e-mentor
DWUMIESIĘCZNIK SZKOŁY GŁÓWNEJ HANDLOWEJ W WARSZAWIE
WSPÓŁWYDAWCA: FUNDACJA PROMOCJI I AKREDYTACJ KIERUNKÓW EKONOMICZNYCH

2018, nr 2 (74)

Bartłomiej Gładysz, Elżbieta Jarzębowska, *International project-oriented training of engineers based on the example of the European Engineering Team*, "e-mentor" 2018, s. 63–72, http://dx.doi.org/10.15219/em74.1354.

International project-oriented training of engineers based on the example of the European Engineering Team

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The authors present their analysis, from the viewpoint of competence development and achievement of learning outcomes, of the first round of the innovative teaching program "European Engineering Team", which was implemented within the framework of the ERASMUS+ initiative. The innovativeness of the program lies in its orientation to engineering projects, which the technical university master course curriculum is enriched with, and the cooperation of four European technical universities. The students independently select and specify engineering problems related to sustainable development. The formula of the program changes the traditional approach to mobility known from other ERASMUS+ activities. During its implementation the students participated in four international meetings, consultations, web conferences and teleconferences, which is in line with the current trends of the global labor market. Between the direct meetings, they have cooperated with each other remotely, simultaneously participating in the regular courses at their home technical universities. The aim of the project was to verify the effectiveness of the proposed approach towards inter-institutional initiatives using blended teaching methods. This approach is aimed at developing competences in the area of defining engineering problems within the framework of sustainable development, the cooperation in international and geographically dispersed teams and working in interdisciplinary projects while utilizing the knowledge from many disciplines. The approach proved to be effective and the students' competences in the assumed areas have increased significantly. At the same time, the experience gained has allowed to identify the areas in which learning outcomes can be increased and the focus will be placed on them in the next round of the program.

Traditional methods of educating engineers are considered to be insufficient in relation to the contemporary requirements (MacLeod, 2010, pp. 21-34). Engineers should be prepared to work in a global environment which is characterized by high volatility, multiculturalism and new social, economic and environmental trends resulting, among others, from globalization. Such a dynamic environment of engineering activity is reflected in the European Union's EUROPE 2020 strategy (EC, 2010, p. 11). This strategy emphasizes the importance of economic growth, job creation, climate change, prosperity and social security. Vernon (2000, pp. 215–225) shows that an effective training of engineers should be focused on the student, oriented to designing tasks and contain the elements of economics and management. There are many initiatives related to the new forms of cooperation between universities (Paci et al., 2013, pp. 487–493), including the education of engineers. One of such forms are the so-called "learning factories", which allow one to acquire the competences necessary for the transfer of technology from the world of science to industry (Ziemian and Sharma, 2007, pp. 199–210). Unfortunately, this approach to education does not include the initial stages of development of innovation. Another well-known approach is the experiential learning (EL) developed in the works of Dewey (2007, pp. 17–97), Lewin (Schein, 1996, pp. 27–47), Piaget (1964, pp. 7–20), or Kolb (2015, pp. 1–354; Kolb and Kolb, 2005, pp. 193–212). Jack et al. (2011, pp. 75–76) indicate that in order to ensure high quality and effectiveness of education of engineers it is necessary to engage students in global travels and projects, including subjects related to global aspects of manufacturing, and in particular the use teaching methods that increase students' involvement.

International project-based training of engineers

Only a few training initiatives for engineers offer transnational and project-based curricula. What they lack is the parallel use of virtual and direct collaboration between students. The initiatives focused on virtual collaboration include:

- an interactive online course based on an internet platform between an American and a German university (May, Wold and Moore, 2014, pp. 12–19),

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- international, interdisciplinary, project-oriented studies in the cooperation with the industry (Flores et al., 2012, pp. 70–74),
- an intercollegiate (5 universities from Romania, Moldova and Croatia) course in education in a foreign language, French (Petrea and Velescu, 2014, pp. 707–711),
- an intercollegiate (3 universities from the USA) project in the field of software engineering (Kurtz et al., 2007, pp. 464–468),
- an intercollegiate (Canadian and Finnish university) course in software engineering (Paasivaara et al., 2013, pp. 1128–1137).

In turn, didactic initiative focused on direct cooperation characterized by short periods of work performed in a specific place are:

- Portuguese-German project on climate change (Sanderson, 2017, pp. 63–65),
- an international, interdisciplinary course for engineers from TU Berlin (Oladiran et al., 2011, pp. 173–186),
- a 28-week international (students from France, Germany, Ireland, Great Britain) course in the field of construction management (Lane, 1994, pp. 443–448).

