Educational Programmes connected with mineral processing in Poland

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Abstract

Mining and mineral processing is a significant field of research in Poland, mainly due to the presence of huge deposits of various raw materials located in the country. Several Polish universities offer studies in the field of mineral processing. AGH University of Science and Technology, located in Cracow is a major Polish university offering MSc programmes in mineral processing. There are also several other universities, where students can gain knowledge in the field of mineral processing. Teaching programmes cover all of the main aspects of mineral processing, in cooperation with copper, zinc and lead, coal and industrial mineral industries. This article describes the mineral processing curriculum in Poland, in addition to issues related to scientific staff. The career development for graduates is also discussed, in terms of potential opportunities and problems.

Introduction

Several universities in Poland offer higher education in the field of mining and mineral processing. Graduates of two universities can gain diplomas as mineral processing engineers, and curricula in these universities offer comprehensive education in the field of raw materials processing and beneficiation technology, including waste management issues, as well as economic aspects. One of these universities is Silesian University of Technology, located in Gliwice, but the primary mineral processing university is AGH University of Science and Technology (AGH UST) in

Cracow. This university has over a hundred years of teaching experience in the field of mining and mineral processing. Graduates from AGH UST in the field of mineral processing are aware of the supply and availability challenges regarding a wide range of raw materials (coal, metallic and non-ferrous metals ores, aggregates, chemical minerals etc.) and derived products, understand the societal function of raw materials and the need for a value chain approach to ensure the sustainable industrial utilization of resources. Mineral processing engineers during their studies also have the chance to acquire entrepreneurial and innovation skills, useful in expanding the existing markets and in creating new ones. Educational activities are therefore closely related to societal needs in general and industrial needs in particular. In general, the graduate gains complete training in the problems associated with physical, physicochemical and chemical separation of the individual components of the raw materials of fossil or mineral waste in order to obtain the concentrates for further processing technologies. Techniques and technologies of beneficiation are among the subjects studied.. Silesian University of Technology offers a course in *Mineral Processing and Management.*

It is worth noticing that AGH UST is the only Polish University that also offers Master studies in the field of Mining Engineering in the English language. This makes the AGH UST the only Polish University in the field of mining and mineral processing that is prepared for the education of foreign students in its MSc courses. It also opens up opportunities for Polish graduates in terms of their international internships and future mobility. The graduates gain knowledge in the field of mining, including various methods of raw materials extraction, together with processing technology and waste treatment.

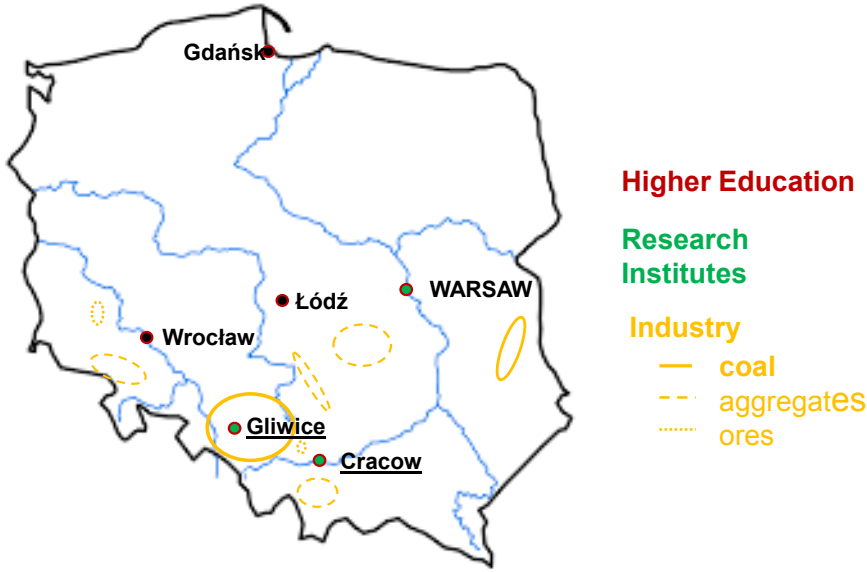
Several other universities offer curricula in the Polish language in the field of mining in which selected aspects of mineral processing are delivered. These graduates are not fully mineral processing engineers, but rather mining engineersthat are taughtsome aspects related to mineral processing. The following universities should be mentioned in this category: AGH University of Science and Technology, Gdańsk University

