory at the Faculty of Power and Electrical Engineering in 2015 and 2017.

A workshop designed to help students develop practical skills in electronics and electrical engineering, as well as promote in-depth interest in these areas among our present and future students, is organized with the financial support of Latvenergo and the Faculty of Power and Electrical Engineering.

In the workshop, students are engaged in the development of electronic and electrical engineering layouts, large-scale printed design, soldering and testing of circuits, and programming of microcontrollers. It is a place where they can bring their ideas to life, work on their own as well as consult experienced teaching staff.

The Latvenergo Creative Laboratory has 12 workplaces, complete with various mechanical processing instruments, measuring instruments and testing equipment. The laboratory is continuously upgraded and supplemented with new equipment. Student groups from secondary education institutions can apply for excursions to the laboratory.

III Checklist of Prerequisites to success

Support from the industry actors

1 to 2 years to establish cooperation, sign agreement and setup the lab

Equipment expenses, additional time for university staff members

EXTEND - EUR BEST PRACTICE 7– RTU

#7 Alumni Association

- ☐ Research & Development
- ☐ Curriculum development and delivery
- ☒ Governance
- ☐ Lifelong Learning
- ☐ Internationalization and Mobility
- ☐ University Enterprise Cooperation

I Quick Facts

EU country: Latvia

WEB page: https://rtuconnect.net/http://alumni.rtu.lv/

Competence enhancement: By inviting alumni of Riga Technical University to act as guest lecturers, people from the industry are encouraged to be a part of the University community and be more involved into the curriculum delivery for exchanging expertise, mentoring and ideas between current students and graduates.

Relation to engineering: Community of engineering graduates.

II Summary

RTU has about 120 000 graduates. RTU Alumni Association is a public organization established on 23 May 2012, and ever since its aims are to unite different generations of RTU alumni, to implement various support programs and to promote the sense of belonging to one's alma mater.

The work of the Alumni Association is based on three key concepts: contacts, knowledge and support. Firstly, contacts mean facilitating cooperation among members of the association, RTU units, employees and future alumni – the current students. Secondly, the association offers obtaining and reinforcing experience based knowledge, organizing different educational, sports and inspirational activities for alumni – visits to innovative enterprises, tours to research laboratories. And thirdly, support, i.e. support provided to alumni by cooperation partners of the University and association, as well as the support the alumni offer to the University – their experience, funding, and bringing in new students. The association regularly informs the public about various activities via its web-page *alumni.rtu.lv*, via monthly newsletters to the member e-mails, as well as through social media. RTU Connect platform allows students to both re-connect with old classmates as well as enables them to utilize the trusted Riga Technical University environment to expand professional networks.

RTU Alumni association is also in charge of hosting RTU Grand Graduation ceremony of students each year that takes place at the biggest concert venue in Riga - Arena Riga. The event has three parts: speeches and musical performances, diploma ceremony and the grand finale. After the graduation, everyone is invited to celebrate together with students' guests at Arena Riga. RTU Connect facilitates the organization process of the graduation, for example, all that each year's graduates have to do is enter the alumni platform *rtuconnect.net* and press the "Going" button at the RTU Grand Graduation event.

III Checklist of Prerequisites to success

Alumni Relationship Management staff

1 to 2 years to establish the Association and IT platform

Costs of IT platform and Alumni Association staff members

EXTEND - EUR BEST PRACTICE 8– RTU

#8 International Week

- ☐ Research & Development
- ☐ Curriculum development and delivery
- ☐ Governance
- ☒ Lifelong Learning
- ☒ Internationalization and Mobility
- ☐ University Enterprise Cooperation

1862
RIGA TECHNICAL UNIVERSITY

I Quick Facts

EU country: Latvia

WEB page: https://www.rtu.lv/en/university/for-mass-media/events/open/rtu-international-week-2

Competence enhancement: University staff and students from abroad are invited to visit and work together with local counterparts during interactive workshops, excursions and cultural events for a week.

Relation to engineering: International cooperation in various engineering fields.

II Summary

Within the framework of the International Week different lectures, presentations and discussions take place, as well as individual participants' visits to RTU faculties and administrative departments. The International Week is a substantial event that is significant for establishing new contacts and consolidating the existing partnerships. During the International Week new cooperation agreements are initiated and later successfully brought to life by students, scholars and staff.

III Checklist of Prerequisites to success

Additional time and input from International Relations Office staff	1 year to develop program and make all necessary arrangements	Costs of venue, catering, materials and guest lecturers

EXTEND - EUR BEST PRACTICE 9– TUD

#1.Technical University Darmstadt : INGENIUM - International Career Researchers

- Research & Development
- Curriculum development and delivery
- Governance
- Lifelong Learning
- Internationalization and Mobility
- University Enterprise Cooperation

I Quick Facts

EU country: Germany

Web page: https://www.tu-darmstadt.de/ingenium_young_researchers/ueber_ingenium/index.de.jsp

Competence enhancement: developing skills for individual, independent, and internationally recognised research.

Relation to engineering: promotion and qualification of early career researchers at TU Darmstadt for both academic and non-academic careers, including counselling and training for TUD doctoral candidates and support during the doctoral and postdoc stages as well as international candidates.

II Summary

Background. Ingenium – Young Researchers at TU Darmstadt is the umbrella organisation for promoting early career researchers. Together with the departments, graduate schools, and research training groups, Ingenium promotes and qualifies early career researchers at TU Darmstadt for both academic and non-academic careers.

Aim, goals, objectives. Although the focus is on support for successful completion of doctoral studies, with respect to timeframe, work quality and professional support, Ingenium also has in view goals with long term effects such as promotion of equal opportunities, professional skills programme for both academic and non-academic careers, internal and external networking of early career researchers with the scientific community, internationalization of the doctoral phase.These goals are implemented through specifically tailored courses on such issues as: *time management, project management, communication and presentation, leadership competences, career counseling*.

The pre-doctoral candidate. INGENIUM meets all the candidate's key concerns whether academic or pragmatic including orientation and decision making, overview over PhD models, financing & funding, finding a supervisor, structure of the doctorate, preparing the doctorate. **The doctoral candidate**. INGENIUM provides assistance on such matters as: structuring of the doctoral phase, further qualification, international experience, career perspectives and career planning in science, career perspectives and career planning outside science, special challenges during the doctorate, preparing the postdoc phase. **The postdoc applicant:** further qualification, international experience, career perspectives and career planning outside science, financing and (research) funding.

III Checklist of Prerequisites to Success

Researchers and doctoral applicants in small group sizes assisted by experienced trainers

Biannual programme (October-March, April-September)

Scholarships and financial support

Free of charge courses

EXTEND - EUR BEST PRACTICE 10– TUD

#2 .Technical University Darmstadt: Center of Educational Development and Technology.

 Research & Development

 Curriculum development and delivery

  Governance

Lifelong Learning

 Internationalization and Mobility

University Enterprise Cooperation

I Quick Facts

EU country: Germany

Web page: https://www.hda.tu-darmstadt.de/hda/index.en.jsp

Competence enhancement: quality management and development in the area of studies and teaching through counselling, evaluation and accompanying research based on promoting higher education didactic innovation through academic reform projects.

Relation to engineering: technical university students, faculty and University staff are offered higher education and didactic qualification as well as counselling services.

II Summary

Background. The Center for Educational Development and Technology at the TU Darmstadt was established in 1985 and serves as a central service facility through qualification and quality development programs targeted on students and faculty. The process of methodological upgrading covers the provision of such services as: *e-learning tools and methods*, *evaluation* - based ona comprehensive process of reflection, practical consulting, development of evaluation instruments, counseling of teaching-, *continuing education and counselling*, *interdisciplinary projects* in the entry phase of studies (KIVA), *qualification* for studies and careers via tutor qualification and key competence strategies.

