FLUID POWER MICROCREDENTIALS - NEW POSSIBILITIES TO ACQUIRE NECESSARY KNOWLEDGE

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Recent events, such as the Covid pandemic, population ageing, the lack of labour, especially in the technical field, and major changes in the field of New Technologies, have also caused urgent changes in the field of Education. Thus, the need to acquire the skills that employers need as quickly as possible emerges as a priority. The solution to this dilemma is offered in the acquisition of so-called microcredits. This also applies to the field of Fluid Power Technology – Hydraulics and Pneumatics. The paper presents the starting points that led to the introduction of microcredits in the field of Fluid Power. One of these is certainly the different implementation of these contents through all levels of formal education, and the offer of additional education, as seen and offered by different stakeholders. The lack of knowledge and the variety of additional offers led to the proposal of accredited microcredits in this field.

Keywords:
fluid power,
education,
courses,
diversity,
microcredentials

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1 Intruduction

Knowledge in the field of Fluid Power Technology i.e. Hydraulics and Pneumatics, certainly belongs to special professional knowledge. Within the framework of the regular education system and programmes, these learning contents are certainly not in the "first plan" of learning programmes, even though at least three quarters of all machines and devices use this technique. Generally, the education system everywhere is divided into three basic stages or levels of education: primary, secondary and tertiary education. The same applies to the Slovenian school system, whereby the qualifications obtained through schooling are classified using the Slovenian Qualifications Framework – SQF. The SQF aims to obtain transparency and identification of qualifications at the national and EU levels, where the main objectives of the SQF are to support lifelong learning, connect and coordinate the Slovenian qualifications subsystems, and to improve the transparency, accessibility, and quality of qualifications in terms of the labour market and civil society. [1]

Content related to Hydraulics and Pneumatics is definitely not in the programmes and curricula of primary school education. These contents are starting to be given in the context of secondary education, which is provided by gymnasiums and secondary (vocational) schools. Very few (or almost none) of these contents are present in general programmes of secondary education (general high school). To a somewhat greater extent, they are present in vocational and secondary vocational and professional education. This is very rarely a subject that would devote itself fully to learning the principles and peculiarities of the operation of hydraulic and pneumatic systems and components (and would also have such a title, e.g. Hydraulics and Pneumatics, Pneumatics and Hydraulics, Fluid Power, etc.). Most often, the contents of Hydraulics and Pneumatics are related to other contents, most often from the fields of Automation, Mechatronic systems, Production systems, Robotics, and are given in the context of variously named subjects. These contents are most often found in the Mechatronic Technician or Mechanical Technician secondary professional education programme.

At the level of tertiary education, which is provided by both public and private institutions within the framework of post-secondary and higher education (Faculties and universities), there are more learning contents in the field of Fluid Power. These are more or less comprehensive, independent subjects, or the individual contents of Hydraulics and Pneumatics are included in the learning contents of another subject.

This also depends on the type of study programme and available teaching and professional staff. It is also important here whether the staff are also engaged in research in this field (research projects, implementation projects for industry), or whether it is only a pedagogical presentation of content. It is also important whether there are adequately equipped laboratories, where it is possible to supplement theoretical knowledge with practical exercises and experiments.

Considering all these aspects and influencing factors, these contents are included in the study process in different ways, more or less extensively and with different "passion" in the delivery of these contents. Thus, at colleges and universities, it is usually an optional subject that is devoted entirely to the contents of Hydraulics and Pneumatics, or as already mentioned, the contents are present in the context of other related subjects to e.g. Mechatronic systems or Automation (e.g. where an understanding is required of the principle of the operation of machines, actuators and their control, and the maintenance of these systems).

Thus, later, employees encounter the content of Fluid Power in more detail only in the context of tertiary education. However, this is not necessary, as, in most cases, it is an optional or general optional subject that the student can bypass, depending on the choice of study course. It is usually only one subject, rarely two or more subjects, where the content would be upgraded or supplemented, e.g. Fluid Power I, Fluid Power II, Hydraulic Control Systems, Mobile Hydraulics, Fluidtronics, etc.