of Technology, Łódź University of Technology, Silesian University of Technology and Wroclaw University of Technology. AGH UST offers two courses with elements of mineral processing: One is run by the Faculty of Mining and Geoengineering, and the other can be found in the Faculty of Mechanical Engineering & Robotics, where mineral processing is taught from the perspective of mining and mineral processing machinery and equipment.

Most of the scientific staff related to mineral processing are located in AGH UST. Twelve professors work in the Department of Environmental Engineering and Mineral Processing at AGH UST, while the other universities employ 1-2 professors of mineral processing each. However if we expand the research field to include mining, the number of professors is higher: AGH employs around 40 professors, while in each of the other Universities there are between ten and fifteen to twenty professors. In total, scientific staff in higher education in this field approaches 150-200 people. About 80% of researchers and educators in the field of mineral processing are located in Cracow area.

The second activity in the field of mineral processing in Poland is related to research institutes. Scientific workers at these institutes, especially professors, supplement educational activities at universities with the scientific development of junior researchers (as reviewers, tutors etc.). The institutes also collaborate with universities within the scope of professional practices, scholarships and industrial trainings. The following institutes should be listed: Central Mining Institute (GIG) located in Katowice, Mineral and Energy Economy and Research Institute of Polish Academy of Science (Krakow), Institute of Mechanised Construction and Rock Mining (Warsaw), Institute of Non Ferrous Metals (Gliwice), CUPRUM (Wrocław), The Institute of Ceramics and Building Materials (Opole, Warsaw, Krakow), Institute of Chemical Processing of Coal (Zabrze), KOMAG, and many minor institutes engaged in research in the aggregates sector and so on. It is hard to estimate the exact number of scientists engaged in all mining and mineral processing institutes, but we might say at least 200 people.

Figure 1: Mineral processing institution in Poland



The third vertex in the triangle of Education-Research-Business constitutes the industrial sector. The mining and mineral processing industry covers copper (KGHM and related companies), coal (mining and processing plants located in Silesia region, and in eastern part of Poland), zinc and lead processing (near Cracow), aggregates sector, represented by many SME and large plants and some other minor types of raw materials. A major role is played by KGHM, one of the world leaders in copper and silver production. It processes 30 million tonnes of ore annually. A summary of this information is presented in Figure 1.

Curricula

Educational programmes related to mineral processing in Poland can be divided into two main groups. The first group includes curricula strictly related to mineral processing (*Mineral Processing Curriculum*). Graduates of these studies gain a comprehensive knowledge of the mineral processing area and, as a result, become mineral processing engineers. The second

category (*Mining Curriculum*) covers programmes in the field of mining, geoengineering and environmental engineering, which includes selected issues related to mineral processing.

The graduates of the *mineral processing curriculum* in Poland has a deep knowledge of techniques and technologies of various beneficiation methods (gravitational, flotation, magnetic, electrostatic, chemical). The graduate is educated in the field of preparatory operations as well as supplementary ones, applied to processing technology, in particular comminution and classification processes, dewatering operations, various methods utilizing gravity, centrifugal, vacuum and pressure forces. Environmental protection issues and problems related to water management and waste utilization in accordance with the principle of sustainable raw materials management and utilization are of key significance during the studies. The graduate is also well prepared for material sampling, in addition to qualitative and quantitative analysis. Other aspects include the operation of processing machinery and equipment, organization, management and economics, process automation, control and optimization, together with practical knowledge of raw materials deposits (geology, geochemistry, mineralogy and petrography).