Most didactic initiatives do not combine virtual and direct cooperation, and such cooperation is characteristic of the modern market. There are also no initiatives combining the guidelines presented by Vernon (2000, pp. 215–225) and Jack et al. (2011, pp. 75–76), whose main focus is to incorporate the assumptions of gaining education through experience for engineers with emphasis on the importance of sustainable development, systems engineering and development of new products. Such initiatives should also eliminate the barriers defined by Sharma et al. (2017, pp. 4032–4040), problems associated with work in multidisciplinary teams, organizational problems and limited involvement of students.

Assumptions of the "European Engineering Team" program

Framework of the program

The intention of the "European Engineering Team" (EET) is to eliminate these deficiencies in the didactic process of engineers by creating an inter-university, project-oriented program and with the use of blended learning (Bonk and Graham, 2006, p. 1), i.e. combination of traditional and long-distance learning in international and interdisciplinary environments, which was developed and implemented at the master studies at 4 European technical universities. The EET is a unique program based on EL principles and which uses a holistic approach, which includes management, broadly understood mechanics and production engineering. Its priority is the principle of sustainable development applied to innovative engineering solutions.

The idea of the EET is shown in figure 1. The entire program of the course is implemented in a rotational model of blended learning (Beaver et al., 2014, p. 7), in which the periods of work and long-distance learning are interwoven with periods of work with a teacher. The EET course consists of four one-week periods of the direct cooperation. The meetings are held in each of the technical universities participating in the project. Between the meetings, a virtual collaboration takes place during which the students simultaneously participate in the course of studies at their home universities. In addition, the education is supported by the lectures which are available online. The scope of those lectures covers the subject matter necessary to implement the project.

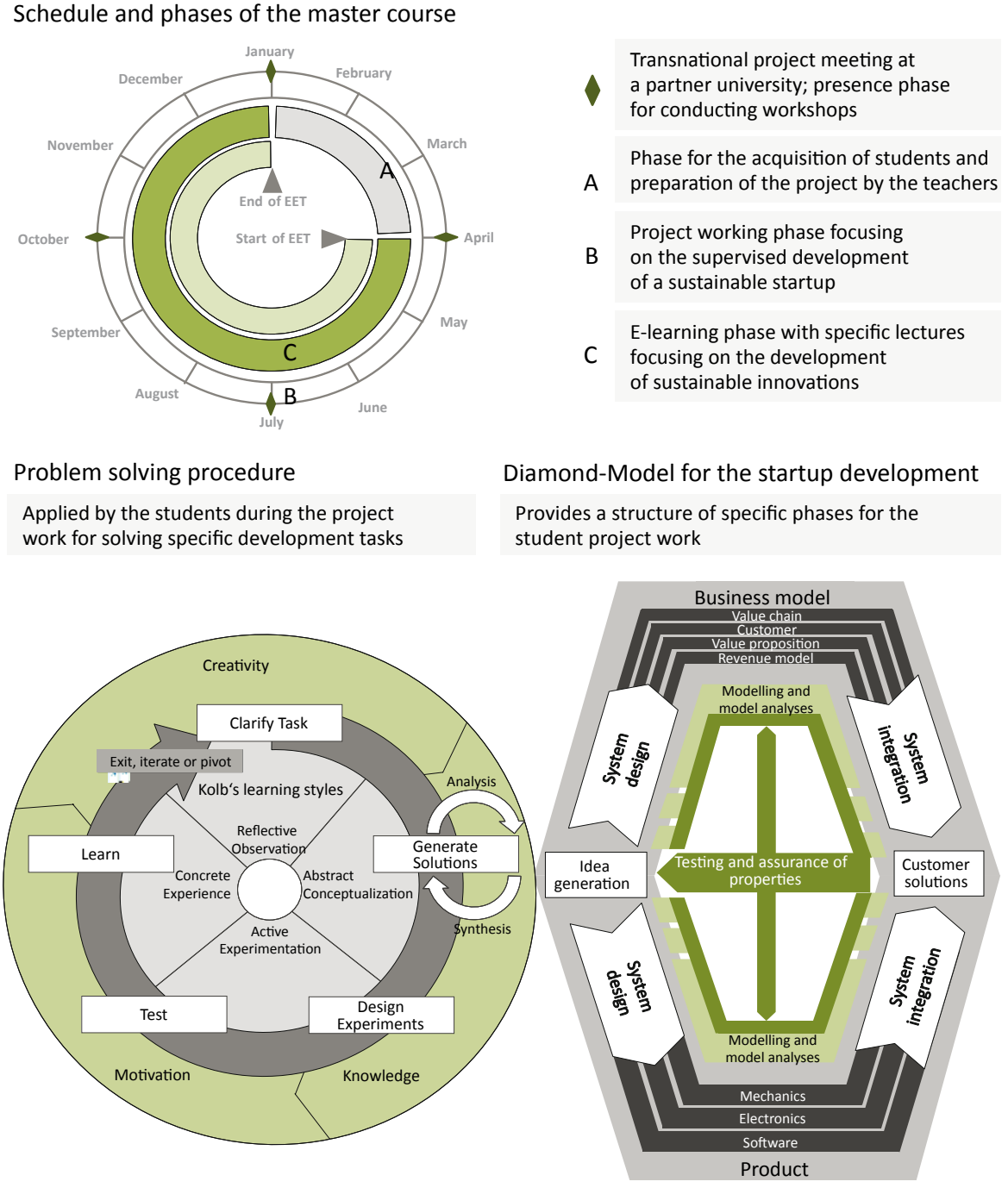
Three students from each technical university participated in the first round of the project, i.e. from the Warsaw University of Technology, TU Berlin, Politecnico di Milano, NTNU Trondheim. Students of the Warsaw University of Technology were recruited from the Faculties of Power and Aeronautical Engineering, Production Engineering, Automotive and Construction Machinery Engineering as well as Mechatronics. Students from other technical universities were students of master's degree courses in the field of industrial engineering. More information on the organization of the EET project and the competences acquired by students participating in the program can be found in (Stock and Kohl, 2018, pp. 10–17; Stock et al., 2016, pp. 1–13). The guidelines for conducting this type of projects are presented in (Stock et al., 2017, pp. 33–40). At present, the second round of the project is coming to an end, with four participating students from each university. The following chapters present the assumptions of the project, the learning objectives and discuss the results of the first round, in particular the increase in the scope of the knowledge, skills and students' competences.

