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Article

A New Face of Mining Engineer—International Curricula to Sustainable Development and Green Deal (A Case Study of the Wrocław University of Science and Technology)

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Abstract: The mining industry in the world has undergone a major metamorphosis in recent years. These changes have forced higher education to modify the curricula in a thorough way to meet the mining entrepreneurs' needs. The paper's scope is to answer the research question—how to attract students and implement Sustainable Development Goals (SDGs) in higher education in mining engineering? Based on the case of international cooperation carried out at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology (WUST) within the framework of educational projects co-financed by European Institute of Innovation and Technology (EIT) and EIT Knowledge and Innovation Communities Raw Materials (EIT RM), the authors prove that the idea of sustainable development can be introduced into the system of teaching mining specialists at every level of their higher education (engineering and master's studies), through developing their new competencies, introducing new subjects taking into account innovative solutions and technologies, or placing great emphasis on environmental and social aspects. Examples of new curricula show a good way to change into the new face of a mining engineer.

Keywords: MEITIM project; EIT raw materials; higher education; innovation; transdisciplinary education

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1. Introduction

Striving for sustainable development results from the provisions of the document Europe 2020—A strategy for smart, sustainable and inclusive growth [1]. This strategy's priorities include developing an economy based on knowledge and innovation and supporting a resource-efficient, which is more environmentally friendly and competitive. According to Poland's National Development Strategy 2020 [2], the education system and conditions for shaping lifelong learning attitudes will be radically improved over the next decade. Young people will obtain the most up-to-date knowledge to function in modern civilization, develop their curiosity about the world, creativity, willingness to search for original solutions, and the ability to cooperate and competencies necessary for independent development in the future. Higher education will strive to combine the educational and research role with the implementation of innovation and business. Its links with industry will be strengthened. Intellectual capital will be strengthened as a solid foundation for a modern and competitive economy. At the same time, activities will be carried out to increase the innovativeness of the economy. Public outlays on R&D will increase, and the efficiency of using these funds will improve, and conditions will be created to stimulate private sector outlays for this purpose. The commercialization of research results will be

improved. The development of advanced technologies will be supported, and the number of innovative enterprises will increase. In connection with the aforementioned priorities, universities are expected to actively support sustainable development and dynamic development of innovation for the economy by, among others: creating and transferring knowledge, creating a knowledge base, conducting interdisciplinary research, providing highly qualified human resources, linking universities with institutions and socio-economic organizations, building multicultural knowledge and science, developing students' creativity manifested in an interdisciplinary approach to knowledge and practical and creative use of the acquired knowledge, initiating intellectual and cultural development [3–7].

According to [5,8–10], academic communities are responsible for building sustainable development, i.e., creating a balance between the individual, the economy and the environment. In this new perspective, universities should become a centre for creating knowledge, thanks to which individuals can develop competencies important in a given sector of the economy and create solutions important from the point of view of society and the development of individuals' potential.

Insight into the mining courses offered by many universities worldwide shows that the academic sector is trying to keep up with mining trends and follow the idea of sustainable development [11]. Despite this, in previously published research [12], the authors presented a statistical analysis showing a decreasing number of mining studies students and graduates. Starting from the academic year 2015/2016, the number of students at Polish universities teaching mining and geology has decreased by approximately 50% in 2018/2019. A similar situation has been observed in Spain, where the only exception is the Technical University of Madrid (UPM), which, thanks to its location in the capital city and the certification system for mining engineers, has not recorded students' decrease' number. This negative trend is not observed in Finland, where mining studies still provide a high level of employment, and where Masters' theses are mostly carried out in cooperation with industry. Given the constantly declining interest in mining studies, especially in European countries, it is crucial to ask what universities should do to attract more students into mining engineering and how they can implement sustainable development into higher education?

The article is an extension of the prior analysis [12], and aims to answer the question based on the case study of Wrocław University's of Science and Technology (WUST) activities. As a research method, the case study was chosen here as it is commonly used, especially in social, medical and environmental sciences [13–18]. Only qualitative research method like this can give a comprehensive view of analysed phenomena [14]. The role of case studies is often underestimated in science [16]; however, they are the ones that provide an in-depth understanding of a phenomenon and the practical application of theoretical research [13].

At first, our work presents the key competencies that an engineer graduating from the mining studies in accordance with the idea of sustainable development should have. Next, in Section 3, it presents ways to implement elements of this idea in curricula, research programs and organisational changes in the functioning of universities. In Section 4, the article describes how to implement these changes in the Faculty of Geoengineering, Mining and Geology of WUST. On the example of international educational projects, it describes the offer of innovative, interdisciplinary and inter-university courses, which allow to implement the principles of sustainable development in education and attract the best students from many countries. These projects entail not only changes in the educational offer, but also organisational changes caused by the internationalisation of studies. The last two sections contain discussion and conclusions with further research directions.

