Technology and Health Care 31 (2023) 1541–1549
DOI 10.3233/THC-229017
IOS Press

Competence development as critical issue for successful performance in HPC technology environment: A case study of Montenegro

Bojana Malisic[1,*] and Sandra Tinaj[1]
NCC Montenegro, University of Donja Gorica, Podgorica, Montenegro

Received 25 November 2022
Accepted 5 December 2022

Abstract.
BACKGROUND: Absorptive capacity is the ability to absorb new knowledge and adopt new technologies. This capacity of an economy is measured through a series of indicators, however, the most important among them are precisely those elements related to the competences required for the adoption of new technologies, as well as their structure.
OBJECTIVE: This paper provides an overview of the concepts and systems needed to develop the competencies needed to implement modern technology such as High-Performance Computing (HPC) in Montenegro.
METHOD: In this research paper competencies are viewed holistically. This paper will elaborate the defined competencies related to the HPC technology environment, identified during the implementation of the EuroCC project in Montenegro, but also based on market analyses, combined with the identified indicators of absorption capacity, generally at the national level.
RESULT: By identifying the innovative and business potential of representatives of the public, academic and economic sectors, with special reference to small and medium-sized companies and the IT cluster that make up the dominant segments in the structure of the market sample, as generators and accelerators of innovation, smart growth and the digital economy, we got a clear picture regarding the development of necessary competencies within the NCC team but also at the national level.
CONCLUSION: There must be a systemic approach and sustainable, dynamic projects and tools for the development of human resources in the development of competences.

Keywords: Competencies, absorption capacity, HPC new technology, knowledge environment

1. Introduction

In work and in practice through the EuroCC project [1] within the National Competence Center Montenegro, we start from a holistic approach to competences, which includes or integrates knowledge, skills, attitudes and values that influence the ability and competence for certain actions, in this case for the adoption and application of technology. Etymology points us to the origin of the term competence, citing the Latin word competentia, which translates as authority or adequacy. There are different attempts to define competences, in practice and in theory.

As part of NCC Montenegro, we used the basic principles according to which, under the term competence, we combine professional knowledge and skills on the one hand, while on the other hand, the

[1]Both authors contributed equally to the study.
*Corresponding author: Bojana Malisic, NCC Montenegro, University of Donja Gorica, Podgorica, Montenegro. E-mail: bojana.malisic@udg.edu.me.

integrating element of competence includes values, attitudes, behavior and personal characteristics. For example, knowledge and skills mean having a certain level of experience and professional qualifications, whereas innovation, motivation, character, self-confidence, enterprising attitude towards life and work, openness to new experiences and knowledge are associated with personal characteristics. In the case of knowledge and skills, metrics and standardization can be applied, in the case of this second integrating element of competencies, and it is very difficult to standardize them and set metrics. The approach to competences in the work of the NCC is based on the education platform at the University of Donja Gorica, which is expressed by the equation S = z*I2 within which the national competence center was founded [2].

In the very development of competencies required for the adoption of High-Performance Computing (HPC)[2] technologies, the starting point was the definition: "Competencies refer to" ... a set of observable performance dimensions, including individual knowledge, skills, attitudes, and behaviors, as well as collective team, process, and organizational capabilities, that are linked to high performance, and provide the organization with sustainable competitive advantage" [3]. Another definition that helped in defining and clearly distinguishing two integrating structures of competences, one group which refer to the content of technical knowledge and skills and the latter, which is more social, mental and cultural in nature. Spencer and Spencer definition from 1993: Competencies are motives, traits, self-concepts, attitudes or values, content knowledge, or cognitive or behavioral skills – any individual characteristic that can be measured or counted reliably and that can be shown to differentiate significantly between superior and average performers, or between effective and ineffective performers [4].

In addition to the starting points related to competences, the first part of the work will identify the points that led to the definition of certain core competences, on the development of which the activities of NCC Montenegro should be focused.

2. Method: Competence-based absorptive innovation capacity

Absorptive capacity is the ability to take on new knowledge and adapt established technologies, which should essentially be a key ability for all development-oriented economies. In the paper, the authors identified available indicators that may be of importance to us in assessing the ability of the MNE economy to adopt HPC technologies. Certain available indicators were selected, but also answers within the research, which carry the most information about the absorptive power of an economy.[3] Here are some analyses of absorptive power primarily based on the available indicators, not those indicators that we might want to analyze. When conceiving the areas in which we will pilot the application of HPC technologies, we followed the priority areas defined by the national S3 Strategy of Smart Specialization. In addition to the above mentioned, we also used Scimago data, which also indicate that, compared to other countries, Montenegro is specialized in agricultural and biological sciences, arts and humanities, computer sciences, economics, econometrics and finance, energy, engineering, mathematics and social sciences [5]. In addition to the above mentioned, the figures based on the same cited source show that in

[2]The developed principle and core competencies can be used in the adoption and application of other new technologies such as HPC.