Project initiation

One of the goals set for the EET program is to teach engineers how to make strategic decisions. In business practice, engineers have to solve problems that are not necessarily well defined and are often characterized by high level of uncertainty and complexity (Claesson and Svanstrom, 2015, pp. 073:1–073:7). Students start their work by choosing a problem to solve, understand it, assess the possible solutions, and then develop and document the specific solution that can be commercialized. The meeting of the EET group started with the introduction on systems engineering (Walden et al., 2015, pp. 5–24) and development of start-ups (Stock and Seliger, 2016, pp. 505–512). Such introduction provides students with knowledge about the possible framework for structuring the cooperation.

Despite the fact that all the students have participated in the courses related to mechanics or production engineering, the curricula of universities differ significantly, therefore the scope of knowledge of

Figure 1. Teaching model in the EET course



Source: Stock and Kohl, 2018, pp. 10–17.

students in the areas such as dynamics, automation, sustainable development concepts or group work skills is very diverse. Tuckman (1965, pp. 384–399) described the stages of development of small teams. Analogous stages of the formation of the EET team are presented in Appendix 1.

An important element in the initiation of the EET project was enabling students to self-formulate a problem and achieve consensus in the group, regarding the choice of the problem, approach to the solution and the methods of its resolution.

A new approach to mobility in education

Traditional training of engineers at bachelor and master studies, usually does not include innovative projects that require self-development of a solution, ensuring its innovativeness and development of the

methods of its implementation. Independent work of students, which has the characteristics of scientific and project work, takes place in student scientific circles e.g. at the Warsaw University of Technology. An example is the Aviators Scientific Circle operating at the Faculty of Power and Aeronautical Engineering, whose participating students annually take part in the international SAE air competitions in the USA and every year they achieve high rankings as well as receive awards. The students of the Aviators' Circle independently design and build planes in accordance with the rules of the competition, they attract sponsors and initiate project consultations with the teaching staff of the Faculty. The Erasmus+ international exchange program also does not provide the students with opportunities to participate in innovative international projects that require self-development of solutions. The exchange within the Erasmus+ program is rather a duplication of traditional education methods, however, at a partner university. Students' mobility in the Erasmus+ program consists of "moving to a new country" and adapting to the new rules of traditional education for a semester or two. Similarly, students' domestic and foreign internships are a kind of substitute of work on the project, even an international one. A student is a participant in the project for a limited period of time and generally does not take part in all the stages of its development neither is not responsible for making the key decisions regarding the methods of solving certain design tasks.