2. Key Competencies of Future Mining Engineer in Case of Sustainable Development

The essential competencies for the mining engineer of the future were defined based on the study done within the MEITIM project. An in-depth literature review and the 1st International Workshop on "Skills and Competencies of the XXI Century Workforce", held

in Finland at Lappeenranta University of Technology (LUT) in November 2020, were the basis for the skills listed in this section.

Following the Ernst and Young's report [19], mineral raw materials and mineral resources industries are facing skills' shortages in many countries. Today's mining companies are looking for graduates and technical specialists with the ability to use sophisticated technology and computing techniques, operating in challenging environments. Regarding new teaching techniques and subject changes, several areas can be mentioned:

- the environmental concepts,
- new technologies, computing and the internet,
- advances in robotics and automation (usually learnt at the workplace),
- social aspect in mining, licensing and public awareness.

In research of Hartlieb et al. [20] we find, that most of the 'soft skills' in business management and social aspects around raw materials education seem to be fairly underrepresented compared to technical skills. They presented skill catalogue in this study defined two levels: skills (practising) and knowledge (experience). INTERMIN project is collecting and analyzing the current and future skills required in the mining sector and comparing them with the learning outcomes of the globally existing universities. From the INTERIM [11] survey on skills, the following can be listed:

- technical (business management, mining systems and equipment),
- soft (translate sustainability to raw materials, social performance),
- recycling and secondary mineral raw materials.
- social aspect in mining, licensing and public awareness.

Young and Rogers [21] present support for the Digital Transformation of mining companies in identified areas, including education, reducing environmental impacts, workforce development, supply chain management, safety, transparency, operational excellence, innovation standards, lowering innovation hurdles, alternative investments and business intelligence. Similarly to this paper, Chikatamarla and Prasad [22] focuses on the need for training mining professionals to face the technological, digital challenges that are pertinent to the mining industry. The adoption of innovative technologies, such as robotics, process automation, and artificial intelligence will augment performance in the mining industry [23]. The new generation of mining and other engineers are expected to embrace the emerging digital technologies i.e., real-time data acquisition, improved data analysis, reporting and enhanced process monitoring covering different aspects right from exploration, planning, project execution, production and marketing.

3. Implementation of Sustainability Elements in the Higher Education Curricula

In the development of education at universities, in line with the implementation of the elements of sustainable development, the qualitative transformation of universities in the field of research, teaching and management and organizational activities is important. The works [3–7,24–27] proposed the following changes at universities:

- technical (business management, mining systems and equipment),
- developing autonomous student recruitment procedures,
- basing study programs on learning outcomes, i.e., developing study plans based on the Qualification Framework opening up the possibility of unifying study programs at universities, which gives students the opportunity for much greater mobility between universities in the country and throughout the European Union,
- facilitating the diffusion between universities and the sector of companies already involved in the process of developing study programs,
- changing the names of fields of study and specializations so that they contain information about the qualifications that the student will receive after graduation and so that the name of the specialization is readable to both students and future employers,
- redesigning the names of individual subjects of study so that the academic lecturer who conducts a given subject is clear about the area in which they should be involved

and what to pay special attention to when preparing the description of the study program,
- introducing new subjects into the course of study so that the studies can develop not only the knowledge but also the students' interpersonal skills,
- introducing new subjects opening the opportunities of a different way of acquiring knowledge, i.e., those that will enable students to be co-creators of the educational process,
- introducing new forms of education to change the way students' competencies are shaped and develop their skills, such as creativity, the flexibility of action, skills in planning their work, cooperation and cooperation skills, e.g., tutoring, coaching, training, workshops, laboratories and field classes,
- introducing new forms of assessment of subjects based on student activation, e.g., student projects, open-book exams,
- organizational changes concerning, e.g.,: student internships, hourly grid or subject shifting,
- initiating and developing student movements and study groups,
- organization of congresses, conferences, seminars, scientific symposia and other activities for sustainable development and education,
- organization of post-graduate studies and courses, not only for teachers, but also for administrative staff, journalists, and other decision-makers in the local community and interested in environmental issues,
- developing, publishing and promoting textbooks and scripts on environmental protection issues, highlighting development perceived in social, economic and cultural terms in line with the idea of sustainable development,
- active participation in national and international programs,
- increasing the scientific and research potential,
- raising awareness among all employees,
- initiating economic development,
- development and implementation of innovative environmentally friendly production technologies,
- creating knowledge about sustainable development,
- establishing cooperation networks between various universities,
- change of human resources policy, e.g., problems of multi-tenurement and multi-working, change of career advancement path,
- improvement by universities of their positions in international rankings,
- increasing support from the administration of higher education institutions for the implementation of sustainable development,
- closer cooperation between higher education institutions' administrations and sustainable development researchers.