The graduates of the *mining curriculum*, who also have gained some knowledge in the field of mineral processing, have an in-depth knowledge in the field of mining, geology, environmental engineering, supported by chosen aspects of mineral processing. These aspects include: Mineral processing equipment, chosen methods of raw materials beneficiation, or selected operations in technological circuits of raw materials processing. The above issues may apply exclusively to selected raw materials (either coal or ores, or aggregates).

Teaching programmes in the field of mineral processing will be described using the example of curriculum applied at AGH UST. As was mentioned previously, this is one of the primary universities in the field of higher education in Poland. However, the respective programme at Silesian University of Technology is similar. Mineral processing curriculum at AGH includes a number of teaching modules that can be grouped into following categories:

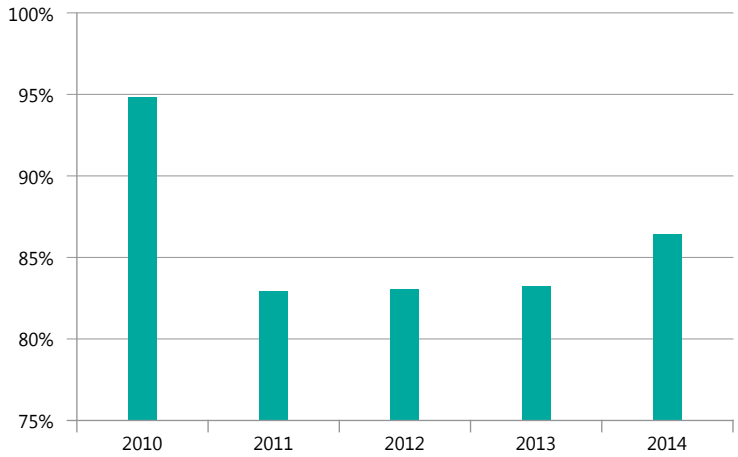
- Base modules, including Statistics, Contemporary Physics, Environmental Management and other similar subjects, which give the student an overall awareness of common laws of phenomena related to the field of study. Base modules cover 84 teaching hours.
- Technical modules, connected with mineral processing technology, including methods of beneficiation, mineral resources economy, waste management, automation and process control, environmental and social issues. This group of subjects gives the student the view of overall and specific engineering problems in the field of mining and mineral processing. The entire group covers 16 modules with nearly 400 teaching hours plus 170 hours of laboratory.
- Humanistic modules (managerial psychology, negotiations) help to develop non-engineering skills, as well as increase selected soft skills of future engineers, such as interpersonal abilities, team working and public presentation skills.
- English modules that, apart from obligatory English language course (30 hours), include an elective course, taught in the English language (30 hours).
- Industrial practice, which is carried out in mining and mineral processing plants, and takes 4 weeks.

AGH UST, is the only university in Poland that also offers regular PhD studies in the field of mineral processing. These four-year studies are offered in the Faculty of Mining and Geoengineering, and are carried out in the Polish language. Studies in English are also possible, but this requires additional arrangements as the programme is tailored for the particular requirements of the PhD candidate. Four main fields of studies are available: *Mining and Geology, Environmental Engineering, Management and Production Engineering, Civil Engineering.* Each of these fields is focused on different engineering issues, and a doctorate in mineral processing is possible in the field of *Mining and Geology* and *Environmental Engineering.* The teaching modules within these studies are connected with the selected field of study, and include the methodology of scientific research and an emphasis on the various types of funds available for research. The doctoral dissertation is usually carried out in cooperation with industry.

Graduates – their future career and professional development

Graduates typically should have no major difficulties in work market. The AGH Career Centre monitors future career of graduates, and the following figures were prepared on the basis of data from the Centre. A high rate of employment among mining and mineral processing engineers is observed, which was well above 80% during the last five years (Fig. 2a). Graduates are also able to find a job relatively quickly (Fig. 2b). A percentage of future graduates have a job even before graduation (Fig. 3), and this number in 2014 was as high as 45%.