The EET concept introduces a new paradigm of mobility in education, which is based on the implementation of an engineering project in an international group from the beginning to the end, including the development of a product implementation plan. This is essentially a type of different activity than, for example, the collaboration in scientific circles. Such mobility requires multiple travels for short periods – the equivalent of short business trips, whose aim is to make progress on the project. Working in transnational teams during face-to-face meetings, whose aims is primarily to integrate the existing results and to plan further work, requires the completion and summary of a larger part of project work. After initial planning and subsequent division of work, students return to their home universities, where they continue their normal course of study and work remotely in the EET project using tools such as cloud, teleconferencing, etc., which is both a business practice and a standard in modern enterprises. In addition, students have online lectures at their disposal, prepared by the teaching staff of the universities participating in the project, which facilitate the acquisition of knowledge and engineering skills required for the EET project, including the so-called soft skills. So far, the students have received the following lectures: sustainable value creation, systems engineering, technology management, circular economy, development of sustainable start-ups, sustainable supply chains, virtual and augmented reality, and digital factories.

Requirements and challenges

Participation in the EET program required the students to develop or acquire new knowledge, skills and competences. Each of the universities participating in the EET has a different semester and examination calendar as well as other curricula. It required students of the Warsaw University of Technology to:

- organize individual courses of study, developed with the deans of each faculty,
- develop the curriculum of the "EET project" module, which is part of the program of study for each EET participant,
- assign the appropriate number of ECTS credits to the module, depending on the faculty and the student's master's degree specialization.

An example of the EET curriculum module for the Faculty of Power and Aeronautical Engineering of the Warsaw University of Technology is presented in Appendix 2.

In order to enable reporting of progress of work and asynchronous communication of academic teachers and students, a dedicated internet communication platform has been provided (Stock et al., 2016, pp. 1–13). This platform is also a place for sharing educational materials, and its basic functionalities are a stream of activities, news, groups and discussion forums, online courses, profiles and a cloud. In addition, it was observed that, apart from the online courses, the meetings initiating the project should start with introductory lectures, e.g. in the field of systems engineering. The teleconferences between the teachers and the students were coordinated by an academic center using only one tool (Skype for business). Regarding synchronous and asynchronous communication between the students themselves, the array of possibility was extended, and they could choose such tools such as Skype, Google Hangouts, Slack, Google Drive or Trello (Stock et al., 2016, pp. 1–13).

The varied level of communication skills and social competences of students turned out to be significant and ultimately had an impact on the work in the project. Some of the students noticed that their arguments, the participation in the discussion, and thus the subsequent arrangements in the project, are completely inadequate to their expectations. They believed that "nobody listens to them", "they cannot reach out with their arguments" to other members of the group. They believed that the others left them "out of the circle of discussion" and that other students "quickly get along with each other." It turned out, after the students' discussion with their supervisor, that they spoke too sparingly, did not repeat and nor paraphrased their views and opinions and they spoke in a too soft voice. It was also observed that the reaction of some students to the failure in their communication was often withdrawal, avoidance to accept difficult tasks in the project or a defensive reaction in the form of disregarding the work. The observed cases are examples of typical behaviors of group work.

The EET project also poses challenges to academic teachers. Above all, leading a group of students educated according to different priorities and study programs, who come from the cultures which perceive technical education differently, using a language other than their native one during the work on the project, caused the teacher to assume a dual role, that of a learner and a leader of the group. The challenge is also to coordinate academic calendars and didactic commitments towards their home universities.

Results

Results of the EET project teams

During the first round of the EET project, the students prepared assumptions for two engineering solutions. These were: a modular pallet and a temperature-maintaining pallet. The task of the modular pallet is to enable deliveries to points of sale in a more flexible manner. The size of one modular pallet is 1/4 of a standard "europallet" (800x1200 mm). The modules are designed in such a way that they can be freely combined with one another, for example, into a 1/2 size pallet or an entire standard pallet. Such solution does not require additional tools for connecting the modules. The students made a part of strength and construction calculations, prepared a preliminary business model and made a physical and virtual model of the pallet (Stock & Kohl, 2018, pp. 10–17). The second solution was the creation of a cover equipped with a wireless temperature sensor, which allows to control the vehicle's cold chamber while transporting temperature-sensitive goods. Students made a physical model and prepared assumptions for a mobile application. They also conducted preliminary numerical simulations and experiments regarding the change of the temperature inside the cover (Gładysz et al., 2018, pp. 18–25).

Students joining the project set a very ambitious goal for themselves, which was to develop prototypes and prepare business models ready to be implemented and commercialized. Considering the short amount of time for the performance of the entire task as well as the assumption that the members of the group simultaneously perform other tasks related to their regular course of study, such goal was virtually impossible to achieve. However, the students made the models of the pallet and the cover, prepared an initial cost estimate and developed a business model.