For many years, the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Technology has been conducting activities aimed at introducing the aforementioned changes into the education system [28–33]. The global political and economic situation and transformations taking place in the last decade of the 20th century and the first decade of the 21st century resulted in the creation of a new global raw material strategy, requiring changes and reforms in the traditional understanding and functioning of the mining and metallurgical industry [34,35]. Today, mining is a global industry. The largest mining companies, operating in many countries of the world, are expanding their activity with new mines [36]. Therefore, there is a need for mining engineers, geologists and other employees connected with the mining industry with a good command of foreign languages and an intercultural sensitivity in the education system. The qualifications required for graduates of mining universities have been expanded and shifted. In addition to traditional exploration and exploitation of deposits, mineral processing, enrichment and waste management have become more important. In addition to purely engineering issues, knowledge of economic, legal and ecological issues is required. In addition to classical min-

ing exploitation technology, infrastructure, transport, storage, distribution, and marketing have become important. The existing perspective of supplying local raw material markets has been replaced by a global analysis, taking into account climate and environmental pollution. Therefore, European universities, that educate staff for the mining industry, have long taken these elements into account in curricula and teaching processes.

4. International Education Projects at WUST for Sustainable Development and Green Deal in Mining

The Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology (WUST) has also undertaken such activities and for many years has been participating in international educational projects, thus increasing the attractiveness of studies and encouraging ambitious individuals to recruit.

4.1. Mobi-Us Project

Mobi-us is an international education project founded by EIT RawMaterials which includes four Universities belonging to East and South-East Europe (ESEE) region [37,38]: AGH University of Science and Technology (Poland), University of Miskolc (Hungary), University of Zagreb (Croatia), Wrocław University of Science and Technology (Poland) (Figure 1). All aforementioned Universities run master programs related to the raw materials sector. The project is also supported by Universities with more experience in creating mobility programs (Aalto University, Vienna University of Technology), as well as by industrial partners, research institutions (La Palma Research Center—LPRC) and other specialists in the field.

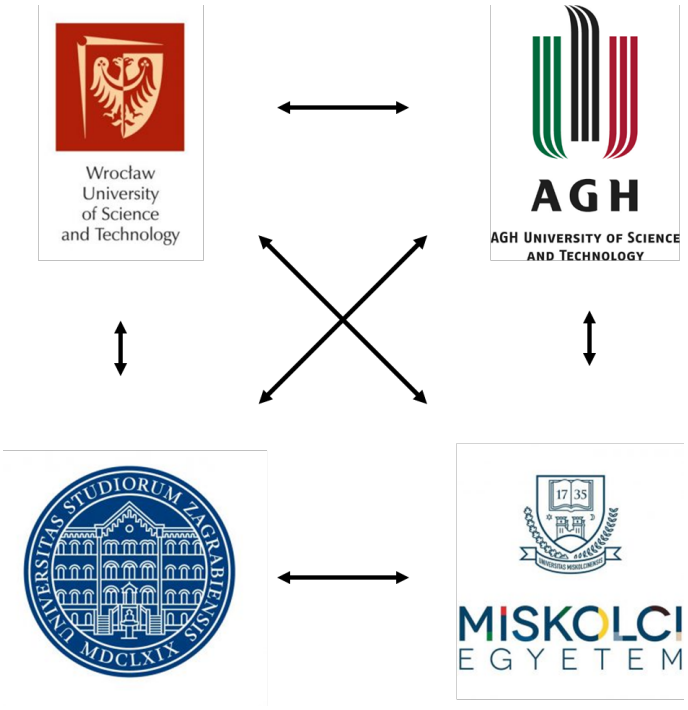

Figure 1. The structure of MOBI-US network [37].

The project aims to strengthen cooperation and create a network between four partner universities as well as develop structure mobility pathways for their master programs. By using the so-called "mobility windows", students will have the opportunity to study one semester of master studies at the partner university (Figure 2). The project aims to improve the existing, sometimes isolated master programs instead of creating new joint programs.

Figure 2. Mobility window [37].

The project is directed primarily to master students who want to acquire knowledge in the field of raw materials (geology, geotechnical engineering, mining engineering, geomatics etc.), studying in countries belonging to the ESEE region. Students participating in the project and using mobility pathways have the opportunity to gain specific professional competencies that are less developed in their home programs. The mobility network between four ESEE partner Universities in Mobi-us project is based on the existing master programs offered there:

Numbered lists can be added as follows:

1. AGH University of Science and Technology (PL):
   · Faculty of Mining and Geoengineering
   - Mining Engineering MSc
   · Faculty of Geology, Geophysics and Environmental Protection
   - Economic Geology MSc
   - Applied Geophysics MSc
2. University of Miskolc (HU):
   · Faculty of Earth Science and Engineering
   - Earth Science Engineering MSc
   - Environmental Engineering MSc
   - Mining and Geotechnical Engineering MSc
   · Faculty of Materials Science and Engineering
   - Materials Engineering MSc
3. University of Zagreb (HR):
   · Faculty of Mining, Geology and Petroleum Engineering
   - Mining Engineering
   - Specialization in Mining Engineering
   - Specialization in Geotechnical Engineering
   - Geology—Geology of Mineral Resources and Geophysical Explorations subprogramme
4. Wrocław University of Science and Technology (PL):
   · Faculty of Geoengineering, Mining and Geology
   - Mining Engineering MSc
   - Geotechnical and Environmental Engineering MSc
   - Geomatics for Mineral Resource Management MSc
   - Geomatics

After analyzing courses within each master program project partners mutually found the additional set of courses in the partner's educational program, which complement their original program with a certain group of competencies. Using this scheme, the partnering universities may extend their original education programs towards other fields. Figure 3 presents an example of mobility pathways between Wrocław University of Science and Technology and the University of Miskolc or the University of Zagreb in the field of Mining and Geotechnical Engineering.

