

Raw materials curricula and sustainable development

Assessment of curricula towards the achievement of Sustainable Development Goals

The project Enhancing the skills of ESEE RM students towards the achievement of SDGs (EnActSDGs) aims to establish an action plan for the realignment of the current raw materials curricula of three universities in East and Southeast Europe towards the incorporation of the sustainable development principles into their educational programs. The action plan will be based on the educational needs of the raw materials sector as defined by academia and students, industry, and professionals. The authors present a preliminary assessment of the three universities' study programs by using a set of assessment criteria defined in cooperation with selected stakeholders.

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Raw materials curricula and sustainable development. Assessment of curricula towards the achievement of Sustainable Development Goals | GAIA 29/4 (2020): 269–271 | **Keywords:** curricula assessment, higher education, sustainability, Sustainable Development Goals

Higher education institutions play a pivotal role in education for sustainable development since they contribute to the production and dissemination of values, competencies, skills, and knowledge. This also applies to engineering education. The importance of engineering addressing sustainable development (SD) has been pointed out by international organizations, such as the World Federation of Engineering Organizations (e.g., WFEO 1991, 1997a), the International Federation of Consulting Engineers (e.g., WFEO 1997b), and the UNESCO *Engineering Initiative* (e.g., UNESCO 2010, p. 6).

Higher education institutions can also be seen as engines for societal transformation: they are educating future leaders and professionals. Furthermore, the connection of higher education institutions with business, industry, policymakers, professionals, NGOs and other key stakeholders is indispensable for the achievement of *Sustainable Development Goals (SDGs)* (UN 2015) as an integrated strategy at all levels of higher education institutions. Thus, the overriding goals of the *Alliance of Sustainable Universities in Austria* for the achievement of the 2030 Agenda, as defined within the project *Universities and Sustainable Development*


Goals (UniNEtZ), are also being followed (Stötter et al. 2019).


In this context, a project called *Enhancing the skills of ESEE RM students towards the achievement of SDGs*¹ – funded by EIT (European Institute of Innovation and Technology) RawMaterials² – was initiated in 2020. The aim is to strengthen the skills and the competencies of raw materials (RM) university students from several countries of East and Southeast Europe (ESEE) towards innovation, entrepreneurship, and effective performance. Moreover, in a multidisciplinary and multicultural environment, skills can be seen as the basis for the achievement of *SDGs*.


EnActSDGs' project overview

EnActSDGs brings together ESEE beneficiary universities – AGH University of Science and Technology (AGH) in Poland, National Technical University of Athens (NTUA) in Greece, and the Technical University of Kosice (TUKE) in Slovakia, innovation providers from Austria (Montanuniversität Leoben), Germany (Technische Universität Bergakademie Freiberg), and

Italy (Uni Trento and Hub Innovazione Trentino S.c.a.r.l.), as well as an industrial partner from Greece (MYTILINEOS). The scope of this two years integrated *Regional Innovation Scheme (RIS)* project is the development of a sustainable network and eco-system between beneficiary and innovation provider universities, research insti-

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<https://doi.org/10.14512/gaia.29.4.13>

1 <https://enactsdgs.fberg.tuke.sk>

2 <https://eitrawmaterials.eu>

TABLE 1: Key stakeholders (n=65).

STAKEHOLDERS	POLICY MAKERS	INDUSTRY	ASSOCIATIONS	RESEARCH ORGANIZATIONS	ACADEMIA
number // percentage [%]	6 // 9	26 // 40	2 // 3	6 // 9	25 // 39

tutes, and industry to provide a pathway that will ensure the incorporation of the SD principles in the educational programs of the beneficiary universities.

Evaluation of curricula: research method

Within *EnActSDGs*, the structure of the studies and the curricula of the RM schools in the three ESEE beneficiary universities were evaluated with the overall aim to assess the incorporation of SD principles in these study programs based on selected criteria. To define and rank the criteria, a two-stage approach was adopted.