Competences of students of the EET project

The surveys were conducted at the beginning, in the middle and at the end of the first round of the EET project. The aim of the surveys was to evaluate the effectiveness of the course curriculum and the assumed approach to education. The surveys were anonymous and completed by all the students. In the surveys, students assessed, on a scale from 1 to 10, their progress in terms of substantive, social, professional and personal competences. The results of the surveys are shown in figure 2. The assessment of the majority of the competences has significantly improved.

In particular, the assessment of competence in the development of start-ups, the development of new processes and products is characterized by a significant increase. At the same time, students assessed that their competences in terms of presentation and mediation, communication and conflict resolution as well as self-confidence, leadership and flexibility in group cooperation have increased. The identified areas of possible improvements in the EET program are the development of students' competencies in the field of sustainable development and problem

Figure 2. Assessment of students' competences

Source: Stock and Kohl, 2018, pp. 10–17.

solving. In the next round of the EET project, special attention will be paid to these aspects. Students' self-esteem coincides with the assessment made by the course instructors from each corresponding university from the didactic point of view, the most important achievement is that the students have increased their competences in the following areas:

- frequent and short-term mobility (four weekly meetings),
- long-term work in geographically dispersed teams,
- defining, analyzing and managing problems that need to be solved,
- understanding the relationship between different disciplines of science, knowledge and business environment.

Summary

The aim of the project was to verify the effectiveness of the proposed approach to inter-university initiatives of engineers with the use of blended learning methods. This approach is designed to develop competences in the field of defining problems related to sustainable development, cooperation in international and geographically dispersed teams, and work in interdisciplinary projects utilizing the knowledge from many fields. The approach turned out to be effective, and the students' competences in the established areas have improved. Despite the large amount of work on the part of the students and leading academic teachers, the logistical challenges in organizing face-to-face meetings and assembling models of designed products, it was possible to develop the models of the pallet and of the pallet cover.

Moreover, it was observed that students of the Warsaw University of Technology are prepared for partnership with students from other universities. At the same time, the areas of possible improvements and modifications of the EET program have been identified, which will be the focus of attention of the program's leaders during its next round. Currently, the third, additional round of the EET program is being implemented. The third round has not been initially planned, however, its implementation demonstrates the commitment of the partners and their belief of the significant didactic value of the EET program.

References

Beaver, J.K., Hallar, B., Westmaas, L. (2014). *Blended learning. Defining models and examining conditions to support implementation*.

Bonk, C.J., Graham, C.R. (2006). *The handbook of blended learning environments: Global perspectives, local designs*. San Francisco (CA): Pfeiffer.

Claesson, A.N., Svanstrom, M. (2015). Developing systems thinking for sustainable development in engineering education. *Proceedings of EESD'15*. DOI: 10.14288/1.0064722.

Dewey, J. (2007). *Education and experience (1st Touchstone Edition eBook)*. New York: Simon and Schuster.

Flores, R.I., Soto, C.M., Holliger, C. (2012). Internationalization and transdisciplinary education in design: success factors and pitfalls. *Strategic Design Research Journal*, *5*(2), 70–74.

Gharfalkar, M., Court, R., Campbell, C., Ali, Z., Hillier, G. (2015). Analysis of waste hierarchy in the European waste directive 2008/98/EC. *Waste Management*, 39, 305–313.

Gladysz, B., Urgo, M., Gaspari, L., Pozzan, G., Stock, T., Haskins, C., Jarzębowska, E., Kohl, H. (2018). Sustainable Innovation in a Multi-University Master Course. *Procedia Manufacturing*, 21, 18–25.

Haskins, C., Stock, T., Gladysz, B., Urgo, M. (2017). *Disciplinary Convergence: Implications for Systems Engineering Research*. A.M. Madni, B. Boehm, D.A. Erwin, R. Ghanem, M.J. Wheaton (Eds.). *Proceedings of the 15th CSER*, 1095–1106.

Jack, H., Mott., R, Raju, V., Conkol, G., Stratton, M., Waldrop, P., Wosczyna-Birch, K., Bates, S. (2011). *Curricula 2015; A Four Year Strategic Plan Manufacturing Education*. Retrieved from: https://sites.google.com/site/curricula2015.

European Commission (2010). *Strategia na rzecz inteligentnego i zrównoważonego rozwoju sprzyjającego włączeniu społecznemu*. Retrieved from: http://ec.europa.eu/eu2020/pdf/1_PL_ACT_part1_v1.pdf.

Kolb, A.Y., Kolb, D.A. (2005). Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education. *Academy of Management Learning & Education*, *4*(2), 193–212.