[3]In the paper, due to the limited available statistics, only indicators that are regularly collected and published as part of the annual monitoring of innovation activities in the countries of the European Union, as part of the so-called "European Innovation Scoreboard", as well as other regular annual statistical reviews of Eurostat, the World Bank and UN agencies, have already used this aspect of explaining the innovation absorption capacity.

the ten-year period, about 1,000 documents of high specialization were produced in the field of IT, 199 in the field of mathematics, while the field of mathematics includes a strong specialization with as many as 245 documents. We singled out these two areas as strong support and absorption capacity for HPC technologies.

In contrast to this indicator, perhaps one of the most important in the analysis, Costs for NI and IR work of the business sector (% GDP), does not send an encouraging message. According to the latest official data, total domestic investments in research and development amounted to 0.32% of GDP. Compared to the EU28, the business-entrepreneurial sector in Montenegro accounts for a relatively small share of the total spending on research and development, i.e. only 0.05% of GDP, while the average for the EU28 was 1.32% in the same year. The business-entrepreneurial sector employs about 7.75% of all persons engaged in research and development in Montenegro [6] and if we start from the assumption that this percentage is slightly higher, this data is still significantly below the average of developed economies based on knowledge. This data from the aspect of further HPC NCC Montenegro represents a challenge, which we tried to solve in the implementation of the project through continuous communication, the organization of training and joint projects, the creation of programs of lifelong learning, but also academic master's and postgraduate studies with the business community, which will also be shown in the part that refers to the system of competence development through education and training. Speaking of education and trainings, especially from the aspect of readiness for the mentioned, when adopting new technologies such as HPC technology, one of the very interesting analyses related to the indicator, which was not available for Montenegro, so its value was determined by the estimation procedure, indicator Participation in lifelong education (as % of active population). In Montenegro, there is no official data related to the indicator, while the indicator obtained by estimation dictates that the country is in a very low position among the analyzed European countries, which can also be identified as a challenge because the introduction of new technologies requires the presence of the process and program of lifelong education [7]. Observed in terms of participation in lifelong education as a % of the active population, Montenegro is in 29th place out of all 35 analyzed countries.

The global index of innovation includes a composite index, which integrates various elements, and its analysis was very significant from the aspect of assessing the national absorptive power and the importance of the country's innovation potential. On the list of the Global Innovation Index (GII) for 2022, Montenegro took the 60th position, among 132 countries included in the research, and has preformas in line with the level of economic development. According to the GII for 2018, Montenegro was among the 20 countries that have better results in innovation compared to the level of development, however, Montenegro ranked 52nd on the list of the Global Innovation Index (GII) 21 at that time [8].

During the assessment of the absorptive power of the national economy, we came to conclusions regarding the areas defined by the Smart Specialization Strategy, which show the most potential, but also the challenges related to the very low percentage of the economy's participation in research and development, the global innovation index, which records a decline, even when analyzing its composite structure of pillars, but also with a very low estimated presence of lifelong learning, which is an initial condition for the application of modern technologies such as HPC.

3. Results: Readiness and capacity to adopt HPC technologies – market analysis

The market research[4] that was carried was conducted by NCC Montenegro, based on the questionnaire