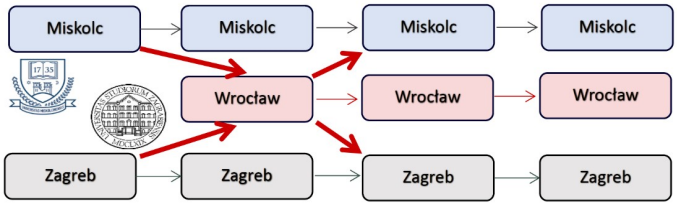

Figure 3. Example of mobility pathways Wrocław-Miskolc and Wrocław-Zagreb.

In 2020 Mobi-us started virtual mobility program. Each partner university selected courses in English which could be offered on-line to the guest students from other partner universities. Virtual mobility program is dedicated to the students that are interested in obtaining new technical and soft skills from other universities' strengths in compatible MSc programs. Students could choose and register for online courses proposed by partner Universities. The lists of offered online courses are presented in Figure 4. The main purpose of the virtual mobility is to show the courses and teaching methods of the partnering master programs, to promote the mobilities of next academic year between them.

Figure 4. Online courses offered by partner Universities [37].

4.2. OpenYourMine

OpenYourMine is a Master education project dedicated to mineral resources and sustainability. It covers an education course for master students that is financially supported for three years, from 2019 to 2021, by the European Institute of Innovation and Technology (EIT) and EIT Raw Materials.

The OpenYourMine Master education program aims at strengthening MSc students' creativity, entrepreneurship and skills for the sustainable development of mineral resources

in Europe. Every year, the project brings together about 40 MSc students to attend 4 teaching units (3 ECTS each) dedicated to mineral resources and sustainable development, namely:

- Mineral resources and sustainable development
- Raw material energy nexus
- Field projects (trips)
- New communication strategies for mining business

These ECTS will be included and shared among already existing master curricula dedicated to resources, the economy of sustainable development, and sociology of innovation from the 3 universities (University Grenoble Alps, France—the leader of the project, Nova University of Lisbon, Portugal, and Wrocław University of Science and Technology, Poland) participating in this project. KGHM Cuprum Ltd. Research and Development Center as the research and industrial partner provides access to geological/environmental data sets for cocreation of case studies and a network of mining industrials in Europe.

OpenYourMine relies on innovative educational approaches based on blended-learning, inverted pedagogy, crowdsourcing contest, and use of state-of-the-art tools for data visualization and integration. It also relies on a strong industry involvement (e.g., AREVA-Orano, Rio Tinto, KGHM, Almonty) at several levels in the proposed curricular: co-creation of case study, participation to short-courses and workshops, adaptation of teaching contents, and placement of the student. By embedding these experts within the university curriculum, we build a strong dedicated network of skilled geoscientists that can steer the mineral resources industry going forward, following the principles of environmental protection and social coexistence. To ensure the conditions of sustainable mineral supply, we open the mind and imagination of the next generation of mineral resource managers. The OpenYourMine project also provides a platform for students and experts from academic, economic and industrial domains to meet and discuss today's and tomorrow's needs and opportunities in mineral supply in Europe. The next generation of mineral resource managers is convinced that there is no future for mining activities in Europe. This education project aims at challenging this view of a continent unable to exploit its resources. Therefore, we train students to the specific social, environmental and economic context of mining in Europe, but also to show them that our continent has many opportunities in terms of mineral resources, employment and industrial development. They must not only be trained to the modern exploration techniques, but they must also consider the potential social conflicts and environmental constraints on production that can limit or deny access to resources. It requires to improve coordination of mineral exploration, business planning, and ability to obtain the community's social license to operate. To achieve this goal, geologists, economists and sociologists of the 21st century must be trained to work together efficiently. We also offer them a tribune, through the yearly workshops, to communicate directly with the students and to share their opinion and point of views with them. Students themselves will promote a community of former students using several web platforms. Besides, a dedicated website for our project will be created and maintained. We will also use social networks such as Facebook to communicate.