Teachers. Teachers are supported in both the process of carrying out course evaluation and implementing teaching methods through goal-oriented evaluations and advisory services covering such issues as: course and seminar evaluations, special evaluation offers for first year lecturers, feedback instruments such as surveys, interviews and midterm assessments, development of TU-study surveys, regular university-wide graduate studies, central coordination unit for internal and external student surveys, support for the evaluation software program EvaSys, counseling on how to handle survey results. Teachers are also strongly urged to extend the everyday life use of digital media to the teaching and studying activity in order to ensure active student involvement in lectures through visualization and instant feedback. A wide range of services and tools is provided by an **e-learning team**. The continuing professional development of teachers is supported for both their teaching and supervising activity. The services provided cover:

- A broad variety of workshops and best-practice examples on teaching, supervision and assessment.
- Workshops on demand.
- A structured qualification program for the Certificate of Higher Education
- Online material and resources at www.einfachlehren.de
- Professional and peer consulting on teaching and learning, supervision, and gender and diversity issues

Alongside offering certifiable qualifications (i.e. Certificate of Higher Education), the services are timeframe friendly, interdisciplinary focused, instrumental and based on problem solving. Consequently beneficiaries may enhance their confidence regarding the use of updated methodology, enrich the range of teaching methods and get more satisfaction from fostering student motivation in learning. Furthermore, the quality of teacher-student relationship is boosted on the one hand by offering teachers opportunities for networking at interdisciplinary and international level as well as by offering tutoring training on such issues as tutoring and mentoring strategies, OWO tutoring (orientation week at the beginning of the study) and E-tutoring. The Centre also supports teachers in the initiation and implementation of interdisciplinary and international study projects, throughout the initialization and conception phase as well as preparation, monitoring and execution of various project formats.

Students. Students are considered main stakeholders of TUD's permanent process of development. Thus special provisions have been made for the students' involvement in the academic community life as well as their personal development. Student voices are taken into consideration via online surveys whose results may be publicly consulted at the following addresses : university-wide result report (English version), …question catalogue (German only), …methodology report (German only). Personal student development is engineered by qualifying students for peer tutoring through training in such soft skill areas as communication and co-operation skills that they can apply during their studies and professional life.

Successful qualification of peer tutoring programs may lead to:tutoring positions, team support leader positions.

These roles develop the students' skills in facilitating groups, promoting learning processes and moderating professional presentations, resulting in successful team and project work groups. Training sessions include topics such as moderating meetings and discussions, presentations, professional configuration of flip chart material and methods for project management including conflict management.

The international edge. The centre supports faculties with implementing interdisciplinary and international project courses for the benefit of first year students. The introduction of cross-faculty and international study projects to all departments of TechnischeUniversität Darmstadt is co-funded by the joint program *Quality Pact for Teaching* of the federal and the state governments in the context of the KI2VA project (*Competence Development via Early and Ongoing Interdisciplinary and International Cooperation*; project funding reference number 01PL16048). The Centre assists faculties in finding partners for interdisciplinary study projects, in advising them on executing their projects, and educating student tutors for team and technical advising in the project courses.

III Checklist of Prerequisites to Success

Students and teachers

demand based training modules

teaching, research and PR Infrastructure

EXTEND - EUR BEST PRACTICE 11– KIT

3Karlsruhe Institute of Technology (KIT) From Graduation to professorship

 Research & Development
 Curriculum development and delivery
 Governance
Lifelong Learning
 Internationalization and Mobility
University Enterprise Cooperation

I Quick Facts

EU country: Germany

Web page:https://www.kit.edu/research/young_scientists.php

Competence enhancement: KIT consistently promotes young scientists in all career phases, from graduation to professorship, by customizing offers to individual scientists with focus of interdisciplinary support.

Relation to engineering: KIT offers innovative concepts for the development of scientific and personal qualities, an excellent environment of university research and large-scale research, and excellent national and international networking.

Background

II Summary

Background

Kit is a top academic and research institution that focuses on research oriented teaching, strong science-industry relations and an internationalization edge. These targets are underpinned byconsistent policy making likely to promote life-long learning, comprehensive advanced training, unrestricted exchange of know-how , and a sustainable innovation culture.

Students

The close interlinking of large-scale research and teaching opens up many opportunities for involving students in research at an early stage. Thus, in the programme of the German federal and state governments for better study conditions and more teaching quality, the federal government funds the project "KIT - LehrehochForschung" (Research-based Education) .

Researchers

The scientist-industry relation is supported by providing opportunities for scientists to present their developments to industry, by placing them on the market, or by involving them in business. Science-industry cooperation features such forms as contract research, research cooperation or KIT transfer projects (KTP).

Entrepreneurs

The development of entrepreneurship is the key target of the “Research to Business” platform where the KIT Innovation and Relations Management Service Unit provides interested parties from industry and medium-sized enterprises easy access to new knowledge, innovative technologies, and close-to-market research and development results. The KIT Founders Forge develops programs to support young entrepreneurs and to enhance entrepreneurial creativity. Actions for specific target groups are to familiarize students and KIT employees with matters relating to startups and the startup process. It is intended to extend and strengthen the network into the startup world. Furthermore, KIT Innovation gGmbH is a limited liability company of KIT. Thiscompany was established to foster the strategic areas of innovation and entrepreneurship.

The international edge

Kit’s Internationalization Program focuses on three objectives:

- Attracting qualified international graduates to doing their doctorate at KIT
- Helping KIT doctoral researchers to increase their intercultural competences
- Establishing sustainable measures to increase the mobility and networking of doctoral researchers by means of fostering international collaborations.

The tools created to implement kit’s internationalization edge covers such measures as:

- The Aspirant Grant that enables KIT professors to invite foreign graduates who are interested in doing their doctorate at KIT to come here for a one-month stay.
- The Internship Grant that offers doctoral researchers at KIT the opportunity to supervise a master student from abroad during a three-months internship at KIT.
- The International Collaboration Package that aims at sustainably by establishing mobility and networking measures for doctoral researchers likely to intensify existing international collaboration. The pilot project's target groups are KIT professors, the heads of KIT institutes or heads of certified KIT junior research groups.

III Checklist of Prerequisites to Success

PHD students, young investigators, junior professors from Germany or abroad

variable (1-3 years), depending on academic status

teaching, research and PR Infrastructure

EXTEND - EUR BEST PRACTICE 12– ORACLE

#4 ORACLE ACADEMY

- Research & Development
- Curriculum development and delivery
- Governance
- Lifelong Learning
- Internationalization and Mobility
- University Enterprise Cooperation

I Quick Facts

EU country: global

WEB page: https://academy.oracle.com/

Competence enhancement: University teachers and students are provided with a complete portfolio of computer science education resources in order to prepare them for life and work in our modern technology-driven global economy:

Relation to engineering: Computer science

II Summary

Background

Oracle Academy offers a complete portfolio of computer science education resources to secondary schools; technical, vocational, and two-year colleges; and 4-year colleges and universities, with the goal of helping students become college and career ready. Each year, Oracle Academy reaches more than 3.5 million students in 120 countries.

Mission of OA: To provide resources to help prepare teachers and students for life and work in our modern technology-driven global economy.

Resources. Oracle Academy supports continuous computer science learning at all levels, making available a variety of resources that can be used in the classroom and in not-for-profit academic course- and degree-related research, including technology, curriculum and courseware, student workshops, educator training, and Oracle industry certification and exam preparation materials.

Students develop IT and business skills while using production software used widely across hundreds of industries,

Educators keep pace with current technology through ongoing professional development.