Therefore, in the case when an employee needs certain knowledge in the field of Hydraulics and Pneumatics, it is only necessary to acquire this through additional education outside the official school system. This includes a wide variety of training and courses or self-study programmes, from simple understanding of the basics of operation to more specific, specialised knowledge, for example, the dynamics of hydraulic servo systems.

2 Forms, scope and offer of additional education

Additional education in the field of Fluid Power is offered by various companies or institutions. This involves more extensive or shorter training or schooling, with only theoretical, or also with practical knowledge of the subject. A review of the fairly extensive offer in this area reveals a great diversity of providers. These are educational institutions such as colleges, universities or institutes, especially where

there are already laboratories or research groups that deal with this topic in regular teaching and research work. Among the training providers, there are also those who deal only with supplementary education, usually of general content, and when conducting professional training, they are assisted by external providers.

Many training opportunities are also offered by various professional associations and organisations that focus more or less on one topic, e.g. Lubricating and hydraulic fluids and problems in the field of Tribology. Also, companies, manufacturers of hydraulic and pneumatic components and systems offer different trainings or courses. Various courses were (probably initially) aimed at educating customers and users of the company's products, as well as educating its own employees, but later they were also offered to other interested parties.

As an example of the diversity of forms of education, only from the narrower field of Hydraulic Fluids and Lubricants, the various options offered by education providers are given in Table 1.

Table 1: Different offers of education in the field of Lubricants, including hydraulic fluids

Provider:	A	B	C	D	E	F
Nr. of courses	6	4	4	10	2	3
Duration (day)	2 to 3	½ to 1	1 to 2		½ to 1	3
Online training	✓		✓	✓		
Short lessons	✓					
On site	✓		✓		✓	✓
Private online	✓					
Studio recording	✓					
Certificate	✓			✓		

Table 1 shows how different educational opportunities can be, both in terms of the duration of each educational unit and the possible ways of acquiring knowledge. The possibilities are very diverse: From the classic method of education at the provider of education (in his education centre), or at the client (e.g. with users in manufacturing companies), or in the online form of self-learning in the way "anytime and anywhere", as well as the possibility of individual education directly with a mentor in a "one-to-one" way. Thus, the interested party or client can choose the most suitable education form, either in a mixed group of participants, or in a closed group only for their employees, or completely individually, or live, or using the e-education approach.

The offer of additional education in the field of Components and Systems of Hydraulics or Pneumatics is even more diverse and wide. For example, some providers offer comprehensive education in the field of Hydraulics and Pneumatics, which also includes modern controls, carried out in a classic way (lectures, calculations, experiments, independent work...), lasting as long as 8 weeks. [4] With a workload of 8 hours/day and five days a week, this would amount to as much as 320 hours of fluid power education content, which, in the ECTS (European Credit System; 1 ECTS = 30 hours) student workload is a course with 10 ECTS. There is no such comprehensive course in the field of Hydraulics and Pneumatics at any Faculty, and we cannot afford such a scope.

Within field of Hydraulics there are special topics e.g. Design of Industrial Hydraulic Systems, Hydraulic Fluids and their Contamination Control, Hydraulic components, Hydraulic Filters, etc., lasting 15 days, 5 days, 2 days or one day. A similar offer of training is also available in the field of Pneumatics: Pneumatic controls - Basic Level (5 days), Electro-pneumatics and Automation - Basic Level (4 days), Design of Pneumatic Systems (4 days), Pneumatic controls - Advanced Level (3 days), Electro-pneumatics – Advanced Level (3 days), Advanced Pneumatics (4 days) and Advanced Electro-pneumatics (4 days). Apart from this, there are also two training courses related to the use of simulation software in the field of Hydraulics and Pneumatics (Fluidsim-P / Fluidsim-H (2 days), and training related to safe work with such devices – Maintenance and Safety of Hydraulic and Pneumatic Systems (2 days).[4]

A completely different way of approaching education and content related to Fluid Power is independent learning based on following shorter e-lessons thematically, from learning the basics of the operation of the entire system, through the operation of individual types of components of fluid technology, all the way to their maintenance. [5] The entire content is divided into 9 sections, with 30 lectures of 3 h 37 min total length. E-lessons are available via mobile and TV, with full lifetime access and a Certificate of Completion. In this way, the learner can look at the available e-material if necessary. Figure 1 provides an example of a part of the e-lessons` offer and their duration.