This project will popularize the sustainable development of mineral resources among MSc students in geology, sociology and economy who start to develop their path career. The main stress is put on creating conditions to convey knowledge on mineral resources as key to the development of the circular knowledge-based economy in the most effective way. The project will develop new entrepreneurial education approaches such as (1) elaboration of innovative teaching methods (e.g., inverted pedagogy, blended-learning, co-creation of case studies with industry) showing the attractiveness of mining and strengthening student creativity, entrepreneurship and skills necessary in further professional life; (2) creating a self-consistent educational program which strengthens strategic operational skills matching the mining industry needs in the field of socio-economy, environmental protection, and geology; (3) establishing cooperation between the industry and educational public schools to improve the attractiveness of vocational education in mining economy, and industry

placements for students. The objective of this education project is to train students in geology, environment, economy and sociology to work together successfully.

The education content is divided into four inter-connected units that cover areas of mineral resources and sustainable development, raw material-energy nexus, new communication strategies for mining business, and field projects (trips).

All these new teaching units rely on innovative educational approaches based on blended-learning, inverted pedagogy, crowdsourcing contest, and use of state-of-the-art tools for data visualization and integration. The participation of policymakers, engineers, and managers is directly embedded within the university curricular. They share their opinions, present the vast array of regulations that apply to mining operations, and provide a critical overview encompassing both the vulnerability and the opportunities in mineral supply for the sustainable development in Europe. The OpenYourMine educational project aims to permanently induce an entrepreneurial mindset and trigger the creative and innovative skills of students. OpenYourMine helps students to make professional contacts within an efficient and dedicated network.

Every year, about 40 students are gathered at one of three partner universities (2019–2020 at Nova University and 2021 at WUST) for one week of the field trip and one week of workshops/lectures/practical activities (Figures 5–8). As an important part of the pedagogic, the approach relies on international teamwork, contests, team projects and inverted pedagogy, a part of this education project does not need students to spend time in a classroom. This means that at least 50% of the time the students work in their university and use web-platform to communicate with each other and with the teachers. The field trip and lectures occur at the same guest university (Nova University—Portugal in 2019–2020 and WUST—Poland in 2021) to simplify the logistic and minimize the travelling cost. Of course, every partner takes part in the preparation and organization of teaching units whatever the location of the field trip and workshops is.

Detailed information on the project and its activities are given on dedicated website https://www.openyourmine.eu/.

Figure 5. Sao Domingo old mine site (Gogolewska A. 2019).

Figure 6. Sao Domingo old mine site (Gogolewska A. 2019).

Figure 7. Costa Vincentina structural geology (Gogolewska A. 2019).

Figure 8. LNEG Aljustrel drilling (Gogolewska A. 2019).

4.3. Geomatics for Mineral Resource Management

Having well-trained geomatics experts is now more important than ever. The reason for this is the ever-increasing global demand for mineral resources, which leads to their extraction in hard-to-reach areas of the geosphere. At the same time, it is necessary to meet the highest safety standards and environmental and social regulations, and it is desirable to make optimal use of natural resources by maximizing recovery. This requires engineers to be able to develop new innovative solutions, to make optimal use of state-of-the-art technologies for extraction, management and analysis of geodata [33,39–43].

To meet the needs of the labour market, an innovative educational project EC-Geo-Sustain: European MSc in Geomatics for Sustainable Mineral Resource Management was prepared, the preparation and implementation of which was financed by the EIT and EIT RM under the project contract No. 17002. The project coordinator was the TU Bergakademie Freiberg university. The project implementation began in 2018.

As part of the project, a new European Master's Degree Program in Geomatics for Mineral Resource Management was prepared, allowing one to study at the best universities in the field of Earth Sciences across Europe. These are Técnico Lisboa (Portugal), TU Bergakademie Freiberg (Germany), Montanuniversität Leoben (Austria) and Wrocław University of Science and Technology (Poland). The studies are intended for undergraduate (engineering) students in the fields of Mining and Geology, Geodesy and Cartography or related engineering disciplines. This specialization offers three study paths (Figure 9). The first year of study (semesters 1 and 2) always takes place at the university where the student enrols. The second year of study (semesters 3 and 4) is conducted at one of the partner universities. In the fourth semester, students write their thesis under the supervision of two professors representing both universities. After defending their thesis they receive diplomas from both partner universities (double diplomacy obtained based

on an agreement signed between the two partner universities). Students can support their studies at foreign universities with the Erasmus Plus mobile scholarship.

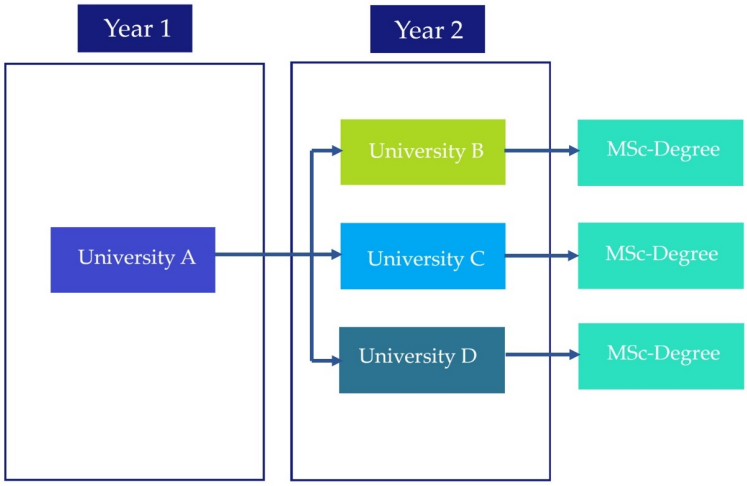

Figure 9. Pathways to Geomatics for Mineral Resource Management [42,43].