III Checklist of Prerequisites to Success

Students and teachers at various developmental stages	On-going	Infrastructure (classrooms and labs), staff (academic)

EXTEND - EUR BEST PRACTICE 13– UPB

#5. Summer Schools organized by Faculty of Automatic Control and Computers, UPBl

- Research & Development
- Curriculum development and delivery
- Governance
- Lifelong Learning
- Internationalization and Mobility
- University Enterprise Cooperation

I Quick Facts

EU country: Romania

WEB page: **/** http://acs.pub.ro/

Competence enhancement: University teachers need to have/increase the ability of conducting projects and workshops with a high practical applicability, correlated with industry needs.

Relation to engineering: Computer science

II Summary

Background

Each year, ACS organises several specialized summer schools, which last 2 months e.g. 3DUPB Summer School (http://3d.upb.ro/),LeMAS "Multi-Agent Systems and Learning Agents" Summer School, etc.

The summer school curriculum is aligned with the mandatory university curriculum and offers extra knowledge. Industry guest lectures are invited to these summer schools. The sustainability of the project depends on the willingness of faculty teachers to organize the summer schools and faculty leadership commitment.

Mission of UPB Summer Schools. To provide advanced educational resources related to specialised fields of computer science, with a high practical focus.

Students. The students can equivalate their mandatory practical period with their participation in these summer schools. Summer schools may be also a starting point for the final bachelor projects.

Governance. Summer schools are a good way of attracting students from other universities to master and PhD studies at UPB.

III Checklist of Prerequisites to Success

UPB Computer Engineering Undergraduates Non-UPB Computer Engineering Undergraduates	Two-months	Free Academic Infrastructure (classrooms and labs), and administrative logistics

EXTEND - EUR BEST PRACTICE 14– UPB

6. Entrepreneurship Centre, UPBIZZ

- Research & Development
- Curriculum development and delivery
- Governance
- Lifelong Learning
- Internationalization and Mobility
- University Enterprise Cooperation

I Quick Facts

EU country> Romania

WEB page: http://antreprenoriat.upb.ro/

Competence enhancement:engineering professionals need to have/increase their entrepreneurship skills particularly with respect to transferring academic knowledge to industry and the other way round.

Relation to engineering: all areas of engineering

II Summary

Background. In the wake of the massive social, political and economic changes of the whole Romanian society after the 1989 collapse of the old regime, the engineering higher educational system was in bad need of updating its content and policy making to the needs of a market led economy. The development of an entrepreneurial spirit was seen as being crucial in this shift. The emergence of UPBBIzz was the answer to such a demand.

Mission of Entrepreneurship Center UPB. The Centre is meant to support, develop and encourage entrepreneurship among engineering undergraduates and graduates, thus contributing to turning UPB into a supporter of the Romanian business environment.

Students. The university educational package is diversified by including a series of activities complementary to the university curriculum. The package includes several courses related to starting a business. Mentorship and success stories are offered to personalize the learning experience of each student.

University Enterprise Cooperation. Industry specialists and experts are involved in the centre activities. Hackathons and startup accelerators are organized.

III Checklist of Prerequisites to Success

UPB undergraduates and graduates	demand based training modules	Free Academic Infrastructure (classrooms and labs), based on engineering teachers with entrepreneurship skills and administrative logistics

EXTEND - EUR BEST PRACTICE 15– IT UNIV

7. IT University, Sweden

 Research & Development
 Curriculum development and delivery
  Governance
Lifelong Learning
 Internationalization and Mobility
University Enterprise Cooperation

I Quick Facts

EU country: Sweden

WEB page: http://www.ituniv.se/

Competence enhancement: University teachers need to have/increase the ability of conducting research and educational collaborative activities with industries.

Relation to engineering: ITC

II Summary

Background. The IT University is a common network between Chalmers and University of Gothenburg. In order to regulate the activities there is an agreement signed by the President of Chalmers and the Vice Chancellor of the University of Gothenburg.

Mission of ITC University. The mission of ITC University is to manage and develop the areas within ICT in Gothenburg that are not already a part of any of the Areas of Advance, departments or of the ordinary education areas, with questions about how the use of IT might boost each business. The IT University is also responsible for linking IT to research, education and other activities where IT is not the subject but only an important tool to reach full potential and achieve excellence in research and education.

University Enterprise Cooperation. The IT University will also actively contribute to the development of a virtual campus at Lindholmen in Gothenburg. **Lindholmen Science Park** is an international collaborative environment for research, innovation and education within the areas Transport, ICT and Media. The universities collaborate with high tech industries and the local community in different development projects. Currently 250 companies, notably Volvo Cars, Volvo Technology, Ericsson, IBM. Over 21 000 employees or students are working or studying at the university site.

III Checklist of Prerequisites to Success

Non-ITC undergraduates

annual

Free

Network costs

academic Infrastructure (classrooms and labs),

and administrative logistics

EXTEND - EUR BEST PRACTICE 16– UPB

#8. Campus UPB, Romania

- Research & Development
- Curriculum development and delivery
- Governance
- Lifelong Learning
- Internationalization and Mobility
- University Enterprise Cooperation

I Quick Facts

EU country: Romania

WEB page: http://campus.pub.ro/

Competence enhancement: Resources and tools for various engineering disciplines are offered.

Relation to engineering: Chemical engineering, electrical engineering and electronics, telecommunications, information technologies, computer science

II Summary

Background. At a time when the world urgently needs more people who understand science and engineering, the CAMPUS UPB extend the power of hands-on problem-solving to companies and institutions around the globe in the effort to explore a new model of university activity — enhancing communities through science. This is CAMPUS's business proposal.

Mission of CAMPUS UPB. The Center for Advanced Research on New Materials, Products and Innovative Processes (CAMPUS) is the UPB's advanced research & development center for multi - and inter - disciplinary technologies. Apart from research, CAMPUS is also an educational center for undergraduate and postgraduate studies and e-learning.The center is uniquely designed, both from the infrastructure point of view, as well as functionality. It holds a state of the art 7 stories green and intelligent building with unconventional power sources, energy recovery, reuse of resources, and intelligent management systems. The building itself is a working lab. It integrates 42 research labs, spread over more than 8,000 square meters, equipped at European standards. The labs are connected in a complete inter - disciplinary technological flow, starting with the study of materials (chemical engineering), going to electrical engineering and electronics (e.g., circuits, antennas), power and mechanics (e.g., alternative energy sources, environmental protection), and then telecommunications, information technologies (e.g. multimedia processing) and computer science (e.g. artificial intelligence).

University Enterprise Cooperation. With national and international companies http://campus.pub.ro/website/collaborations

III Checklist of Prerequisites to Success

Undergraduates, postgraduates, PhD students, Researchers

Annual

Free

Network costs

academic and logistic Infrastructure (staff, classrooms and labs)

EXTEND - EUR BEST PRACTICE 17– UMINHO

EU BEST PRACTICES
Active learning strategies (see glossary)
Project-Based Learning
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: University of Minho, Portugal Program: Industrial Engineering and Management Integrated Master (4th Year, 1st semester) Obs.: Project develop by teams of students in an industry context; Interdisciplinary approach (content of all courses must be included); teachers from the different courses need to cooperate to each other.
Short description (details and further information)
The following text is an excerpt of the following reference: Lima, R. M., Dinis-Carvalho, J., Sousa, R. M., Alves, A. C., Moreira, F., Fernandes, S., & Mesquita, D. (2017). Ten Years of Project-Based Learning (PBL) in Industrial Engineering and Management at the University of Minho In A. Guerra, R. Ulseth, & A. Kolmos (Eds.), PBL in Engineering Education: International Perspectives on Curriculum Change (pp. 33-52). Rotterdam, The Netherlands: Sense Publishers. Our program is an Integrated Master degree in Industrial Engineering and Management, an engineering program of 5 consecutive years (10 semesters), in which the master program is not separated from the bachelor. The PBL model adopted for the 7th semester involves the development of a project within industry, incorporating the knowledge and competences inherent to all the courses of the semester. Typically, 5 to 6 teams of students are created (each one with 7 to 9 students) and each company, depending on its size, may receive 1 or 2 teams. The courses of the semester are: (i) Organization of Production Systems II (OSP2 – Lean concepts), (ii) Information Systems for Production (SIP), (iii) Production Integrated Management (GIP), (iv) Ergonomic Study of Workplaces (EEPT), (v) Simulation (SIM) and (vi) Integrated Project on Industrial Engineering and Management II (PIEGI2). The course PIEGI2 formally includes the PBL concept on the curriculum, and its grading system considers not only the developed technical competences but also transversal competences, as well as peer assessment. Along the years, the typology of these projects has followed a common pattern, mentioned at the beginning of this section: (i) analysis and diagnosis of the production system and (ii) development of improvement proposals. The duration of the first phase should not exceed half of the semester and the analysis and diagnosis is conducted in the context of all the courses of the semester. More specifically, the production system is subject to: (i) characterization and classification, (ii) performance evaluation, (iii) waste identification, (iv) identification of the main functions and techniques of production planning and control and

