Involvement of Experts From Practice in Practical Laboratory Teaching – A Way to Increase the Competencies and Skills of Science Study Programs Graduates

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The Barcelona Conference on Education 2022
Official Conference Proceedings

Abstract
The current society requirements need close interconnectedness between children's and young education process and the labour market, namely in industry and services. Workers in the 21st century must have the skills to process information, including reader literacy, mathematical literacy and problem-solving skills. Today, the school is only one of the places where students learn. In this context, the role of dialogue between schools and employers is increasingly recognized. These time requirements should also be addressed to educational institutions in chemical professions. The subjects of practical education in the area of natural education are crucial for the readiness and applicability of graduates in the labour market. The social situation in Slovakia shows that connection between the young people education and practical experiences from industry and services is necessary for a future prosperous society. Practical training must develop skills important for the workforce living in a technologically advanced economy. Based on these requirements, in cooperation with employers, Institute of Chemistry PF UPJŠ in Kosice is preparing a new professionally focused study program for future students. The new study program will meet European educational standards and will also include compulsory electives and elective courses, which will be partially attended by experts from practice. Students' professional practice lasting three months in contracted laboratories of industry and services is a compulsory subject. The paper will present our previous experience in creating new professionally focused study program “Chemical Laboratory Technician - specialist” as well as in involving experts from practice in contact teaching.

Keywords: Practical Education, Experts From Practice, Collaboration

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Introduction

Human society has changed more than ever in the last 50 years. This change is about our lifestyle and labour market and also about employers' requirements for young school graduates. The 21st century workers must have information processing skills including literacy, numeracy and problem-solving skills. In addition, they must also have "generic" skills, such as interpersonal communication, independence, and ability to learn. Today, school is only one of the places where students learn.

Today, we often encounter challenges to support the principles of partnership and cooperation of all parties that are involved in education and training. Therefore, the role of dialogue between schools and employers is increasingly recognized. These connections are requested in all areas of the economy, such as automotive, chemical, food, and pharmaceutical industries, but also service areas such as healthcare and education. The goal of the connection is to significantly reduce the departure of young people from Slovakia who are looking for work abroad.

Educational institutions in chemical fields should also respond to current social and labour requirements. Practical subjects in the field of natural science education are significant to the readiness and applicability of graduates on the labour market. Since the current trend in the chemical economy is to prefer accepting prepared graduates without the willingness to finance their practice, universities must respond to these needs. Based on these requirements, we connected the content of the practical exercises at the university with the content of works that are done directly in companies laboratories, and we incorporated their to the practical laboratory exercises of study programs of the fields of chemistry (inorganic chemistry, analytical chemistry, physical and biochemistry).

The aim of this connection was to develop the scientific and digital skills of graduates necessary for employment on the labour market, such as creating hypotheses, designing solution procedures, experimenting, collecting data, formulating conclusions, argumentation, working in a team, as well as skills such as critical thinking, problem solving, cooperation, because these are in direct proportion to the economic growth of countries (1).

The Institute of Chemistry at Faculty of Science of Pavol Jozef Šafárik University in Košice took place several meetings of teaching staff and experts from practice, where the participants exchanged their experiences (pedagogical staff informed the experts from practice about the content and methodology of the practical laboratory exercises, and experts informed about chemical-technological procedures, which are implemented directly in production or laboratory operations in the companies).

Teachers and experts from practice proposed specific methodological procedures used in practice which they implemented in practical laboratory exercises:

Basic laboratory practices from Inorganic chemistry (2):

1. Limestone analysis - according to STN (Slovak technical standards) 72 12 16 (determination of CaO, MgO, non-decomposable fraction)
2. Determination of the content of nitrous gases (NOx)
3. Determining the degree of conversion

4. Quality parameters determination of technical nitric acid HNO_3 (HNO_3 content, HNO_2, chlorides, Residue determination after annealing)
5. Determination of the quality parameters of calcium nitrate (CaO content, granulometric composition, ammonia nitrogen content, total nitrogen content, water-soluble fraction content)

Laboratory practices from Physical chemistry (3):

1. Chemographic proof of post-shot waste products
2. Microscopic examination of textile fibers
3. Analysis of trace amounts of explosives by the ion mobility spectrometry

Laboratory practices from Analytical chemistry (4):

1. Titration determination of alkalinity of decontamination agents containing potassium hydroxide
2. Titration determination of the content of active chlorine in calcium hypochlorite
3. Spectrophotometric determination of Pb, Cd, Cu, Al in water leachates, as waste from technological process
4. UV-VIS spectrometry using special reagents forming with toxic chemicals coloured product
5. Identification of paraffins, dyes and other substances in the form of stains on the surface of products for hygiene, which show a technological error, with the use of Raman and infrared spectroscopy

Basic laboratory practices from Biochemistry (5):

1. Making latent dactyloscopic traces visible by chemical and physico-chemical methods
2. Taking a comparison set of fingerprints on a dactyloscopic card

Based on the pilot verification of work procedures, other forms of student involvement in practical companies' education were proposed, in the form of short-term internships directly in the companies or in the institutes. For the implementation of the internship, pilot program of students' work activities was proposed, in the form of so-called Educational plan of professional practice of the student (6). This proposal also includes the education schedule. To support the feedback principle, we also included formative assessment tools (e.g., self-assessment card, survey, exit ticket) in the work procedures of the laboratory exercises, which pointed out misconceptions and positive and problematic aspects of the implemented experiments (2, 3).