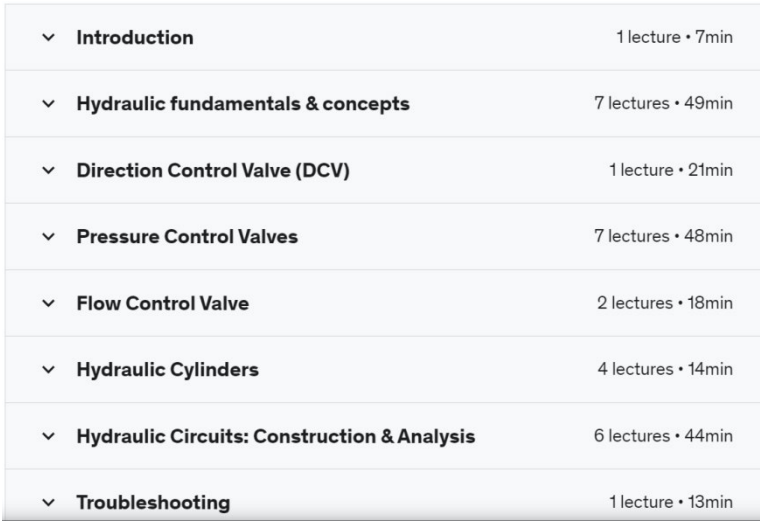

Figure 1: Part of the available e-lessons in the field of Hydraulic Basics [5].

The third example of the offer is training offered by companies, manufacturers of hydraulic and pneumatic equipment and systems. The scope of the offered courses and topics, as well as methods of implementation, varies from case to case (e. g. [6] to [10]). Perhaps the Bosch-Rexroth Academy stands out among these, with a very extensive range of educations at three levels, from basic to advanced, and, further, to specialist and targeted [11]. Only at the level of training in the field of Industrial Hydraulics is it possible to choose between thirteen basic training options, from the basics of the operation of hydraulic systems to understanding the operation of individual types of components. It is similar for training related to other thematic areas. As an example, Figure 2 shows the different levels and content of fault-finding training.

Usually these training sessions (at the mother company in Germany) are offered in the German language variant, and in the classic, live way also called "face-to-face". Certain training sessions are also offered in English, and also as e-learning. The training bundles relate to individual fields of expertise and purpose – from Industrial Hydraulics, Pneumatics, Mobile Hydraulics, For Designers, Safety Technology, Maintenance, etc., or are also multidisciplinary and thematically oriented, such as Energy Efficiency, Digital Transformation, Linear Motion, etc.

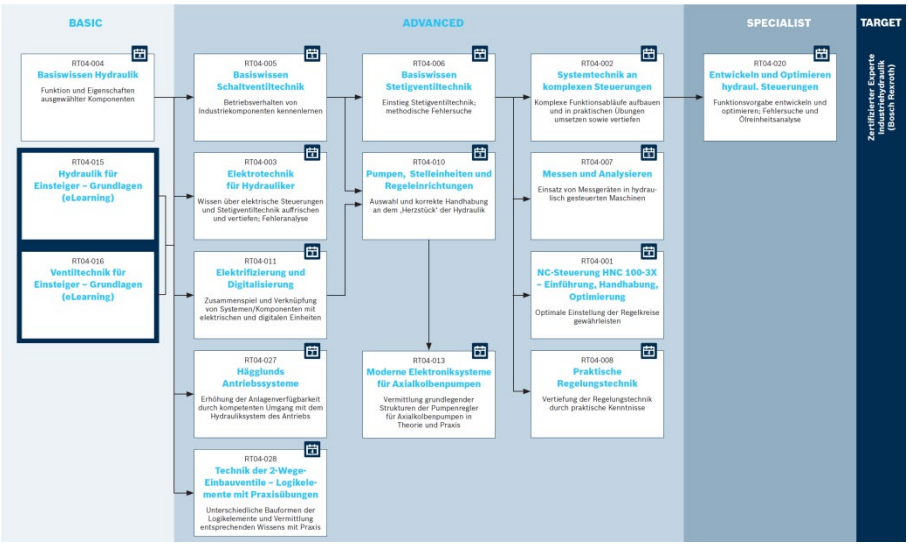

Figure 2: Example of Content Upgrade – Failure Analysis Practice [12]

The choice of training method is also different, from Face-to-face training (Theory combined with a high proportion of practical exercises, in close cooperation with experts), e-learning (at home, at an available time and place), online training (live with experts in a virtual classroom, or via training videos) and as hybrid learning.