how they are integrated, (v) identification of the information flow , (vi) evaluation of the adequacy of existing software regarding the functional and information requisites of the production system, and (vii) characterization of the workstations' ergonomics and physical environment. Items (i) to (iii) are inherent to the course OSP2, (iv) and (v) to GIP, (v) and (vi) to SIP and (vii) to EEPT. Note that (v) is conducted in the context of both GIP and SIP. The contents of the course SIM (namely the simulation models) are only applied in the second phase of the project in order to explore possible alternative solutions and estimate the corresponding results.

EXTEND - EUR BEST PRACTICE 18– UMINHO

EU BEST PRACTICES
Active learning strategies (see glossary)
Project-Based Learning
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: University of Minho, Portugal Program: Industrial Engineering and Management Integrated Master (1th Year, 1st semester) Obs.: Project develop by teams of students; Interdisciplinary approach (content of all courses must be included); teachers from the different courses need to cooperate to each other.
Short description (details and further information)
The following text is an excerpt of the following reference: Lima, R. M., Dinis-Carvalho, J., Sousa, R. M., Alves, A. C., Moreira, F., Fernandes, S., & Mesquita, D. (2017). Ten Years of Project-Based Learning (PBL) in Industrial Engineering and Management at the University of Minho In A. Guerra, R. Ulseth, & A. Kolmos (Eds.), PBL in Engineering Education: International Perspectives on Curriculum Change (pp. 33-52). Rotterdam, The Netherlands: Sense Publishers. PBL implemented in the first semester, first year of the Industrial Engineering and Management program (IEM11_PBL) has been implemented since the 2004/05 academic year. The PBL model implemented is based on the six courses of the semester, three from the School of Sciences and three from the School of Engineering. The objective of the project is that students simultaneously apply contents and develop the required competences of that semester, during the project development. Learning outcomes are defined in a learning project guide, which is a document prepared by the coordination team to serve as a guide for students. In this document students find information about the PBL learning methodology, the teachers' contacts, tutor information, learning outcomes of each course (including of the project), scheduled classes and project milestones, assessment model and physical resources (e.g. room project, lockers,…) and e-learning platform. The coordination team, normally, includes six or seven teachers pertaining to the Project Supporting Courses (PSC) and six tutors (one or two teachers are simultaneously teachers and tutors). Educational researchers have also been involved in this team. As the members come from different schools/departments, there is always a wide diversity of ideas and experiences. The project theme is usually related with sustainability issues for two main reasons: (1) to raise students awareness on this underlying dimension of human development, and (2) to be contemporary and attractive for the students. The IEM11 class is divided into six teams of about seven to nine students each. Each team has the support of a tutor. Each team must organize their tasks properly and manage their project in a more formal way. Peer assessment and individual evaluation are used as mechanisms to prevent free riding. The project progress and individual competencies are monitored during the semester by assessing the project deliverables after the accomplishment of the milestones, by the tutors and the perceptions from the PSC teachers.

EXTEND - EUR BEST PRACTICE 19– UMINHO

EU BEST PRACTICES
Active learning strategies (see glossary)
Project-Based Learning
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: University of Minho, Portugal Program: Several engineering programs Obs.: Project develop by teams of students from different engineering backgrounds; Interdisciplinary approach (content of all programs must be included); teachers from the different programs need to cooperate to each other.
Short description (details and further information)
The following text is an excerpt of the following reference: Lima, R. M., Mesquita, D., Dinis-Carvalho, J., & Sousa, R. M. (2015, 6-9 July 2015). Promoting the Interaction with the Industry through Project-Based Learning. Paper presented at the Seventh International Symposium on Project Approaches in Engineering Education (PAEE'2015), part of International Joint Conference on the Learner in Engineering Education (IJCLEE 2015) (pp. 198-205), San Sebastian, Spain. The ENGINNOVA project (Engineering Projects of Innovation and Entrepreneurship) refers to a PBL model of university-business cooperation, involving teams of students from different engineering degrees of University of Minho. This project was introduced in 2014/15, with two students' teams and two companies, and was inspired in five similar projects carried out between 2007/08 and 2011/12, under the designation PIEI (Innovation and Entrepreneurship Integrated Project). Each team has a tutor from university and a supervisor from the company. One team was composed by 5 students, 1 from IEM-IM, 2 from IECE-IM (Integrated Master in Industrial Electronics and Computers Engineering) and 2 from ME-IM (Integrated Master in Mechanical Engineering), and the project was developed in a company dedicated to the development of semiconductor devices. The other team had 8 students, 1 from IEM-IM, 3 from IECE-IM, 2 from ME-IM and 2 from BE-IM (Integrated Master in Biological Engineering), and the involved company was a tyre manufacturer. The purpose of ENGINNOVA projects is the development of solutions for real industrial problems identified by the companies. This includes, as intended outcome, the elaboration of a detailed report describing the proposed solution and a prototype. Before the beginning of the semester, several meetings between the projects' coordinators and the companies took place in order to define the main goals of the project and the operational details (e.g., it was defined that students' teams in the ENGINNOVA project could visit the companies every Wednesday and companies provide an appropriate workspace). In the early days of the semester a meeting was scheduled in each company with the corresponding students' team, university tutor and company supervisor. After that initial meeting, the team became the main responsible for the interaction with the company, namely in terms of information exchange, rescheduling of visits, etc. Frequently, team tutors also visits the company and interact with company supervisors in order to help in some decisions about project details. Occasionally some teachers also interact with company to clarify specific details of the project. At the end of the project, each team performs a final presentation to company representatives in the company facilities about the mains findings, proposals and results. After this last presentation, companies are asked to report their conclusions and feedback to project coordinator.

EXTEND - EUR BEST PRACTICE 20– UMINHO

EU BEST PRACTICES
Active learning strategies (see glossary)
Serious Games
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: University of Minho, Portugal Program: Several courses related to Lean Manufacturing concepts in the following master degrees: Industrial Engineering and Management Integrated Master, Industrial Engineering Master, Systems Engineering, and Quality Engineering and Management.
Short description (details and further information)
The following text is based on the following reference: Sousa, R. M., Alves, A. C., Moreira, F., & Dinis-Carvalho, J. (2014). *Lean Games and Hands-On Approaches as Learning Tools for Students and Professionals*. Paper presented at the 7th International Conference on Production Research - Americas, Peru. Several courses on Lean Manufacturing, from University of Minho use different games. The four games identified in this best practice are about production and performance indicators dynamics, 5S methodology and the last two about Single Minute Exchange of Die (SMED). With the exception of the 5S game, which based on pencil and paper, the other three have a strong hands-on simulation approach. These hands-on approaches use different type of equipment, tools and materials. As an example the dynamics game use electric plug products to be assembled by the students. One of the SMED games uses a steel simulation machine made and combination and hex wrenches. These are activities that can be used for in-class activities of 1 to 4 hours, depending on the game.