Kolb, D.A. (2015). *Experiential learning: experience as the source of learning and development*, 2nd edition. Upper Saddle River (NY): Pearson Education.

Kurtz, B., Fenwick, J. Jr, Ellsworth, C., Yuan, X., Steele, A., Jia, X. (2007). Inter-University software engineering using web services. I. Russell, S. Haller, J.D. Dougherty, S. Rodger, G. Lewandowski (Eds.). *Proceedings of the 38th SIGCSE*, 464–468.

Lane, T.J. (1994). Educating European Construction Managers of the Future: The Development of a Transnational Taught Master's Course. *European Journal of Engineering Education*, *19*(4), 443–448. DOI: 10.1080/03043799408923311.

MacLeod, I.A. (2010). The education of innovative engineers. *Engineering, construction and architectural management*, *17*(1), 21–34.

May, D., Wold, K.A., Moore, S.L. (2014). Developing Cultural Competencies through Transnational Learning Experiences in Active Online Learning Environments. *International Journal of Engineering Pedagogy*, *4*(5), 12–19.

Oladiran, M.T., Uziak, J., Eisenberg, M., Scheffer, C. (2011). Global Engineering Teams – A Programme Promoting Teamwork in Engineering Design and Manufacturing. *European Journal of Engineering Education*, *36*(2), 173–186.

Paasivaara, M., Lassenius, C., Damian, D., Raty, P., Schroter, A. (2013). Teaching students global software engineering skills using distributed Scrum. D. Notkin, B.H.C. Cheng, K. Pohl (Eds.). *Proceedings of* the *35th ICSE*, 1128–1137.

Paci, A.M., Lalle, C., Chiacchio, M.S. (2013). Education for innovation: trends, collaborations and views. *Journal of Intelligent Manufacturing*, *24*(3), 487–493. DOI: 10.1007/s10845-012-0631-z.

Petrea, E., Velescu. E. (2014). An Example of Science Students' Interaction in a Foreign Language for the Implementation of Inter-university Research Projects.

Procedia – Social and Behavioral Sciences, 141, 707–711. DOI: 10.1016/j.sbspro.2014.05.124.

Piaget, J. (1964). Development and learning. R.E. Ripple, V.N. Rockcastle (Eds.). *Piaget Rediscovered: A Report on the Conference of Cognitive Studies and Curriculum Development*, 7–20.

Sanderson, H. (2017). Bottom-up Climate Adaptation Strategies towards a Sustainable Europe. *Impact*, 1, 63–65.

Schein, E.H. (1996). Kurt Lewin's change theory in the field and in the classroom: notes toward a model of managed learning. *Systems practice*, 1, 27–47.

Sharma, B., Steward, B., Ong, S.K., Miguez, F.E. (2017). Evaluation of teaching approach and student learning in a multidisciplinary sustainable engineering course. *Journal of Cleaner Production*, *142*(4), 4032–4040.

Stock, T., Kohl, H. (2018). Perspectives for International Engineering Education: Sustainable-oriented and Transnational Teaching and Learning. *Procedia Manufacturing*, 21, 10–17.

Stock, T., Seliger, G. (2016), Methodology for the Development of Hardware Startups. *Advanced Materials Research*, 1140, 505–512.

Stock, T., Haskins, C., Gladysz, B., Urgo, M., Kohl, H. (2017). A guideline for planning and implementing an action-based and transnational course in higher engineering education: A Case for Sustainable Value Creation. J.C. Quadrado, J. Bernardino, J. Rocha (Eds.). *Proceedings of the 45th SEFI Annual Conference*, 33–40.

Stock, T., Haskins, C., Gładysz, B., Urgo, M., Kohl, H., Strandhagen, J.O., Jarzębowska, E., Tolio, T. (2016). Development of a Project-Oriented and Transnational Master Course for Training the Engineering Competencies Required in an Increasingly Demanding Work-life in Europe. *Proceedings of the 44th SEFI Annual Conference*. 1–13.

Tuckman, B.W. (1965). Developmental sequence in small groups. *Psychological Bulletin*, *63*(6), 384–399. DOI: 10.1037/h0022100.

UN (2015). *Sustainable Development Goals*. Retrieved from: http://www.un.org/sustainabledevelopment/sustainable-development-goals.

Vernon, J. (2000). Engineering Education: finding the centre or 'back to the future'. *European Journal of Engineering Education*, *25*(3), 215–225.

D.D. Walden, G.J. Roedler, K.J. Forsberg, R.D. Hamelin, T.M. Shortell (Eds.) (2015). *Systems Engineering Handbook: A Guide for System Life Cycle Processes and* Activities, 4th ed. Hoboken (NY): John Wiley & Sons.