and methodology developed by the Slovenian partner [9] within the EuroCC project, as a kind of tool, the purpose of which is qualitative and quantitative analysis of HPC knowledge, competences and capacities of companies in Montenegro. This tool, whose purpose was primarily for HPC technological and promotional purposes, the team gathered around NCC Montenegro, integrating certain results, created a potential for research purposes. When we say research purpose, we primarily mean the collection of input for the creation of training and education programs in the field of strengthening the absorptive capacity for HPC technologies. By identifying the innovative and business potential of representatives of the public, academic and economic sectors, with special reference to small and medium-sized companies and the IT cluster that make up the dominant segments in the structure of the market sample, as generators and accelerators of innovation, smart growth and the digital economy, we got a clear picture regarding the development of necessary competencies within the NCC team but also at the national level. In addition to the goal of this tool - to raise awareness of advanced technologies of information and intelligent society, to identify HPC needs, expectations and challenges, i.e. to see the potential for incorporating HPC into the strategic priorities, production cycles and business processes of Montenegrin companies, we also used the tool as input for further development of competences and creation of programs for those purposes. The research included three segments of the survey consisting of 32 closed questions, which are structured in parallel for the current and future period, grouped in the following areas: Readiness, Cloud technologies, and HPC technologies. For the needs of other works, a complete market analysis will be used, while in this work only the results of the market analysis will be used, which are related to the readiness in the context of existing but also desired competencies. Readiness, as an area of this work, includes 18 questions that describe general HPC knowledge, competencies, applicability in the economic sector, marketing, financial and business implications, investments in research and development, hardware and software capacities for the adoption of HPC and Could technologies.

Based on the answers from the first 18 questions, we tried to identify whether there is readiness as well as absorptive capacity and necessary competences in the analyzed Montenegrin companies, through approximate and inductive insight into a better understanding of the knowledge and readiness of Montenegrin companies to use HPC and Cloud technologies in the current and the future period (up to 5 years). For the needs of the work, we have selected some of the responses that contributed to the creation of the education and training system that should improve the situation.

What was encouraging at the very start of the response analysis was the attitude towards computer simulations that represent core activities when it comes to HPC technology, which is an exceptional starting platform for further successful performance of HPC technology. Currently, 8 out of 10 companies in Montenegro have a positive attitude towards the possibilities of applying computer simulations (Fig. 1), with 1/5 companies (21%) are already seeing great potential, and as many as 54% of companies believe in their great potential in the future. As many as 41% of companies believe that in the next 5 years, simulations will play a crucial role in the development of new products, that is, that the competitive development of new products will practically not be possible without access to advanced methods and models of computer simulations. Over 60% of companies believe that in the future there will be even more enhanced competitive pressure for the application of computer simulations, which is becoming a key

[4]The research was conducted in Montenegro, July – December 2021, based on the online survey procedure, with the availability of personal support when filling out the online questionnaire, 53 Montenegrin companies actively participated. When it comes to the application of this tool, it is a pilot project and research, because it was carried out for the first time in Montenegro in a wider economic and industrial framework, including a focus on the IT sector as generators of digitization, innovation and smart growth, with direct involvement and the interest of the representatives of the scientific and research community as another bearer of all the above, but also the disdain of the representatives of economic activities.

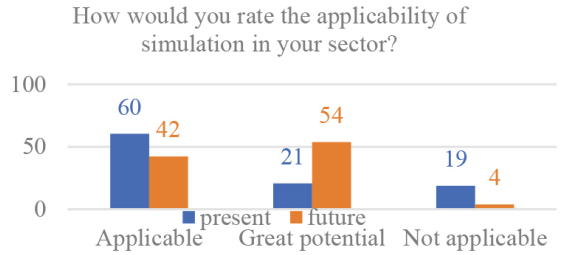

Fig. 1. Applicability of computer simulations in the sector (%).

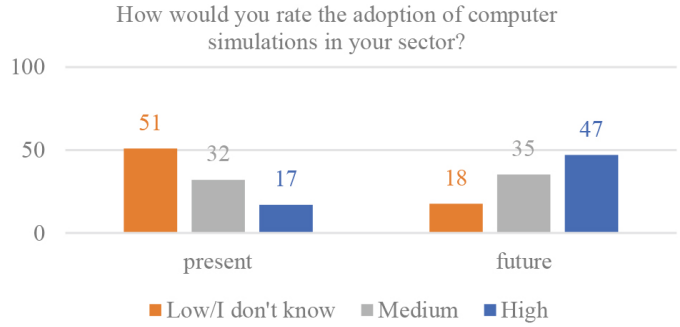

Fig. 2. The degree of adoption of computer simulations in the sector (%).

factor in encouraging investment in new technologies, research and development. Also, most companies believe that the use of HPC solutions and simulations brings a positive marketing effect (57%), and a positive business effect (43%) and that investments in advanced technologies (Cloud and HPC) are at the level of covering the costs of investing in them (49%).