EXTEND - EUR BEST PRACTICE 21– CUT

EU BEST PRACTICES
Active learning strategies (see glossary)
Serious Games
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: Częstochowa University of Technology, Poland Program: Master in Management and Production Engineering, Course (Decision support system and knowledge management) Obs.: course related skills and soft skills for accomplishing blended learning tasks
Short description (details and further information)
The MSc program in Management and Production Engineering on CUT offers number of courses that use blended learning approach. In this approach traditional classes are complemented with e-learning course becoming integrated learning system. In case of Decision support system and knowledge management course the tasks are using number of methods and approaches combining the two learning systems. The key characteristics of activities used are: - group task appointing with individual task accomplishing (teacher explains common rules and assessment criteria for tasks and give students free hand with choosing the topics / companies to accomplish them) - combining different modes of working in project groups (group setting and project scoping sessions, group tasks roaster, individual work and group work, traditional and e-learning tasks) - gamification of learning process by introducing additional assessment and valuation criteria (badges system, time dependent bonuses for accomplishing tasks, requirements to follow criteria, student polls for awarding best project / performances) - combining web-quests and stakeholder interviewing for double verification of data sources. Using e-learning courses could be problematic for programs oriented on specific engineering competences and ICT systems skills (like in Industrial Engineering). Therefore, blended approach is proposed that combines traditional learning with e-learning tasks. That enables from one hand direct monitoring of learning outcomes, teacher-led distribution and explanation of tasks and practically oriented program specific skills acquisition. On the other hand, it enables individualization of learning process, virtualization and gamification based enhancements, quick feedback to problems arising in learning process.

EXTEND - EUR BEST PRACTICE 22– DUT

EU BEST PRACTICES
Active learning strategies (see glossary)
Various approaches: while some take a teacher-centered, theoretically-driven approach, others have adopted active, student-centered learning across the curriculum. For example, in Industrial Design Engineering, more than 50% of the curriculum is project-based.
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: Delft University of Technology, The Netherlands Programs: eight Faculties in engineering, applied science and design Obs.: growth of open and online learning
Short description (details and further information)
The following text is an excerpt of the following reference: R. Graham, "The global state of the art in engineering education" in Massachusetts Institute of Technology (MIT) Massachusetts, USA, 2018. TU Delft's educational approach focuses on: 1. deep disciplinary knowledge; 2. the integration of engineering, science and design; 3. an ambitious student culture of initiative and hands-on learning; 4. a pioneering approach to blended and online learning. The institution's early decision to become a pioneer in open-access online learning and its highly ambitious extra-curricular student-led projects. In other words, a strategic institutional investment was made in areas with the potential to catalyze educational change across the institution: in the teaching skills of academic staff, in educational technologies and in extra-curricular student-led learning. The TU Delft Extension School in open and online education was opened in spring 2014 and focused on four core areas: (i) open courseware; (ii) MOOCS; (iii) online academic courses with paid enrollment; and (iv) professional education courses with paid enrolment. In September 2017, TU Delft launched the Teaching Academy. Tt brings together the support functions previously supplied by the Extension School and OC Focus (TU Delft's teaching and learning support center, originally established in 2007). The new Teaching Academy will offer: • professional development courses, workshops and UTQ training; • 'hands-on' support for online or on-campus course development; • focused one-to-one support for teaching innovations, both online and on-campus.

EXTEND - EUR BEST PRACTICE 23– Aalborg University

EU BEST PRACTICES
Active learning strategies (see glossary)
Problem and Project Based Learning
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: Aalborg University, Denmark Program: all educational programs adopted a purely Problem-Based Learning (PBL) approach. Obs.: https://www.en.aau.dk/about-aau/aalborg-model-problem-based-learning/
Short description (details and further information)
The following text is an excerpt of the following reference: R. Graham, "The global state of the art in engineering education" in Massachusetts Institute of Technology (MIT) Massachusetts, USA, 2018. The Aalborg model includes project work based on authentic problems, self-governed group work and collaboration. The Aalborg model provides students with tools for independent acquisition of knowledge, skills and competences at an advanced academic level. During their studies, many students will also have the opportunity to cooperate with external partners on the solution of scientific problems. The basic principles of Aalborg Model are the following: A project represents a time-limited and targeted process in which a problem may be phrased, analysed and solved, resulting in a tangible product. In order to ensure that they become familiar with a wide range of theories and methods which they can use in their project work, students will participate in obligatory as well as optional courses. The courses require a large amount of student activity, including lectures, workshops, seminars and exercises. A group of students work closely together in managing and completing a project over an extended period of time, taking a problem as the point of departure for their work. The students' mutual support is essential for the successful completion of the project. The curriculum framework, supported by the supervisor, aims at ensuring that students' project work is exemplary as regards both content and approach. Exemplarity implies that learning outcomes achieved during concrete project work are transferable to similar situations encountered by students in their professional careers. Within the framework and objectives of the curriculum, the students are largely free to choose the content of their own projects, and thus to determine key elements of their study programme. At the same time, students are responsible for a considerable part of their own ongoing academic self-reflection.

More details: https://www.aau.dk/digitalAssets/148/148025_pbl-aalborg-model_uk.pdf

UNESCO Centre for Problem Based Learning - contributes to a reform strategy to higher education by combining Problem and Project Based Learning (PBL), Engineering Education Research (EER) and Education for Sustainable Development (ESD). This is a unique combination of Research & Development areas that are mutual dependent and complementary. For example sustainable knowledge and skills require complex learning processes across existing disciplines and PBL is a learning methodology beneficial for that purpose.

EXTEND - EUR BEST PRACTICE 24– UCL

EU BEST PRACTICES
Active learning strategies (see glossary)
Project based-learning
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: University College of London (UCL), UK Program: Integrated Engineering Program Obs.: The Integrated Engineering Programme (IEP) is a new integrated framework that combines innovative teaching methods and an industry-oriented curriculum with discipline-specific, accredited degree programmes. Students are given the opportunity to participate in interdisciplinary activities and develop their transferable professional skills in the context of real-world engineering projects. http://www.engineering.ucl.ac.uk/integrated-engineering/
Short description (details and further information)
The following text is an excerpt of the following reference: R. Graham, "The global state of the art in engineering education" in Massachusetts Institute of Technology (MIT) Massachusetts, USA, 2018. IEP education is integrated across the core curriculum for all engineering students. Focuses predominantly on the first two years of the BEng and MEng curriculum at UCL Engineering.75 Years 3 and 4 of study are largely determined by each department, but most bring together individual or group projects with electives and core disciplinary content. The educational approach focuses on: - multidisciplinary learning through cross-Faculty projects and experiences - the application of knowledge to practice - focus on engineering as a vehicle for positive world change - development of professional capabilities At a Faculty level, teaching and learning support and training is provided both through the central IEP and through the Centre for Engineering Education (CEE). At a university level, UCL Arena provides a number of pathways for professional development support in teaching and learning as well as access to the UCL ChangeMaker72 grants, which funds collaborative staff/student educational reform projects. The curriculum activities includes different approaches:

• Challenges: two immersive five-week projects at the start of Year 1 introducing students to the role and scope of engineering and setting a context for their studies;

• Scenarios: a series of five-week curricular cycles where students spend four weeks building critical engineering skills and knowledge that they subsequently apply to tackle a one-week intensive design project;

• Design and Professional Skills: a structured program of skill development that students can apply and build upon in their Scenarios and Challenges;

• Minors: specialisms, often at the interface between engineering disciplines, such as sustainable building design, ocean engineering and regenerative medicines;

• Core engineering modules: largely discipline-specific engineering modules.