Figure 2: Employment rate (a), and the duration of the job search (b) among graduates



(a)

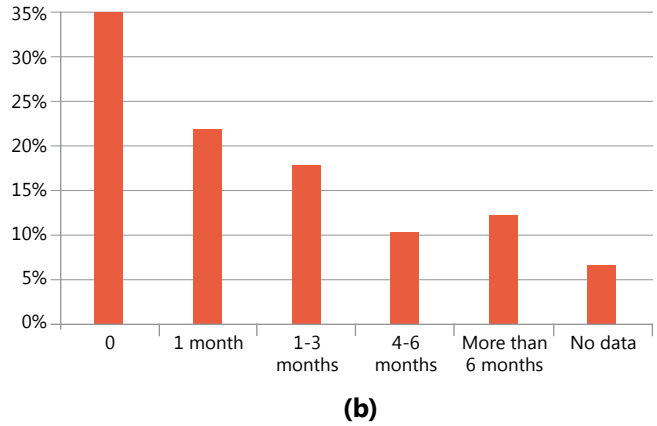
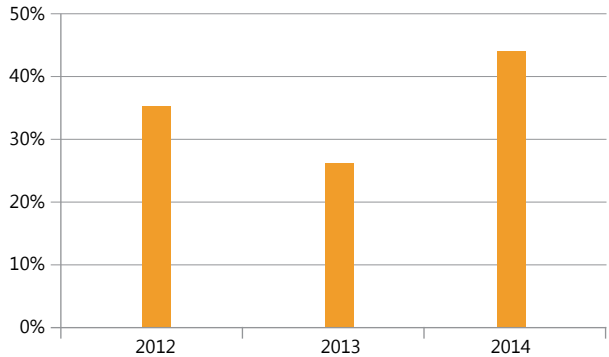


Figure 3: Percentage of undergraduates with a job prior to graduation



As many as 67.3% of graduates claim that their job is fully compatible with the profile of completed study. A further 9.6% think that the job is partially compatible, and 19.2% consider it as incompatible. 3.8% of graduates did not respond.

Figure 4 shows the main factors regarded as significant in recruitment, while Figure 5 presents the priorities that graduates take into consideration while choosing a potential employer. Type of completed studies and work

motivation play the most significant role in employment. Graduates consider the possibility of self-development at work and stable work conditions as key priorities in making decisions when choosing a potential employer.

Fig. 4: Significant factors in recruitment

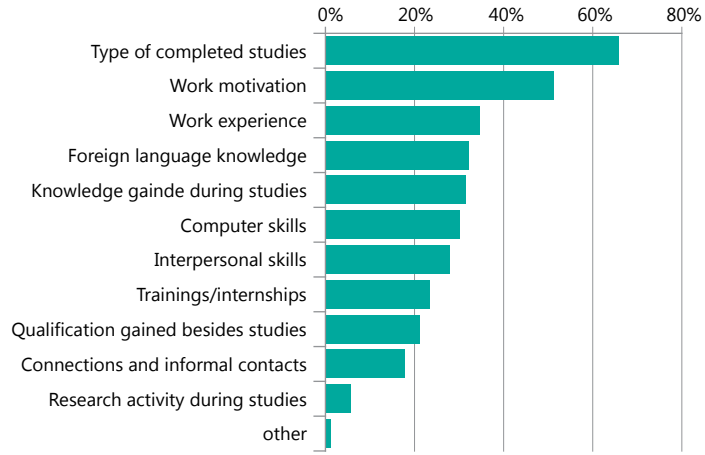
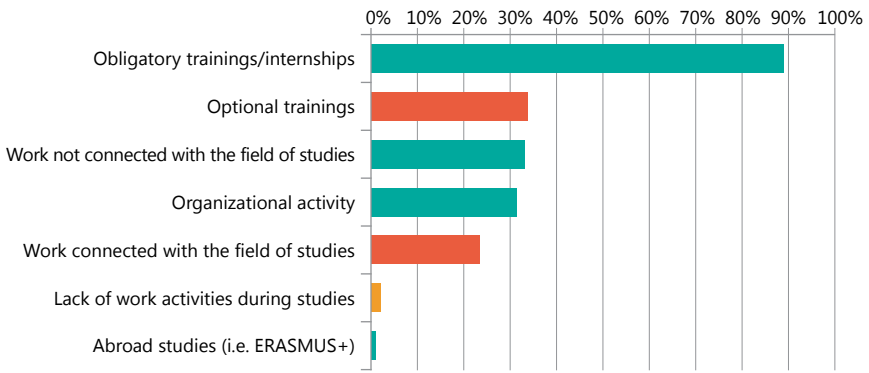