Firstly, a qualitative survey consisting of five open questions was designed to collect the views of selected stakeholders representing the knowledge triangle (e. g., academia, industry, research-technology organizations), concerning the principles of SD and the criteria that could be used for the curricula assessment. The first survey was conducted in April 2020. 27 experts participated, and the data collected were analyzed and combined into clusters. This process resulted in the definition of the curricula assessment criteria that were combined with other EU and international criteria used for the external evaluation and accreditation of higher education institutions (EC 2020). Then, the second stage of the survey aimed to quantify the relative importance of the abovementioned criteria for the assessment of the curricula regarding their incorporation of SD principles and the capacity of their graduates to achieve the *SDGs*. In this second stage, 65 questionnaires were completed by the key stakeholders (table 1 shows the sample size for each target group). The internal consistency of the collected data was satisfactory, with Cronbach's alpha for positive affect = 0.85, indicating the reliability of the collected data. The statistical analysis of the above data through ANOVA and nonparametric tests (Kruskal-Wallis) indicated that there is no significant difference between the stakeholder groups regarding the criteria ranking.

Furthermore, the structure of studies, that is, bachelors, masters, integrated masters, and curricula-specific data, like the number of students and academic staff, were collected from the aforementioned ESEE universities, while key performance indicators were used to describe and compare the examined curricula.

Results

Definition and ranking of assessment criteria

The assessment criteria ranking listed below is based on the average of the responses received from the 65 questionnaires. The scale ranges from 1, very relevant to 5, least relevant for the subsequent assessment of the university curricula.

The 17 criteria defined for the curricula assessment are listed in table 2. The ratings regarding the relative importance of the criteria range between 1.48 and 2.73. Therefore, they can be generally regarded as important for the curricula assessment. According to the ranking given from the key stakeholders, the most important criterion for the assessment is the practical content of the curricula (1.48), which is a subcategory of the content of the curricula. University-business cooperation (UBC) was ranked as the second most relevant criterion (1.58) followed by the theoretical and technical background (1.60), the lecturers (1.62), as well as the participatory methods (1.66) within the teaching and learning approach.

Universities assessment and key performance indicators

According to the assessment criteria described above, the required data were collected at the institute/school/faculty level to acquire an insight into the respective institute/school as well as at the respective bachelor, master, or integrated master degree study program. For the final assessment and the benchmarking of the performance of the ESEE university curricula, both the 17 assessment criteria as well as

key performance indicators, from the *European Innovation Scoreboard 2020* (EC 2020), were used to provide a comparative assessment. The study programs assessed are:

- Faculty of Mining and Geoen지니어ing (FMG) at AGH: Bachelor *Mining Engineering* (7 semester – sem; 210 European Credit Transfer System credits, ECTS) and Master *Mining Engineering* (3 sem; 90 ECTS)
- School of Mining and Metallurgical Engineering (SMME) at NTUA: Integrated Master *Mining and Metallurgical Engineering* (10 sem; 300 ECTS)
- Faculty of Mining, Ecology, Process Control and Geotechnologies – Institute of Earth Sources at TUKE: Bachelor *Raw Materials Engineering* (6 sem; 180 ECTS) and Master *Technologies of Mining & Tunneling* (4 sem; 120 ECTS).

The structure of the examined study programs, as well as the results of the curricula assessment based on the criteria with the highest importance ranking, are discussed in the following paragraphs.

Content of curricula – practice, theoretical and technical background

In all three study programs, students must complete an average of 30 ECTS per semester or 150 working hours and an average of 300 ECTS for a combined bachelor and master's degree and/or an integrated master's program to graduate within the planned study period. We observed differences regarding the inclusion of internships as compulsory courses, despite the fact that stakeholders assigned high significance to such internships for the practical transfer of knowledge from industry and other companies to university students. The institute at TUKE does neither provide a compulsory internship for the bachelor's nor the master's program. At SMME (NTUA), two internships or 19 ECTS are included in the integrated master's program, accounting for 6.3 percent of the ECTS required. At the faculty of AGH, one percent of all ECTS for

the bachelor's program *Mining Engineering* is accounted for as a compulsory work placement. We also observed differences in the integration of sustainability aspects into the compulsory courses: 18 percent of all ECTS of compulsory courses at SMME (NTUA) and five percent in the bachelor's degree and one percent in the master's degree at the faculty of AGH are allocated to sustainability-related topics. No SD-related courses were reported in the institute at TUKE study programs.