EXTEND - EUR BEST PRACTICE 25–IPG

<EU BEST PRACTICES
Active learning strategies (see glossary)
Research / work based learning
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: Institut Polytechnique de Grenoble, France Program: Master in Industrial Engineering – Sustainable Industrial Engineering program Obs.: setting the student within industrial / research partner
Short description (details and further information)
For the last semester of the MSc program students are sent with the mission to industrial company or to research institute in France or abroad. The mission is obligatory for all of the students. The mission could be related to specific industrial or research problem or the research / innovation idea of the student that could constitute the diploma thesis of the student. If the scope of a mission is given by the partnering organization it is firstly discussed with the tutors and students. Basing on the specific IE skills and capabilities of students, as well as their language competencies, they are qualified for the missions. If the mission is proposed by the student, the appropriate research / industrial organizations are contacted In both cases, the preliminary schedule and program of a mission is developed by tutor / student and it is due to acceptance of partnering organizations. Student spend one semester on a mission, reporting periodically the developments on the mission, as well as, preparing the thesis. The scope of the mission is to achieve specific industrial / research goal but the circumstances during the mission could change so the goals could be changed. During the mission students are focused on their goals but also acquire industry / research specific skills and get to know working conditions and codes of conduct. The mission require number of skills and knowledge from their studying courses and implies highly practical oriented approach. Additionally, students get multiple occasions to test their program related and soft skills. Depending on the scope of the mission, students acquire new skills and knowledge that significantly broadens their understanding of IE and prepares for challenges of industry and research.

EXTEND - EUR BEST PRACTICE 26–DTU

EU BEST PRACTICES
Active learning strategies (see glossary)
Research-based learning Project-based learning
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: Technical University of Denmark (DTU), Denmark Program: General Engineering programme (BSc) Obs.: interdisciplinary study programme that focuses on the broad and general engineering competences. https://www.dtu.dk/english/Education/Bachelor-BEng-and-BSc-/bsc/General-Engineering
Short description (details and further information)
The BSc in Engineering programme is a research-based basic engineering programme qualifying the student for an MSc programme. The BSc graduate must have a solid basic academic foundation in the fields of technical science, IT, and natural science and be able to understand and apply mathematical and physical principles and methods. The BSc graduate must be able to combine research-based and practical knowledge to find suitable technological solutions, propose ways of implementing them, and make an overall assessment of their usability with due consideration for ethical, economic, social, and environmental conditions. The BSc graduate must have insight into the types of knowledge and competences on which the engineering subjects are based and be able to view technological solutions in a broad social perspective. The programme also helps develop social and communicative competences, so that the graduate is able to use the professional knowledge in collaboration with others. Throughout the entire programme students work on design-build projects, which are practice-oriented, interdisciplinary group projects. Together in teams, students must propose an engineering solution to a specific problem from the real world. This will make students familiar with the engineering approach to solving problems, and how to communicate and work together with your group to find the best solutions in real-life settings. General Engineering is in English. About half of the students and lecturers on the programme have an international background. In this way, students become a part of an international study environment which prepares them for a career in the global labour market.

EXTEND - EUR BEST PRACTICE 27–TU

EU BEST PRACTICES
Active learning strategies (see glossary)
Several active learning strategies: lectures, seminars, laboratory work, tutorials, group work, assignments
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: Tampere University, Finland Program: International Degree Programme in Science and Engineering, BSc (Tech) Obs.: International focus (English and / or Finnish) https://www.tuni.fi/en/study-with-us/science-and-engineering#show-field-degree-structure-studies
Short description (details and further information)
Is a cross-disciplinary programme that gives a solid grounding in several core fields of engineering. The major subjects available in the programme are Mathematics, Physics, and Information and Communications Technology. By studying in a multicultural group with students from all over the world, it is expected that students also acquire strong language, communication and collaboration skills and the ability to operate in a multidisciplinary and international community. Besides providing a strong theoretical foundation for further studies in the fields of engineering, the programme places special emphasis on internationality, employability and connections to the industry. The program is committed to investing in new and innovative learning environments and encourage the use of new technological solutions to continuously develop the quality of teaching and learning. Courses often consist of a combination of lectures, seminars, laboratory work, tutorials, group work, assignments, independent study and an examination. Students at Tampere University work both independently and in close collaboration with their fellow students. Besides developing their theoretical and analytical skills, our students learn to work independently, take responsibility for their studies, and become accustomed to communicating and working as part of a multicultural group.

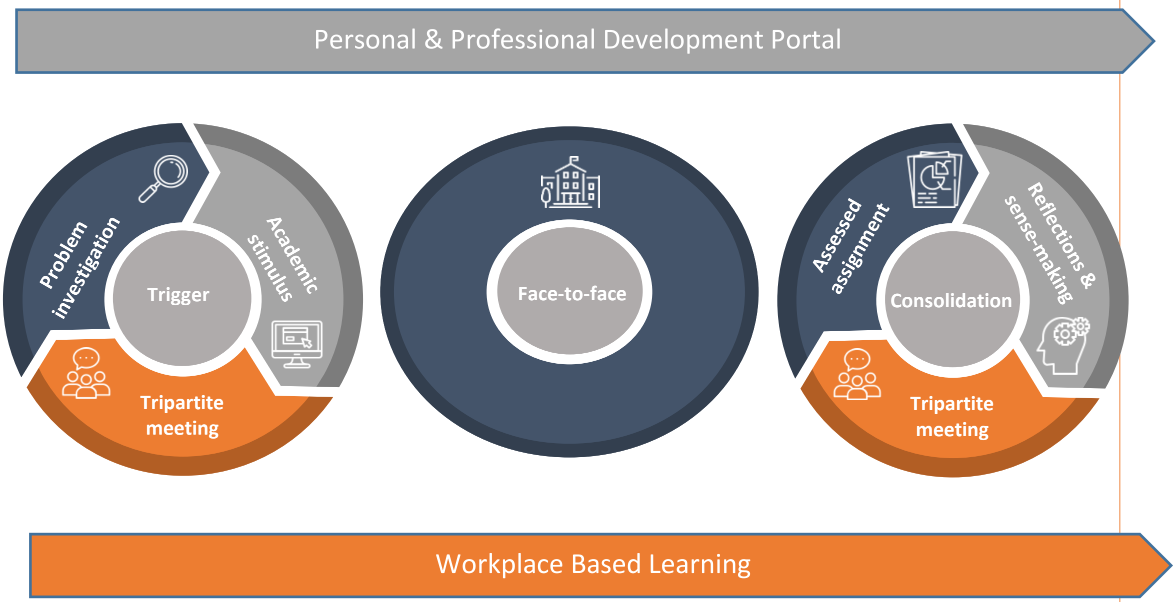
EXTEND - EUR BEST PRACTICE 28–MU

EU BEST PRACTICES
Active learning strategies (see glossary)
Project-based learning
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: Maastricht University, The Netherlands Program: Data Science and Knowledge Engineering Obs.: this program has been ranked as the #1 Artificial Intelligence bachelor's programme in the Dutch University Guide: Keuzegids 2019 with a score of 72 points. https://www.maastrichtuniversity.nl/education/bachelor/bachelor-data-science-and-knowledge-engineering/courses-curriculum
Short description (details and further information)
The curriculum of the bachelor's in Data Science and Knowledge Engineering has a broad set-up that allows students to participate in the DKE Honours programme (KE@Work or Research track) in year 2 & 3, to go abroad for a semester in year 3, or to specialise in the finale stage of the programme. Within an international environment, the programme provides a broad base in mathematics and computer science, but it also includes courses on knowledge management, cognitive psychology, logic and the philosophy of science. Students work on projects in small groups of 5-6 students, applying recently acquired knowledge to open ended problems, that are often based on real-world situations. The assignments are may be provided from companies and organisations in healthcare, IT and logistics. For example, students can develop a program that records river water levels and issues timely flood warnings for a local government. But they also can be asked to study the traffic flow at major highways and road junctions and come up with effective ways to manage them.