The latter option is interesting, which is a combination of all the aforementioned methods – for example, online training for the theoretical part, followed by face-to-face practical training, as it represents an approach to short training courses in the future, and, somehow, according to the current view of the approach to additional education, represents a suitable combination between saving time and the effectiveness of learning about the problem, as well as the time distribution of educational content according to needs.

An overview of the offer of additional education in the field of Fluid Power shows how diverse the offer is, both in terms of the scope of the offer, duration and method of implementation of individual thematic education, as well as in terms of the possibility of upgrading and expanding knowledge, and also in terms of the choice of education method and the demonstration of adopted content through the issuance of Certificates. Certificates can only be of a "confirmation nature", but they can also be generally valid and recognised through professional Associations or

Chambers. Examples of such Certificates, sometimes also called badges, are shown in Figure 3.

Figure 3: Badges for proving certain acquired knowledge in the field of Fluid Power

These Certificates do not confirm that someone has only attended a certain education, but that he has also completed it successfully, with an exam, test or some other way of demonstrating knowledge.

3 Needs for a new educational approach – Mikrocredentials

The industry is facing many challenges today. One of these is the still present lack of manpower, especially in technical professions. Regarding the general staff, many companies still somehow help themselves by hiring foreigners, but the bigger problem is with staff mastering the knowledge and skills related to today's modern technologies (Industry I4.0). There is also a fair gap between the scope and type of necessary knowledge, which the current employees have acquired through their education in the past, and the knowledge and skills that are needed based on the current state of technology: Available vs. necessary.

The problem is even bigger when it comes to specific skills, which include knowledge in the field of Hydraulics and Pneumatics. As presented in Chapter 2, these skills are not necessarily an integral part of compulsory learning content, so employees may or may not have them after completing schooling. However, if they have already encountered these contents during schooling, this knowledge is of varying depth and scope. This is also one of the reasons why various institutions, associations, colleges and manufacturers offer additional training – Chapter 2. The very diverse range of different training courses in this field proves the general "market fact: if there is a need, there is also an offer".

The mentioned facts do not apply only to the field of Hydraulics and Pneumatics, but to various necessary skills that enable various additional qualifications, and, as quickly and efficiently as possible, to acquire knowledge from various fields.

Thus, more than ten years ago, in various countries around the world, e.g. in New Zealand and Japan, and in Canada, Indonesia, America and elsewhere, the idea emerged of the so-called Microcredentials. As an example, the offer of "educational certificates" via the NZQCF portal (New Zealand Qualifications and Credentials Framework) includes more than 340 short courses in various fields, with a duration of 5 to 40 credits (one credit is equivalent to ten national learning hours), which, with microcredits, enables the achievement of ten levels of qualification, from obtaining an individual Certificate (levels 1 to 4) all the way to a Doctorate (level 10). [13]

In response to the ever-changing demands of the labour market, the Mozilla Foundation first proposed microcredits in 2012 as an online verified claim of specific skills or experience valued by employers. Displayed via digital icons on social media platforms such as LinkedIn and Twitter, microcredentials now often contain online 'metadata', such as when, how and by whom learners are assessed – serving to reinforce Microcredential credibility and trustworthiness with employers. However, as the use of Microcredentials continues to grow and mature, the original understanding is now often expanded to encompass much broader applications. These web icons, now known by many nicknames, such as "nanodegrees", "digital badges" and "open badges", can reflect a common understanding or experience that may or may not be relevant in the workplace. As Microcredentials become more common and broadly defined, many labour market stakeholders are working to reach a working consensus on how micro-credentials should be understood and implemented widely in academia and the labour market. [14]

The term Microcredentials has come into force for the mentioned shorter, supplementary education opportunities, which are named differently. There are several definitions for Microcredentials, but they are all more or less similar: »*Microcredentials certify the learning outcomes of short-term learning experiences, for example, a short course or training. They offer a flexible, targeted way to help people develop the knowledge, skills and competences they need for their personal and professional development.*« [15]

The need for changes in educational programmes, adaptation to new needs and ways of imparting knowledge, reducing the gap between existing and necessary knowledge, and the need for retraining of employees, is recognised all over the world, and everyone solves it in their own way.