University-business cooperation

The university-business cooperation is essential for knowledge transfer. In the last five years (2015 to 2019), industrial partners have been very actively involved in the activities of the universities as the number of nationally or internationally funded projects indicates: at the faculty of AGH, 150 projects were completed in cooperation with the industry. At SMME (NTUA), industry partners were involved in 97 of 139 projects. At the institute at TUKE, five projects were carried out in cooperation with industrial partners.

The following activities were carried out in cooperation with the industry:

- industry conferences,
- company-dedicated scientific research,
- company-related direct research
- technical advisory and support,
- testing technological solutions,

- study visits to industrial plants,
- guest lecturers.

Lecturers and students – lecturers

The number of academic staff is a key factor for the assessment of a curriculum. For the classification of academic staff, the international classification into professor, experienced researcher, early-stage researcher was used. Of all universities, SMME (NTUA) has the highest numbers (199 professors, experienced and early-stage researchers) followed by the faculty of AGH with 132. The percentage of females in the RM academic staff ranged from 40 percent at the faculty of AGH to 35 at the institute at TUKE and 28 at SMME (NTUA). Both, SMME (NTUA) and the faculty of AGH have a female quota of 33 percent among the experienced researchers, whereas the institute at TUKE has 38 percent. The faculty of AGH has a higher proportion of females in early-stage research (58 percent) as compared with SMME (NTUA) (44). No foreign academic staff was reported for the ESEE universities.

Learning and teaching methods and pedagogical tools – participatory methods

All universities reported a balanced usage of various methods (e.g., group work, presentations, lectures). Within participatory courses, the focus is more clearly on learning by doing as well as on group work and

the project- and problem-based learning approach fostering an active involvement of students in their learning processes.

Conclusion

Current RM curricula of three ESEE universities in Greece, Poland, and Slovakia were evaluated with regard to the incorporation of SD principles and their capacity to provide the skills to the RM graduates to achieve the SDGs. Following the ranking of the assessment criteria, stakeholders from academia, industry, policymakers and professionals have given the highest ratings to criteria such as the studies content and the cooperation between the universities and the industry. Based on this assessment process and the subsequent benchmarking between universities, conclusions on educational needs and implications for a subsequent action plan will be generated in the next stages of the project *EnActSDGs* to close the gap between the education needs of the RM sector and the existing curricula and thus contributing to the transformation towards sustainable universities in the ESEE region.

Research data presented in this article were obtained within the *EnActSDGs* project, No. 19258 funded by *EIT RawMaterials*, which is gratefully acknowledged.

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TABLE 2: Ranking of assessment criteria. Scales: 1 = very relevant, 5 = least relevant.

UBC = university-business cooperation, RM = raw materials, SD = sustainable development.

CRITERIA	RANKING
content of the curricula – practice	1.48
enhancement of UBC – cooperation with industry	1.58
content of the curricula – theoretical and technical background	1.60
lecturers and students – lecturers	1.62
learning/teaching methods – participatory methods	1.66
content of the curricula – soft skills	1.68
enhancement of UBC – internships	1.68
content of the curricula – decision-making techniques	1.71
feedback	1.80
structure of the curricula	1.95
employment in the RM sector	2.11
funded projects especially with emphasis on SD	2.13
learning/teaching methods – passive methods	2.18
visibility of graduates	2.22
lecturers and students – students	2.51
number of publications with emphasis on patents relevant to SD	2.67
patents submitted as a result of the research conducted in the university	2.73