The experience gained during the cooperation of companies and the university led to the proposal to create a professionally focused study program.

To offer for students a high-quality study program, we took place an analysis of the teaching status of such or similar study programs in Slovakia and abroad. We carried out analysis in secondary schools, universities, and in industry companies and institutions.

Based on meetings with teachers at vocational secondary schools, who in the past participated in the education of chemical laboratory technicians in Slovakia, we found out that such a field of study is currently missing in Slovakia. Secondary schools provide

vocational complete secondary education in accordance with the State educational program for vocational education and training for the group of study and teaching fields Technical and applied chemistry in the study fields (6):

Biotechnology and pharmacology
Technology of environmental protection and creation
Chemical informatics
Control analytical methods
Chemical production
Operator of rubber and plastic production
Chemist operator
Chemistry and environment
Pharmaceutical production operator
Chemical and pharmaceutical industry

Moreover, we also took place a survey directly among the teachers at secondary schools who ensure the implementation of such training. We carried out a pedagogical survey using the questionnaire method (we prepared 15 questions) (7).

In addition, we also accomplished an analysis of universities similar study programs abroad to see if they offer such a study program (or a similar one). Based on this information, for example, we found out that it is possible to study a specific study program called "Laboratory diagnostics in health care" at the CTU in Prague at the Faculty of Biomedical Engineering.

At the Masaryk University in Brno, at the Faculty of Science, the Institute of Chemistry, there is also a program called "Analytical Chemist - Manager of a Chemical Laboratory" in the offer of bachelor study programs.

At the Palacký University in Olomouc, they take place the study program "Chemistry analyst specialist".

At the Metropolitan University of Applied Sciences in Helsinki, they train bachelors in the study of laboratory sciences. The program is called the Laboratory Science Study Program and provides students the skills and know-how for professional and practical tasks in various areas of laboratory science. Bachelors of Laboratory Services are experts in laboratory operations and they know how to perform their work according to common quality systems (7).

To find out whether industrial companies or relevant institutions are interested in such graduates, we also took place a survey in these companies and institutions (we prepared 12 questions) (7).

Based on the facts mentioned above, the aim of our work is to prepare and offer to young people a new professionally focussed study program. The intensive cooperation of various resorts in Slovakia (secondary schools, universities, and companies (from the field of production or services) is necessary (Fig. 1).

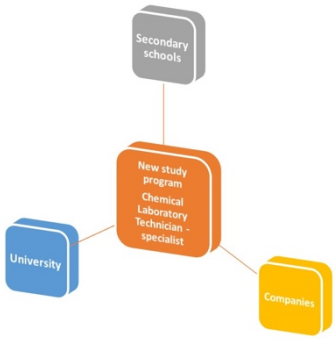

Figure 1: Cooperation between secondary schools, university and companies leads to the creation of a new study program.

Conclusion

Conclusions of analysis and survey in secondary schools

Based on the analysis of the State educational program for vocational education and training in the study and training group 28 Technical and applied chemistry, obtained conclusions from the pedagogical survey in the form of a questionnaire as well as personal interviews with secondary school teachers, it can be concluded that currently the interest of young people in studying these fields is less than it was in the past. Besides that, teachers of vocational subjects' state that the technical security of secondary schools as well as the legislation itself do not allow schools to operate a technical and instrumental infrastructure with a demanding need for service as well as operation and maintenance. Vocational secondary schools provide teaching in those fields for which they have at least adequate material conditions, they would prefer internships, excursions, while their students would also gain knowledge from working with modern devices, techniques, etc. Such training of experts at secondary schools is insufficient for the training of chemical laboratory technicians who would be prepared for modern laboratories at the same time.

Conclusions of the analysis at universities

Based on information obtained from available sources as well as personal experience from visits to universities, we found out that the Chemical Laboratory Technician study program or its related fields has either been intensively implemented in the surrounding countries for several years (Germany, Finland) at universities or started to be implemented in the last years (Czech Republic). It is clear from the offer of subjects as well as the topics of the final theses that the programs are built with the needs of laboratory practice in mind at the same time and provide students with a huge space to ensure high-quality and competent skills for laboratory work and work with high-quality, top-quality infrastructure that is currently being used in industry. healthcare, pharmaceuticals and many other services require.