We also recognised them in Europe, and wrote them into our programmes, agendas and resolutions. Based on this realisation and the need for changes in the education system, the Council of the European Union (EU) adopted the Recommendation on learning for the green transition and sustainable development on 16 June 2022. The recommendation is a Key Policy Statement underlining the key role of education and training in efforts to achieve the goals of the European Green Deal. The accompanying Staff Working Document serves as a handbook for practitioners, providing relevant examples and best practices from across Europe. [16]

These guidelines are followed by all members of the EUR with their national programmes, including in Slovenia: Resolution on the National Programme of Higher Education in Slovenia until 2030, strategic goals in the fields of Social Development and the higher education system are given. [17] The act lists eleven goals that express the need to improve the international comparability and disciplinary plurality of the higher education system. Among them, the closer integration of higher education, research and technological development, the intensification of cooperation between public research institutes and higher education institutions, and the raising of the quality and efficiency of higher education in accordance with the Bologna process, etc. are mentioned, and also the goal that, by 2030, at least 50 % of Slovenian citizens between the ages of 30 and 34 will complete one of the levels of higher education, which is in accordance with EU Acts.

The share of residents in the mentioned age population who have completed tertiary studies successfully (e.g. at a university or a professional institute of higher education) in the last 20 years is 49 %, which is already very close to the target of 50 %. A more detailed analysis of the share by gender reveals that the share of men with such education is lower than 40 % – Figure 4.

It makes sense to improve this proportion, especially for educational programmes that are considered to be "more masculine professions or profiles", e.g. technical professions. Thus, on the one hand, it is necessary to establish an appropriately

updated method of teaching, which will be aimed at students for successful and timely completion of their studies, and, on the other hand, with various forms of additional education, it is necessary to enable those who did not complete regular schooling for various reasons to do so in a flexible way.

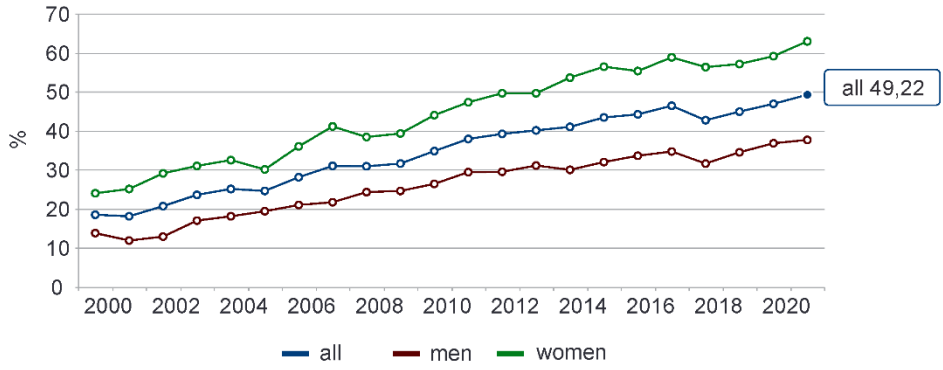

Figure 4: Population with tertiary education by gender in Slovenia [17]

A more detailed picture of tertiary education According to Eurostat data, in 2013 Slovenia exceeded the specific goal of the Europe 2020 Strategy, according to which 40 % of the generation aged 30 to 34 should have attained tertiary education. In Slovenia, this share was 46.9 % in 2020 ([18]). Data from SURS (Statistical Office, Republic of Slovenia) for 2020 show that the share of young people aged 30 to 34 who achieved tertiary education is 40.8%. In 2020/21, 58 % of 19-year-olds participated in tertiary education. The percentage of residents with tertiary education is increasing constantly. According to data from the Statistical Office, the share of Slovenian residents aged 25 to 64 with a tertiary education was 15.3 % in 2002, 23.7 % in 2010, and 30.1 % in 2021. [19]

In view of this situation, and in view of the fact that we are working longer and the knowledge acquired in regular education "years ago" is already outdated, it is necessary to intensify the approach to lifelong learning.