EXTEND - EUR BEST PRACTICE 29–UW

EU BEST PRACTICES
Work Based Learning (see glossary)
Engineering Degree Apprenticeship
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: University of Warwick (for this model) Program: Applied Engineering Programme; Digital Technology Specialist
Short description (details and further information)

The Degree Apprenticeship is a model of education which blends academic study with workplace based learning. It is a blended learning model with online, classroom and work-based components. Students work full-time in their parent company but are released a minimum of 20% of their time for academic study. The programme is designed to blend personal, professional and academic development into a seamless whole. Students undertake a range of academic modules depending on the programme, up to 6 per annum (depending on size) over 4 years.



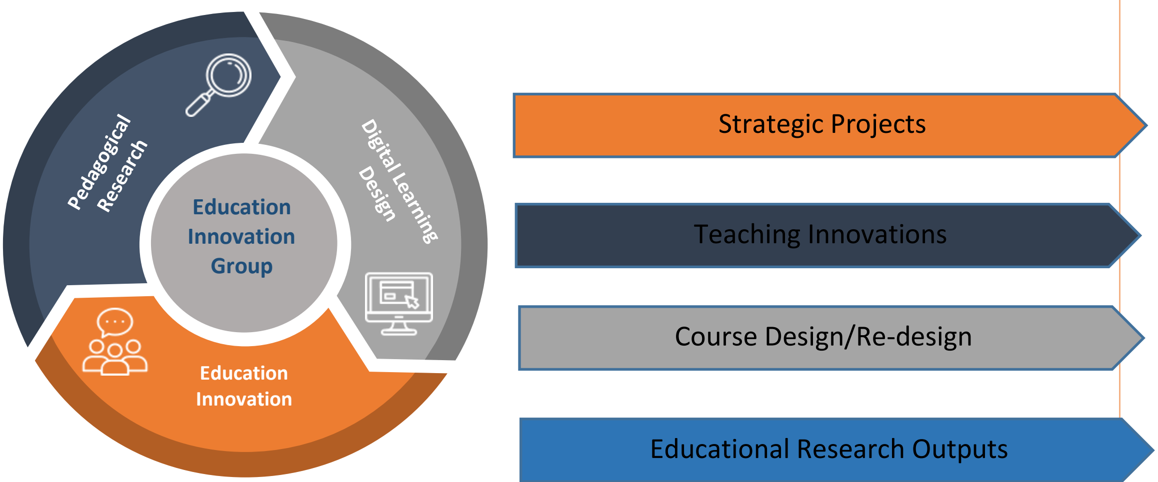
As shown in the diagram, each academic module begins with a trigger activity which will be a combination of academic content (delivered online) and an organizational challenge related to the area of study. The students work together or in groups to develop artefacts, reports or presentations which will feed in to a short, action-learning oriented face-to-face intervention (typically 2 to 4 days duration) on campus. The student will then return to the workplace to complete a practically oriented assignment related to the module of study.

In parallel, and linked to the academic study students undertake workplace learning activities focused on practical skills and behaviours and are supported in this by workplace learning mentors (from the company) and Apprenticeship Tutors (university). They also access a personal and professional development portal where they can develop skills and maintain a portfolio mapping their growth in both aspects.

EXTEND - EUR BEST PRACTICE 30–UW

EU BEST PRACTICES
Teaching Development
Education innovation Group
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: WMG, University of Warwick Program: Across All Programmes
Short description (details and further information)

The Education Innovation Group (EIG) is a strategic resource within the department set up to support the transformation of Learning and Teaching within WMG. The group is a blend of Learning Design specialists (with a particular focus on blended and technology enhanced learning), Pedagogical Researchers, Learning Technologists and Educational Innovators.



The group undertake strategic projects such as the design and delivery of a WMG 'Digital Experience' - which defines the standards and approaches for online engagement with students during their time with Warwick or the development of learning spaces and pedagogic practices to create a transformative learning and teaching environment.

The group further support the design and re-design of new/revamped courses by taking course teams through a rigorous process using approaches such as Signature Pedagogies, Design Thinking and Journey Mapping. This approach allows courses to be strategically developed for the desired student experience and outcomes while making the best use of staff and resources (both physical and virtual).

The group also support innovation at the session and module level by engaging with teaching staff through workshops, focused design-test cycles and integrating technological developments.

All of these are underpinned by rigorous research and scholarship practices (including publications) which are designed to build credibility with colleague practitioners and the wider academy.

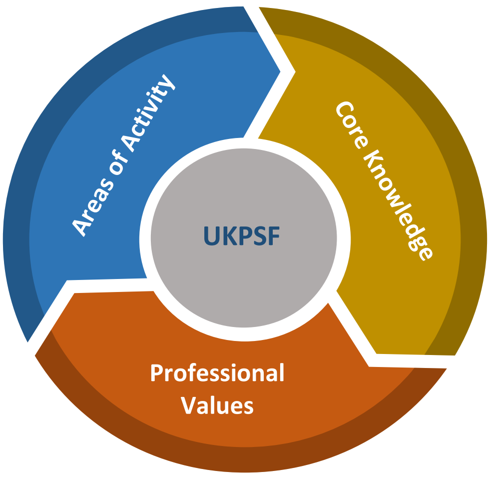
The group consists of a core of full-time expertise supplemented by short-term (6 to 12 month) secondees who work with the team on innovations and take their learning back into their own practice. The team engages with teaching, research and administrative staff and students to co-create robust and effective solutions.

EXTEND - EUR BEST PRACTICE 31–UW

EU BEST PRACTICES
Teacher Development
Higher Education Academy Recognition
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: WMG, University of Warwick Program: Across All Programmes
Short description (details and further information)

The Higher Education Academy (HEA) is a UK Based non-profit independent organization committed to world-class teaching in higher education. Part of its portfolio of activities is the accreditation of various levels of Fellowship. HEA Fellowship demonstrates a personal and institutional commitment to professionalism in learning and teaching in higher education. Across four categories, from Associate to Principal, Fellowship provides individuals with recognition of their practice, impact and leadership of teaching and learning.

The categories of Fellowship are mapped against the UK Professional Standards Framework (UKPSF). The UKPSF has three key areas:



Areas of Activity looks at the breadth of engagement of the teacher in learning and teaching activities (from design of individual sessions to development of whole programmes). **Core Knowledge** considers the level of understanding of pedagogical theory and practical application to real issues within teaching and learning. **Professional Values** evaluates the teacher's engagement with core values such as respect for learners, equality of opportunity and the use of evidence informed practices.

Fellows demonstrate these criteria at an individual level, Senior fellows demonstrate departmental or team leadership in the criteria and Principal Fellows demonstrate this at an institutional or national level.

WMG has mandated that all module owners must be at, or working towards, Fellowship level and all Course directors must be at, or working towards Senior Fellowship. The requirement to achieve external recognition of their capabilities and contribution as a teacher has four principal benefits:

- Increased quality of learning for students
- More innovation and improvement within teaching programmes
- Improved recognition for individual teachers
- Higher profile for teaching within the institution

EXTEND - EUR BEST PRACTICE 32–UW

EU BEST PRACTICES
Active Learning
Reflective Practice & Learning Logs
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: WMG, University of Warwick Program: All Degree Apprenticeship Programmes
Short description (details and further information)

Reflection is a core element of learning, and also of becoming an effective practitioner. Engineers need to be able to make sense of their experiences in the light of theory, and develop improved action and decisions for the future whether this relates to improved designs or better processes.