Conclusions of analysis and survey in companies

The analysis among experts from practice provided information that in operational or institutional laboratories there are employees close to retirement age and that job positions have recently been difficult to fill because Chemical Laboratory Technician graduates are lacking on the labour market. Based on this, employers fill these positions with graduates of the 2nd level and even the 3rd level of study, while such high expertise is not necessary for

the requests of normal laboratory practice. On the contrary, potential employers rather need graduates adequately prepared for operational work in a modern laboratory, which uses top laboratory technology in the 21st century. The meeting and survey also revealed that potential employers themselves are looking for ways to educate a new generation of experts for routine laboratory chemistry practice.

They organise various excursions and short-term trainings, and in some cases, they also directly participate in the preparation of final theses.

At State chemical institution in Michalovce, under professional supervision, approx. 40 bachelor or diploma theses were defended. Active cooperation is carried out with UPJŠ Faculty of Science Košice, Technical University Košice, University of Prešov, Slovak University of Agriculture Nitra, University of Economics Bratislava.

The Company Chemko, a.s. Slovakia provided dual education and professional practice for the Secondary Vocational School of Technology in Humenne. They also participated in the subject Chemical Management (UPJŠ in Košice - Faculty of Sciences, study program Inorganic Chemistry) in the form of external lectures on the real picture of the management of operations and companies, business-production strategy, and marketing of individual industries, and they also accomplished excursions.

The Company Kovohuty Krompachy, a.s. participated in the training of a student from TUKE in Košice, from the Faculty of Mining and Ecology, Management and Geotechnologies as part of a bachelor's thesis entitled "Proposal of statistical regulation of processes in metallurgical production".

The Criminalistics and Expertise Institute of the Police Force takes place excursions and short-term internships for UPJŠ students at their workplace.

Based on the above-mentioned analysis, survey and the involvement of experts from practice in teaching, we are compiling a new professionally focused study program Chemical Laboratory Specialist in Slovakia.

Proposal for a new study program:

<u>Mandatory subjects</u>

1st year
General chemistry
Chemical calculations I
Chemical nomenclature I
Basics of mathematics
Basics of physics
Basic methodologies in the chemical laboratory
Analytical chemistry
Chemical calculations II
Inorganic chemistry
Practical course in inorganic chemistry
Organic chemistry
Practical course in analytical chemistry

Chemical nomenclature II
Basics of chemical technology

2nd year
Practical course in organic chemistry
Biochemistry
Physical chemistry
Practical course in physical chemistry
Practical course in biochemistry
Analytical chemistry in practice
Quality management and good laboratory practice
Instrumental laboratory practice
Basic methodologies in the chemical laboratory II
Basics of chemical engineering

Compulsory elective subjects

Safety regulations in chemistry
STN standards of chemical industry products
Chemical technologies (contribution of all departments)
Basics of electroanalytical methods
Basics of separation methods
Basics of optical methods
Environmental chemistry
Basics of chemical production
Green analytical chemistry and measurement automation
Instrumental practicum (contribution of all departments)
Chemical industry
Basics of economics
Basics of law
Basics of management

Elective subjects

Industrial ecology
Biotechnologies
Basics of pharmaceutical chemistry
Nanotechnology
Battery and hydrogen technologies
Basics of mineralogy
Basics of bioanalytical chemistry

3rd year

Instrumental laboratory exercise in practice	block*
Professional stay	block**
Professional stay	block***

* Block exercises in the first half of the semester - (rotating around the contracted laboratories, a different external workplace every week)

**professional internship at contracted workplaces in the winter semester - (each external workplace would have one maximum of two students)
***professional internship at contracted workplaces in the summer semester - (each external workplace would have one maximum of two students)

State final exam (SFE)

Subject SFE	Chemistry
Final thesis	Defence

The content of most subjects is available in the information system of the university (8), but new practically focused subjects have information sheets in the stage of creation.

As an example, we present the syllabi for the block subject Professional internship, which will be implemented at external workplaces in companies or state institutions:

- Initial health and safety rules training and fire training
- Getting to know the organizational structure of the company and the system of organizational guidelines
- Operation of the production of nitric acid (fertilizers, steel, copper, etc.) depending on the place of implementation of the practice - conditions of production, management of the technological process, interoperation methods of production control to ensure its standardization, management of production documentation
- Quality control methods of input raw materials, materials and finished products
- The student's own work on the assigned task
- Analytical and statistical processing of results
- Elaboration of the protocol

Other subjects closely related to processes in real operating and attestation chemical laboratories are Chemical technologies, Chemical engineering, STN standards, Occupational safety, etc. and will be part of the new study program. Moreover, we are interested in approaching colleagues from other faculties in providing subjects related to operational management of laboratories (Basics of economics, Basics of law, Basics of management).

At the moment, intensive work is being done on the preparation of their content, and at the end of next year, we plan to apply for the rights to implement education within the new professionally focused Chemical laboratory technician - specialist.

Acknowledgements

This work was supported by Ministry of Education, Science, Research and Sport of the Slovak republic under the grant no. KEGA 006UPJŠ-4/2021.

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