Fig. 5: Priorities in choosing a potential employer

The usefulness of knowledge gained during the studies is assessed as very high and high, at 41.3%. The next 55.2% of graduates claim that the gained knowledge and qualifications are sufficient. Only 3.5% graduates consider their gained knowledge as low. Graduates also assess that studies have prepared (17.2%) or partially prepared (69%) them for the job. The remaining 13.8% have a negative opinion of this issue. Figure 6 shows what types of activities graduates have taken up during their studies. The low mobility among students is a concern. On the other hand, a significant percentage of graduates would like to continue their professional development in postgraduate/PhD studies. Nearly 25% graduates want to enroll on postgraduate studies, while around 40% consider that possibility. Furthermore, about 8% is already undertaking postgraduate studies.

Figure 6: Main activities during studies



Feedback from the industry

The other side of the assessment of graduates is the opinion of employers. Some feedback from the industry sector was collected and the most relevant opinions are presented below. It is worth noting that employers tend to assess their employees in two ways: Taking into account their gathered knowledge and practical skills and considering their personal skills. The knowledge of mineral processing engineers graduating from AGH UST is

considered to be good or very good, in general. They are also regarded as ambitious people. On the other hand their foreign language knowledge is considered to be good or average. Among the other negatives, the following are mentioned:

- Poor practical utilization of the gained knowledge
- Unhealthy competition (too ambitious)
- Poor task concentration skills
- Poor communication skills, both written and oral. This may be connected with the many digital gadgets utilized daily by young people (smartphones, smartwatches, laptops etc.), which results in lower exposure to personal communication with contemporaries and colleagues.

Considering the fact the AGH is considered as the Polish leader in higher education in the field of mining and mineral processing, it is reasonable to assume that candidates from the other universities might obtain different results in terms of positives and negatives.

As was mentioned previously, employers have assessed the personal skills of graduates/employees. Among the main positives, they considered the mobility of workers. It appears that if necessary, employees are ready to move, even abroad. The other positive feature is the very good knowledge of electronical technology and practical utilization of Internet. Several negatives were also mentioned: Poor team working skills, too high demands at the very beginning of their professional career, poor self-organization, attitude and lack of independence. At the same time, the industry determined the profile of their perfect graduate. Such a person:

- Should be aware of general problems relating to raw materials availability and supply
- Should understand societal/environmental function of raw materials (value chain approach, sustainable utilization of resources etc.)
- Should have a deep knowledge, which is important but not critical
- Should have professional skills (team work, report writing), analytical thinking, problem solving and data analysis, which are of great significance.

Conclusions and final remarks

Mineral processing education in Poland is in a strong position, however some improvements are advisable. Many university teachers and industry representatives agree that improvements should be made to:

- Further develop and manage of educational programmes and activities related to raw materials
- Developprofessionals who have a deep understanding of specific issues related to mineral processing
- Bring together three aspects: Business (large companies and SMEs), higher education institutions and research centres.

The above activities can be run locally and globally. Universities and research centres cooperate with the industry sector within this area. Educational programmes are being modified and adjusted to the changing conditions. Teaching staff are up to date with recent scientific achievements which are utilized in educational programmes. One example of solutions at a global scale is the European initiative KIC Raw Materials. This international programme aims at increasing the competitiveness of Europe in the field of raw materials, through various educational activities.

Literature

AGH University of Science and Technology, CAREER CENTRE – Unit for monitoring of Graduates Professional Development - reports