Ziemian, C.W., Sharma, M.M. (2007). Adapting Learning Factory Concepts Towards Integrated Manufacturing Education. *International Journal of Engineering Education*, *24*(1), 199–210.

Abstract

The paper presents the first cohort of the innovative project "European Engineering Team", which was conducted within the ERASMUS+ program. The innovativeness of the project lies in the cooperation of 4 European universities of technology and its project-based approach. Students participating in the EET project independently defined problem domains related to sustainability. The mobility attributed to regular ERASMUS+ initiatives was redefined. Students and supervisors had to travel frequently for short periods (4 week-long meetings), reflecting the actual needs and demands of a global labor market. Students cooperate virtually and attend classes in their regular courses at home universities between direct meetings. The goal of this project was to verify the effectiveness of the proposed approach to transnational and inter-university initiatives, utilizing blended learning. The goal was to develop student competencies in terms of sustainability, cooperation in transnational and geographically dispersed teams, who worked on multi-disciplinary problems utilizing knowledge from different domains. The approach was effective and most of the student competences improved throughout the project. However, some areas of possible improvement were defined and supervisors are focused on them during the ongoing second cohort of the EET.

Keywords: project-based learning; experiential learning; blended learning; transnational cooperation; short-period mobility

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Appendix 1. Observations of students' activities during the first EET meeting

Stage	Day	Observation
Formation	1	1. Opening presentations of coordinators and academic teachers from universities participating in the project.
Reaching out		2. Discussion of proposed project topics, analysis of alternatives that did not meet the criteria for "sustainable development". Changing the discussion by asking the question "which areas are problematic?", which resulted in the decision to focus on waste management due to the context of the UN's sustainable development goals (UN, 2015).
Standardization	2	1. Presentation of the "diamond" model for the development of innovations and start-ups.
		2. Reconciliation of continuation of analysis in the area of waste management based on the EU waste hierarchy (Gharfalkar et al., 2015). Developing a matrix of potential solutions in relation to the waste hierarchy.
		3. Review of the literature, in order to better recognize and understand the matrix of potential solutions.
		4. Review of the matrix and the selection of the preferred problem domain (vote).
		5. Cataloguing the competences of team members. Agreeing on the criteria for assessing alternative proposals and determining the weights of the criteria.
		6. Combination of certain proposals and ordering problem domains.
		7. Voting on the preferred problem domain and choosing 3 of them.
		8. The creation of student sub-groups to the three selected domains, i.e. smart cities, suitability of food for human consumption and packaging.
	3	1. Mixing groups in order to obtain a new look at the problems.
		2. Groups were encouraged not to focus on specific solutions too early and to maintain three problem areas in order to maintain a multi-dimensional product/problem perspective.
		3. Student presentations – 3 components: solid waste management in cities, food waste and packaging.
		4. Comments from the teachers leading the EET program: focus on important economic and other factors causing the generation of waste, thus focus on solving the problem, not removing its symptoms.
	4	1. Effective students' own work.
Implementation	5	1. Selection of the project manager in the EET group, assigning students to the groups based on their own preferences, discussions and mechanisms, set by themselves, to ensure the satisfaction of the entire team.
		2. Work of project groups to prepare a list of tasks and agree on a detailed action plan for the next direct meeting.
		3. Development of a general action plan for the next meeting.
		4. Group presentations made by the team leader and discussion of the current progress of the group's work. Assigning a teacher to each of the four three-person groups in order to handle: food waste, municipal waste; household waste, packaging waste.
		5. Discussion of teachers leading the EET program and the entire student team.
		6. Individual consultations of teachers with groups of students.
		7. The end of the weekly work period.

Source: Stock et al., 2016, pp. 1–13; Haskins et al., 2017, pp. 1095–1106.

Appendix 2. Module EET for master degree studies at MEiL PW

Title of the module: European Engineering Team – interdisciplinary and transnational project-oriented learning	ECTS: 24

Module purposes
This Master's course module activity aims to incorporate the project-oriented teaching and learning course "European Engineering Teams" into the local curriculum of each university.
This course aims to increase the learning and teaching productivity in the education of engineers by establishing an interdisciplinary and international team of students and supervisors from four different European universities. This European Engineering Team (EET) will work together on a sustainable engineering project (selected during the first team meeting) supported by e-learning lectures in form of special lectures (called MOOC's). This module is incorporated into individual study programs for participating students.