The second set of questions, which was related to the current state, application and innovation, confirms the views expressed in the absorptive capacity section and corresponds to that state, activities are at a very modest level. When it comes to the rate of adoption of simulations (Fig. 2), currently more than half of the surveyed companies (51%) believe that it is low (or they do not know, they are absolutely not familiar with the situation), but also almost half of the companies (47%) expect that be high within 5 years. About 1/3 of companies believe in the moderate adoption of computer simulations both now and in the future

In addition to the need to improve competencies and the overall absorption capacity when it comes to the HPC environment, the answers related to the available and required knowledge and skills speak volumes. Assessments of the current level of knowledge correspond to the results presented in the framework of the global index of innovation. When it comes to HPC systems, parallel programming and computer simulation methods, $>$ 50% of Montenegrin companies consider that they have basic knowledge (or rely on external experts), 1/3 do not have any knowledge, and only 1 out of 10 companies can boast of advanced knowledge of HPC systems and simulations. In the future, $>$ 50% of surveyed companies believe that it will be necessary to provide advanced knowledge and competences, that is, competent experts in the field of HPC technologies and parallel programming for performing complex computer simulations. Figure 3 speaks in support of the above. This result of the survey, together with the analysis of national integral data, created key indications of the necessary investment in educational and professional programs in the field of advanced technologies, in order to provide the necessary, competent and competitive human resources. The biggest challenge in the future is the knowledge of parallel programming (still $^1/_4$ of the companies believe that they will not have competent staff available).

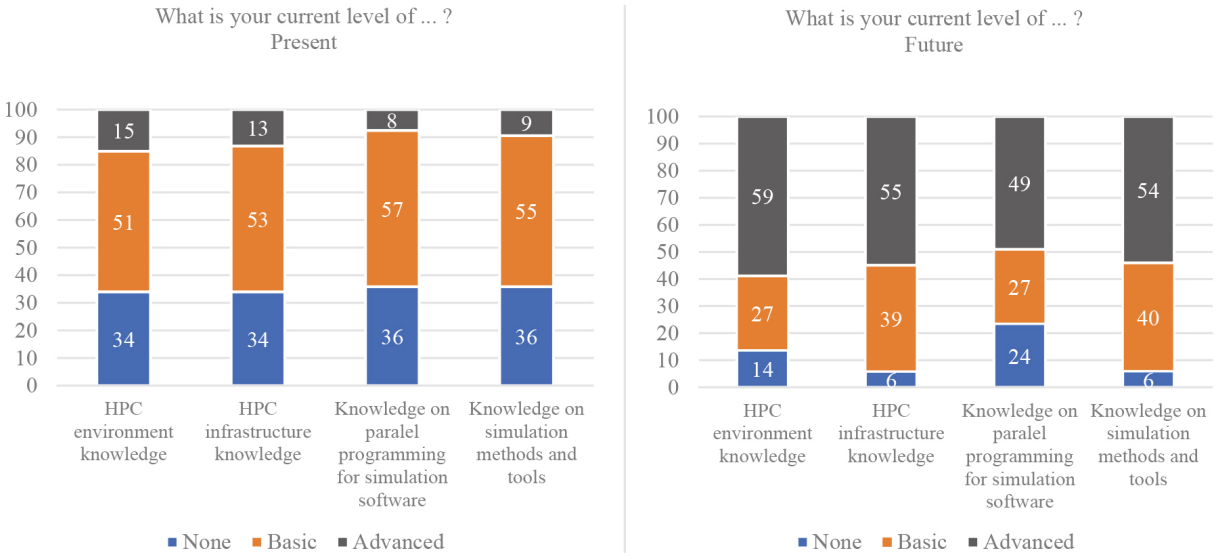

Fig. 3. a) Current level of knowledge about HPC (%); b) Future level of knowledge about HPC and simulations and simulations (%).

4. Discussion: Development of competences through supporting systems of education and training

After identifying the need to improve the HPC environment through two processes, especially in the part of the necessary conditions for the application of HPC technologies, we identified certain core competencies, primarily at level I within the NCC team, and then also in national frameworks. We mapped core competencies in such a way that they must be shared and nurtured through the entire system of education and training shown in Fig. 4. What we emphasized during the definition of competencies is that competencies are defined in this way, a dynamic category, that with the change in the development phase, the dynamics of the EUROCC project, the circumstances, must also change. Those set up in this way represent a platform for further development. In this unpredictable context, there is a continuous need to conduct competency assessment to identify or determine the new competencies. In other words, "the process of competence development is a never-ending story" [10].