The study topics include the acquisition, storage, processing and provision of geographic or spatially related information tailored to the needs of the raw materials industry. The program content of the new specialization (Figure 10) focuses on three main areas: remote sensing methods used for mining data acquisition (Geo-Data Acquisition), spatial data collection (big data) with its visualization (Geo-Data Management and Visualization) and spatial data processing and modelling (Geo-Data Analysis and Modelling). The authors of the project assume that such a choice of the scope of Master's studies will be very interesting for students, and at the same time it will be a topic related to the latest scientific research conducted at leading partner universities, responding to the current needs of the industry.

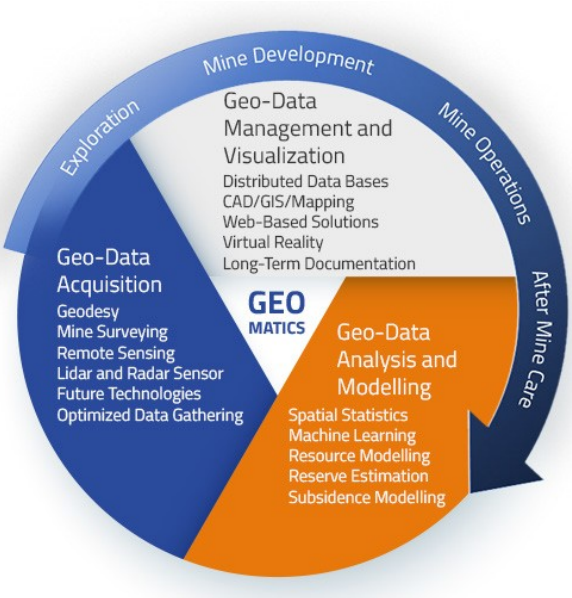

Figure 10. Content of the three main pillars of the Geomatics for Mineral Resource Management program [42,43].

This new master's program is designed to enable students to integrate these three pillars into innovative concepts of Geomonitoring. Students have the opportunity to learn about the latest research coming from several major European research projects. The im-

plemented interaction with several local industry partners enables students to work on real projects, understand the needs of the industry and train and develop entrepreneurial skills. Thanks to a guided but flexible exchange program between the partner universities, students have contact with different fields of knowledge and cultural backgrounds. Graduates are expected to be future leaders in technology development and innovation, introducing modern geomatics concepts to marketable products to ensure a secure future in the mineral industry.

Modern didactic methods were used in teaching, the emphasis was put on the training of competencies in the area of professional, interpersonal communication and entrepreneurship. The educational results are achieved through active forms of teaching, such as case studies and project tasks, solved by students in international groups. Cooperation with companies in the raw materials industry will provide students with real industrial data and authentic problems to solve. In this way, students will get to know the needs of the industry better and will be trained in entrepreneurship. The studies are international. Thanks to the mobility paths designed by the partner universities, students can learn about the different areas of competence of the visited universities and gain intercultural experience. All these expected learning outcomes are important to achieve the assumed profile of graduates who will be future leaders and technological innovators in the area of geomatics. Using modern concepts of geomatics they will be able to create products and services sought after by the market.

In addition to Geomatics for Mineral Resources Management specialization, the project offers Massive Online Open Courses (MOOC) consisting of a series of online videos with single course content. The MOOC courses will be conducted by the world's leading experts in the relevant research field. They aim to encourage candidates and students to take part in the program and they are an introduction to the individual subjects taught within the offered speciality (https://study-geomatics.eu).

4.4. MEITIM Project

Having the experience from previously mentioned projects and analysing the newest reports on future mining, the authors realized that the minerals industry is facing a changing talent landscape [12], with digitization necessitating new skillsets, that technology cycles are getting shorter and shorter transmitting pressure in the need of trained workforce, and that mining companies need to ensure that their boards and staffs are properly constituted to support the transformations which the sector is currently undergoing, including fluency in such areas as technology, integration, systems security, and cybersecurity.

The mining industry must deal with difficulties related to the integration of business problems with the practical application of technologies. The key is to develop multifunctional teams that understand both mining operations and the technologies and know-how to integrate new technologies into operations and measure their impact. Companies must be able to acquire the systems-integration skill set right to maximize value creation. The mining companies which recognize this shift today and adapt to changes ahead will be the winners of tomorrow.