Learning outcomes
The globalized European environment is faced with the challenge to meet the continuously growing worldwide demand for capital and consumer goods, while simultaneously ensuring a sustainable environment for human existence. Young engineers motivated to set up sustainable initiatives will be identified and trained in European universities. They will gain knowledge and skills to expand sustainable engineering to competitive innovations for empowering a sustainable development. The mobility and internationalization of workplaces is currently incentivized by the European economy. Human cohabitation within European society will be characterized by cross-border interactions between European citizens. This development can be clearly observed within European companies. Cross-border project works between different sites and transnational cooperation are essential for ensuring competitiveness within increasing globalization. Engineers are not only required to have state-of-the-art technical knowledge, but also to apply it in international teams. They must with colleagues, suppliers, and clients from different countries, operate as part of a team, and master the challenges of virtual cooperation in engineering tasks and within international value chains. **Motivated by the needs of modern European society, a multidisciplinary and intercultural team of Master's students from four European universities, the so-called European Engineering Team (EET), will work together on a joint research project aiming for a sustainable technological innovation. The innovation will be subsequently transferred to a sustainable startup, established by the team of Master's students.** The European Engineering Team will face challenges of sustainability in engineering science and strongly foster entrepreneurial thinking. **Consequently, this Master's module provides the competencies required within a dynamic European economy, by developing skills for working across disciplines, borders, and cultures in the area between new technologies, social change, ecological responsibility, and entrepreneurial opportunities.**

Learning content
The teaching and learning activities of the module combines theoretical knowledge transfer, project work, and transnational and intercultural experiences for the students. Also, the teaching and training activities aim to foster sustainable thinking in engineering processes.
The following content is to be taught within the module:
- Working and communicating in transnational and intercultural project teams
- International project management
- Methods and tools of Sustainable Engineering
- Methods and tools of Startup Development
- Methods and tools of Process and Product Development
- Creative Problem Solving
- Virtual communication and project management tools.

Parts of the module, workload and credit points (1 ECTS equals 15.0 hours)

Sustainable Engineering – lectures			60 h
Description of effort	Multiplier	Hours	=
Active time	16.0	1.0h	16.0
Preparation and follow-up time – student work	16.0	2.75h	44.0
Collaboration in transnational projects			120 h
Description of effort	Multiplier	Hours	=
Attendance time	20.0	3.0h	60.0
Preparation and follow-up time	20.0	3.0h	60.0
Project on European Engineering			180 h
Description of effort	Multiplier	Hours	=
Attendance time	15.0	4.0h	60.0
Preparation and follow-up time	15.0	8.0h	120.0

continue – Appendix 2. Module EET for master degree studies at MEiL PW

Title of the module: European Engineering Team – interdisciplinary and transnational project-oriented learning	ECTS: 24
Form of teaching and learning The teaching and learning activities of the module will follow the idea of action, in combination with blended-learning. The students from WUT will work together on a project with Master's students from three European partner universities (Norwegian University of Science and Technology, Politecnico di Milano, and Berlin University of Technology), focusing on the development of a technological innovation for coping with a sustainability challenge. All students will select a specific project topic they will work on during the first project meeting. During the last three months of project work, the developed technological innovation will be put into industrial practice by developing a sustainable startup. To support the project work, the teaching and learning activities of the module will also include meetings at each partner university for training the mobility, self, and intercultural competencies, as well as strengthening the teambuilding of the participating students. In order to improve methodical and professional competencies, the project work will be supplemented by e-learning phases, in the form of e-lectures addressing different topics on Sustainable Engineering. In summary, the required teaching and learning workload of 12 ECTS for the module is carried out by three mandatory teaching and learning activities: an e-learning lecture on Sustainable Engineering (2 ECTS), a collaboration on transnational project work (4 ECTS), and a project in European Engineering (6 ECTS).	
Requirements for participation and the exams A good command of the English language is required for transnational project work. Group report documenting full outcome and personal report documenting individual input.	
Duration of the module Two semesters.	
Max. number of participants Four students per university.	
Registration formalities The application should be submitted before February 20th and before the start of the summer semester. Applications should be sent via email to elajarz@meil.pw.edu.pl	
Lecture notes Available only in the electronic version.	
Other The module is part of the EU ERASMUS+ program. Teaching and learning activities are funded by the European Union.	

WE RECOMMEND

17th International Conference – WWW/Internet, 21–23.10.2018, Budapest, Hungary

The WWW/Internet 2018 Conference aims to address the main issues of concern within WWW/Internet. WWW and Internet had a huge development in recent years. Aspects of concern are no longer just technical anymore, but other aspects have arisen. This conference aims to cover both technological as well as non-technological issues related to these developments.
More information:
http://internet-conf.org