Therefore, the establishment of a functioning system of lifelong learning at the higher education level, including appropriate evaluation and recognition of learning outcomes, is extremely important. Only in this way will the largest possible part of the active population be able to acquire the latest scientific and professional

knowledge. This is especially true in the case of specific professional skills, which also includes knowledge in the field of Hydraulics and Pneumatics.

4 Fluid Power Microcredentials – possibilities and opportunities

Based on the presented starting points and today's needs of industries for modern knowledge, as well as the direction of development of the field of Education given in the previous chapters, the first proposals and pilot implementations have appeared, as well as the related dilemmas of how to deal with Microcredentials in general, and also in the field of Fluid Power. Given that imparting and receiving knowledge must be flexible, uniform, targeted, short term, learner-friendly and accredited, Fluid Power Microcredentials represent a big enough challenge for all stakeholders, especially how to offer the right approach and content format.

The approach to a new way of acquiring the necessary knowledge usually comes from the experience of a regular educational programme, as well as the experience gained through the implementation of various schools and training sessions. The latter were carried out as supplementary education for participants from the industry, which actually belongs to the field of Lifelong Education. In terms of content and structure, micro-evidence must enable both vertical upgrading and horizontal linking of content, and include a modern, usually hybrid method of implementation.

Thus, based on many years of experience in conducting a wide variety of educations/training for participants from the Slovenian industry, we could propose the following Fluid Power Microcredentials as a starting point:

- Basics of hydraulics HID-1,
- Hydraulic drive technology – HID-2 upgrade,
- Servohydraulics HID-3,
- Hydraulics for designers HID-Pro,
- Hydraulic fluids and their maintenance HTN-1,
- Hydraulic fluids and their maintenance HTN-2 upgrade,
- Maintenance of hydraulic systems,
- Pneumatic controls and systems.

Each of the proposed Microcredentials would last/be evaluated with 1 ECTS (30 hours), whereby knowledge can be upgraded vertically and supplemented horizontally. It is also possible to connect horizontally with other contents, for example, related to Tribology and lubricants in general, to Automation, or, e.g., to the design of very complex modern mechatronic systems, where the contents of fluid technology are of key importance.

The following will be required for the implementation of training in the form of Microcredentials:

- Prepare suitable material for each Microcredential, designed according to individual thematic sections, with the possibility of real-time knowledge verification.
- Prepare a workbook for each Microcredential.
- Prepare e-tests to determine prior knowledge and placement in the appropriate level of education, as well as to check acquired knowledge after each chapter and at the end of the completed education.
- Prepare e-materials for the implementation of practical work, by individual chapter, for the purposes of pre-familiarisation with individual practical exercises and experiments,
- Prepare shorter e-lessons related to individual topics for independent learning, and
- Prepare an online tool for monitoring individual progress.

The experience of the online implementation of the pedagogical process, which the recent pandemic forced us to do, will come in handy in this regard.

5 Conclusion

Digital transformation, automation and globalisation not only offer companies opportunities today, but they also present them with new challenges. With a view to the current available workforce and their skill sets, the shortage of skilled workers that can already be observed in many places will intensify. In order to cope with these challenges, the need to retrain staff and upgrade skills is emerging as a priority all over the world. The solution to this problem lies in a change in the approach to

imparting the necessary knowledge and in lifelong learning, which each education provider "sees in his own way". All this is offered by the Microcredentials system.

The solution is offered by the Microcredentials system, whereby imparting and receiving knowledge is flexible, uniform, oriented, short-term, learner-friendly, as well as stackable, wide base, specific oriented, and of course trustful and accredited. We are already facing these challenges in the field of Fluid Power technology i.e. Modern Hydraulics and Pneumatics.

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