Facing challenges related to the mining of the future, the industry must ask itself several questions. What about future workforces? How a "new face" of a mining engineer will look like? How to adapt employees to change related to sustainable development and green deal?

While the raw materials industry is focusing on digitalization and automation, and also on how to implement concepts like Industry 4.0, technology integration, smart mines, no MSc program in technology integration for the development of professionals needed by the industry exists. There are many initiatives regarding different technologies and their mining application, but nothing regarding how to focus on the above-mentioned issues from a strategic point of view of a company, converting this integration into a competitive advantage. It was a reason why the Master in Entrepreneurship, Innovation and Technology Integration in Mining (MEITIM) project, co-financed by European Institute of

Innovation and Technology (EIT) and EIT Raw Materials, was born. MEITIM is focused on filling the educational gap by developing an innovative, completely new EIT-Labelled, 120 ECTS, MSc program which one interested in being the mining engineer of the future will follow [Herrera, 2020].

This industry-driven project is developed by a consortium of three universities—the Technical University of Madrid, Spain (UPM)—the leader, Wrocław University of Science and Technology, Poland (WUST), Lappeenranta University of Technology, Finland (LUT), and industrial partners as well as research centres: the Finnish Minerals Group Suomen Malmijalostus Oy, MetsoOutotec Oy, The Geological Survey of Finland, Atlantic Copper S.L.U. and The Spanish National Research Council.

It aims to define and set up a multidisciplinary MSc program educating a new generation of technologists by complementing their deep technical knowledge and skills in raw material disciplines with a piece of sound knowledge in modern technologies and with the ability to integrate innovations and new technologies into feasible and sustainable business solutions in the sector of raw materials.

The project objectives are focused on increasing the attractiveness of the Mining MSc program, implementing an international MSc course, preparing a new educational offer oriented towards innovative, sustainable and technologically advanced mining of the future. Special emphasis is laid on the European Commission's guidelines concerning sustainable development policies along with objectives of the new growth strategy, i.e., the 'Green New Deal' for the European Union and its citizens. Moreover, the project establishes cooperation between international higher education institutions, increases participants' professional and linguistic competencies, and Leads to sharing the cultural heritage of partner countries.

By incorporating sustainable development goals, innovation, technology integration, creativity, and entrepreneurship, graduates of this program will have the ability to transform real problems into research challenges and generate innovative, sustainable ideas and strategies with an entrepreneurial vision. The activities related to innovation and the conception, design thinking, manufacture, evaluation, certification and marketing of technology products and services will be, among others, professional competencies associated with this degree.

This MSc level program will be oriented to educate the mining engineer of the future by [44]:

- Enhancing the creativity and innovation capacity of engineers,
- Providing in-depth knowledge of technologies (by practical training) that are entering the primary sector of the raw materials value chain (geology, mining, mineral processing and metallurgy). This will help graduates to understand the technical, business, social and economic aspects, as well as giving them a broad understanding of innovation and entrepreneurship in the raw materials sector,
- Stimulating technological innovation and technologies integrated with the vision of creating new opportunities and added value,
- Improving the mindset of entrepreneurship,
- Expanding the KIC community of professionals in this dynamic and innovative activity sector,
- Complementing the T-Shape profile of professionals trained.

Looking into the future, in 25–50 years forward, one can ask a question about the needs of the future mining industry. The project is structured in a way that enables a kind of forecast and lets to follow future trends by strict cooperation with the mining industry. It can be achieved by [44]:

- Defining with the industry which is the role and profile of the workforce needed to carry out technology integration projects in 10, 20, 50 years,
- Defining a study program which meets industry future needs as a result of the definition of the kind of professional that will be desirable to take ahead technology integration projects,

- Structuring and developing a university program which meets universities and EIT Raw Materials Academy criteria,
- Having the MSc program verified by the National Education Quality Authorities according to National and European Regulations,
- Having the MSc program accredited with the EIT Label.In the mid-term, focusing also on achieving EUR-ACE Accreditation, that gives the students the capacity for full international mobility.

A periodical evaluation of the results is planned to assess the project's effectiveness and the reliability of its assumptions. The initial assessment plan includes several Key Performance Indicators (KPIs), such as (1) Number of applicants to MEITIM labelled Master program (from partner's countries, EU, non-EU), (2) Number of graduates from MEITM labelled Master program (from partner's countries, EU, non-EU), (3) Creation of entre- and intrapreneurship minded people (number of graduate's start-ups or companies established), (4) Career tracker—number of graduates working in/out raw materials sector. All the KPIs will be monitored yearly starting from 2022/2023 as the first academic year of running the program. Moreover, to assess the curriculum and follow the most actual mining trends, the yearly market review will be held, and regular contact with industrial partners will be maintained through dedicated events, polls, and workshops. It allows for gaining constant feedback on the program.

All aforementioned issues will lead to open the gate for the education of the mining engineer who will not be afraid of new challenges, new technologies, a new vision of sustainable, green mining based on the practice and with a sense of business value creation. The development of the project can be followed on the dedicated website www.meitim.eu.