Degree Apprenticeships are programmes of blended learning where students are employed in industry and spend 20% of their time on degree level study. Degree Apprenticeship programmes in WMG make the development of reflective practice an active part of the curriculum as an important meta-skill which supports and informs all the other aspects of becoming a professional engineer. Students use the Gibbs Reflective Cycle to structure reflections on activities within modules, whole modules and their performance on assessments:

- **Description:** What happened?
- **Feelings:** What were you thinking/feeling?
- **Evaluation:** What was good or bad?
- **Analysis:** What sense can you make of it?
- **Conclusion:** What else could you have done?
- **Action:** What will you do in the future?

This can be a group or individual activity, and students are encouraged to conduct separate personal and professional reflections. The student uses these micro-reflections to build a 'Learning Log' of significant elements of both their course and their experiences within their employing organization, from both a personal and professional perspective. The Log is a narrative of their development as individuals and as professional engineers, and is assessed at various points in the programme and as a final submission on completion. This document is also very useful to graduates in helping determine their future career direction, and to provide evidence to their present or future employers of their competences and learning.

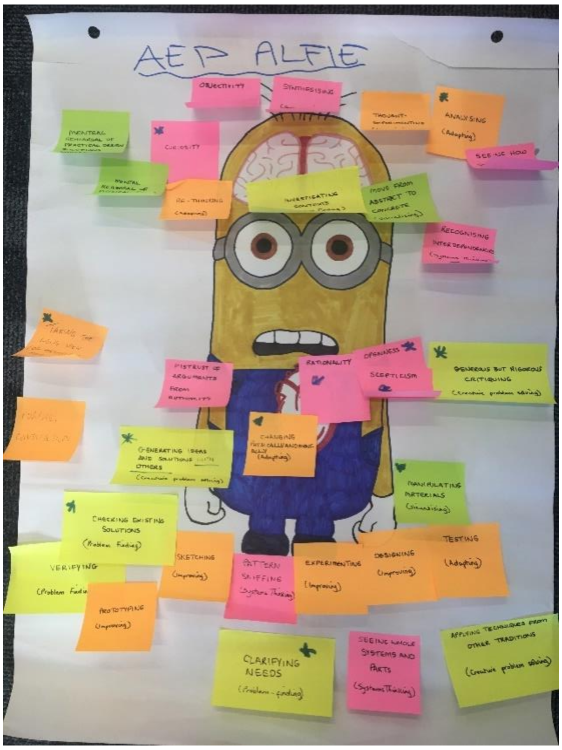
EXTEND - EUR BEST PRACTICE 33–UW

EU BEST PRACTICES
Developing Programmes of Study
Signature Pedagogies & Design Thinking
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: WMG, University of Warwick Program: Applied Engineering Programme
Short description (details and further information)

Signature Pedagogy is the concept that every discipline has a particular way of engaging with the world. This is broken down into three categories:

- **Habits of Head:** How do engineers think?
- **Habits of Heart:** What do engineers believe?
- **Habits of Hand:** What do engineers do?

By considering these questions for the graduates of a course it is possible for the course team to develop a clear view of the 'ideal graduate' of the programme. An example developed in a workshop by the AEP team is shown below:



This ideal graduate then becomes the 'product' of the course, and we can use design thinking to develop both the content of the course and approaches to learning and assessment which will promote the habits that are central to the desired graduate in the discipline. So, for example, if 'curiosity' and 'experimentation' were habits of AEP Engineers there would be implications for content (we should teach experimental methods and appropriate analytical techniques), teaching approaches (use problem based learning linked to the real world) and assessment (assess how students develop an understanding of a complex situation & how they experiment with parameters).

EXTEND - EUR BEST PRACTICE 34–UW

EU BEST PRACTICES
Active Learning
Self-Assessment
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: WMG, University of Warwick Program: Selected modules on a range of programmes
Short description (details and further information)
The ability to accurately assess the quality of one's work is a critical skill for any professional, and especially for engineers. In professional practice it is common for engineers to be set complex tasks with minimal supervision and the individual in question must be able to judge how well they are doing without constant recourse to feedback from others. Students on modules such as Quality Systems, Quality Techniques, and Product Design are set assignments to assess their attainment of the module learning outcomes in the usual way with a normal briefing. Within 24 hours of the submission of the assignments the cohort is called together and each student is given access to the detailed assessment rubric. They are then asked to assess their own work against the criteria, giving both a mark and feedback on strengths and opportunities for improvement. To ensure that students engage with the process, and to give appropriate value to the skill of self-assessment an incentive is applied – If a student accurately self-assesses (within 5% of the tutor's mark and with appropriate comments) they will receive the higher of the two marks plus 3%. At the end of the session the tutor collects the self-assessments and refers to them **after** marking the assignments to see how well the students have understood the quality of their work in relation to the brief. The tutor will then write feedback which uses the comparison of the student's perception to their own as its main input. There are a number of benefits to the students from this practice: • The feedback is more clearly targeted on areas of misunderstanding and is more useful in improving future performance as a result. • The students are agents in their own assessment and so feel more empowered. • The assessment process is more developmental and students feel more engaged with it as part of the learning process. • Students report significant improvements in performance on subsequent modules as a result of the use of this approach. • It develops a useful life skill for their professional practice. • If used on a number of modules the patterns can indicate where particular students struggling to understand what is expected of them and targeted support can be offered.

EXTEND - EUR BEST PRACTICE 35–UW

EU BEST PRACTICES
Teacher Development
Warwick International Higher Education Academy & Warwick Award for Teaching Excellence
Teaching and learning context (Institution, program, interdisciplinary approach, etc.)
Institution: University of Warwick Program: Across All Departments & Programmes Link: https://warwick.ac.uk/fac/cross_fac/academy/
Short description (details and further information)
The Warwick Higher Education Academy (WIHEA) was launched in 2014 with the aim of raising the profile of teaching within the institution and creating a community of practice around excellent educational practice and student experience. Every year all departments are invited to submit cases for high performing teachers and teaching related staff in their area to become Fellows of WIHEA. These cases are reviewed by a team of senior teaching academics against criteria related to the candidates' engagement, impact, collegiality and potential. Approximately 20 staff are selected each year and are appointed Fellows for 3 years, after which time they become Alumni. Fellowships are not paid, and Fellows do not receive a time allocation for their activities as part of WIHEA. However, what fellows do receive is the opportunity to engage with higher-level decision making in the University (Committee membership and involvement in key projects) and to enhance their reputation and recognition within the wider University community (and beyond). Fellows can also bid for exclusive funding for projects which enhance learning and teaching in Warwick and also have access to targeted development opportunities. WIHEA now has over 50 active fellows and over 20 alumni. They have contributed to key University policies (for example, helping to develop a new promotion criteria raising teaching and learning excellence onto the same level of prestige as research excellence) and a significant number have achieved promotion as a result, in part, of their WIHEA activities. Perhaps, more importantly, they now form the hub of a vibrant learning community around teaching which allows colleagues to learn from and with each other across faculties and departments. Much of WIHEA's work is done in collaboration with the student body allowing them to develop additional skills and creating a true educational partnership. The Warwick Award for Teaching Excellence (WATE) is an annual award which recognises 7 individuals who have made outstanding contributions to learning and teaching at Warwick and commends up to 7 others. There is also a corresponding award for post-graduate students involved in teaching. Nominated by colleagues and students each award winner receives £5000 to spend on improving their teaching practice (commendees receive £2000). The awards are celebrated as part of the degree congregation ceremonies and are seen as highly prestigious. Award winners are required, as part of their recognition, to share their practice at University wide events in order to help to spread effective learning and teaching behaviours around the university.

The importance of these initiatives is in recognising the views of students and staff on what is excellent practice, and in rewarding and encouraging staff who are innovating and having impact in their teaching activities.