5. Discussion

The article combines broadly understood sustainable development with a didactic process aimed at future mining engineers. An attempt was made to diagnose the important role of this process in higher education for the strategy of sustainable, green governance. Several priorities have been identified, which will aim at improving the quality of education by, among others, updating educational programs as an interdisciplinary, innovative educational and research offer.

The article answers the steps to be taken to increase the attractiveness of the courses at WUST. As demonstrated by the statistics published in the paper of Adach et al. [12], a change in the Faculty's teaching offer is necessary, because since the academic year 2017/2018 a significant decrease in the number of graduates of the course in mining and geology has been noted. It has been shown that there is a link between the condition of the mining industry in Poland, its reputation and the number of people who want to study in this field. Therefore, the research objective has been achieved in several stages. The starting point was an analysis of the latest guidelines on the competencies that an engineer finishing a mining course should have, in line with sustainable development. Moreover, there was indicated the need to transform the University and Faculty in terms of research, teaching and management, and organisational activities. In the next step, the scope of already undertaken didactic and organisational activities was presented at WUST, through internationalisation and cooperation with leading European universities. The description of these projects (Mobi-us, OpenYourMine, Geomatics for Mineral Resource Management) confirms that they are team initiatives that develop new technological skills. To provide students with comprehensive, modern knowledge and enable them to acquire practical skills and introduce them to sustainable mining-related issues, the projects implemented at WUST are interdisciplinary and complementary (Figure 11). The effects of these programs, in their entirety, will be assessable when all of them are launched (e.g., in terms of the number of students/graduates). The MEITIM project expands this innovative, engineering range of programs to include sustainability, entrepreneurship, and technology integration, drawing on partner universities' organisational and didactic experience from Finland and Spain.

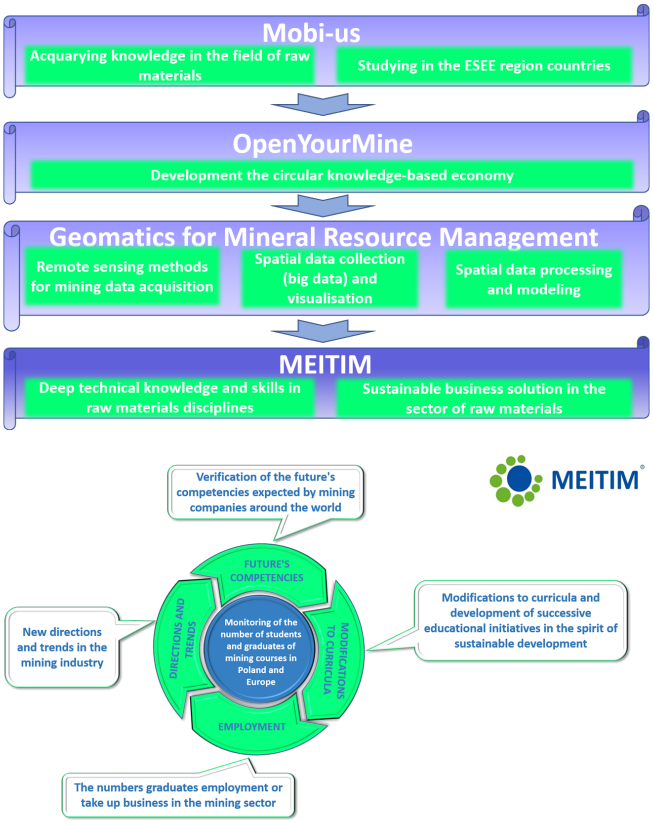

Figure 11. Comprehensiveness of the educational projects implemented at WUST.

6. Conclusions

Based on WUST's example we can conclude that Universities should become a centre of knowledge in creating a balance between the individual, the economy and the environment. A qualitative transformation of the university is necessary at the didactic, organizational and research level. The article indicates the future key mining competencies, necessary in the era of digital challenges. Apart from innovative, technical skills (robotics, process automation and artificial intelligence), areas of competence related to environmental protection, social aspect or real-time data acquisition, analysis and reporting were indicated. The Wrocław University of Science and Technology actively participates in the education process including eco-technological innovations through the implementation of international education courses, in cooperation with leading European centres. The most important educational projects currently implemented at the Faculty of Geoengineering, Mining and Geology of the WUST show the way for sustainable development and green deal in GEO-sciences. The research objective has been achieved by indicating what steps need to be taken in the didactic process to attract students and implement SDGs in higher education in mining engineering at WUST. Further research will consist of periodic market research and verification of the future's competencies expected by mining companies around the world. The number of students and graduates of mining courses in Poland and Europe and their long-term development will also be continuously monitored. The success of universities' activities will be determined by how many graduates will find employment or take up business in the mining sector. This will be the basis for further modifications to curricula and development of successive educational initiatives in the spirit of sustainable development.

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