As stated at the beginning of the paper, we have conceived two types of competencies that will support the creation of an HPC technology environment, using the classic study design using criterion sample method [11]. The first type refers more, although not completely, to competencies that are of a social and valuable character, while the competencies of the second type are professional and specialist.

Type I competencies that support the implementation of HPC technology:

1. Entrepreneurial competences (when spreading and implementing modern technologies, we need to have people exclusively entrepreneurially oriented towards life and work);
2. The ability to work in multicultural, multifunctional and multidisciplinary teams (realization of projects such as EUROCC and the creation and development of the NCC center requires extremely team-oriented people. Also, the application of HPC technology requires an exceptional orientation towards teamwork in which participants of different profiles gather on all grounds);
3. The ability to continuously learn and train (with most modern technologies, especially sophisticated ones such as HPC, there must be a readiness for continuous education);

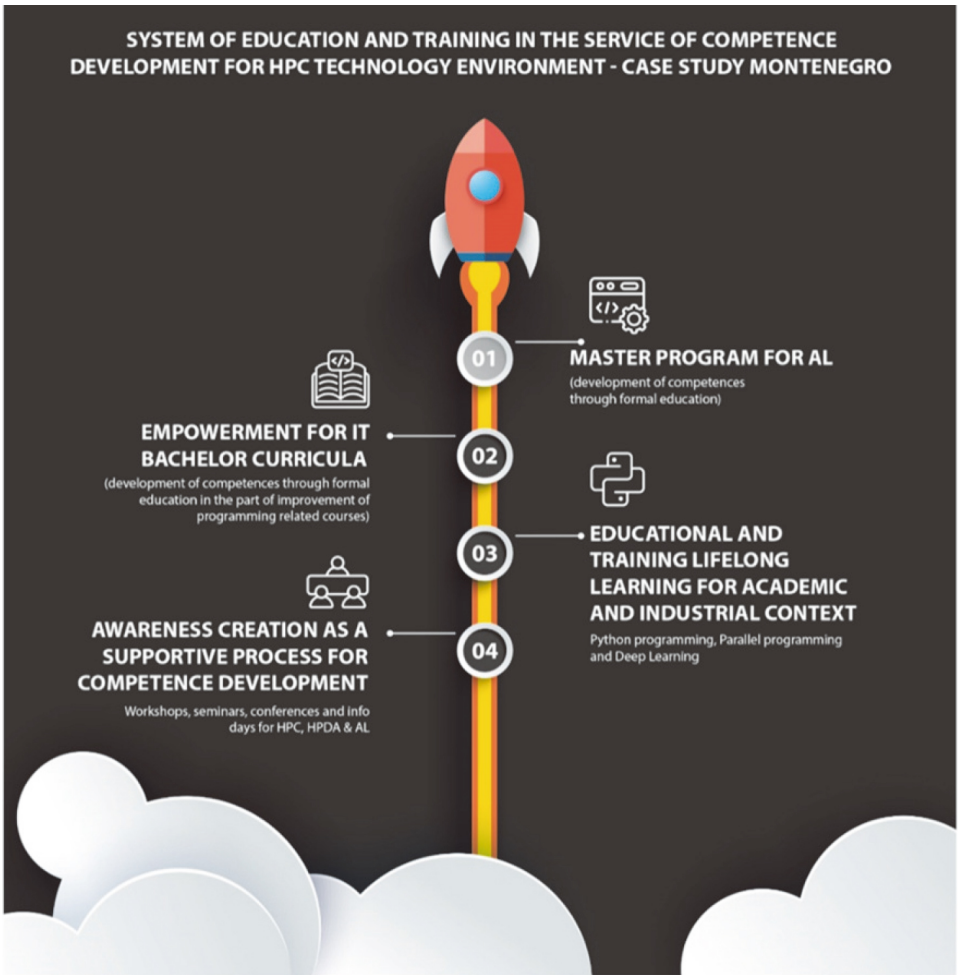

Fig. 4. System of education and training in the service of competence development for HPC technology environment – cast study Montenegro (created by the authors [13]).

4. Innovativeness and creativity (innovativeness and creativity, according to most studies, represent the most important competencies of the digital age, any wider application of HPC technology without a high level of innovative and creatively oriented people is absolutely not possible. The development of these competencies is perhaps the most demanding process);
5. Problem solving competencies (We have stated in the plural because it includes segments of knowledge and skills, analytical, practical, and creative part).

Type II competencies that support the implementation of HPC technology:

1. Advanced digital skills (These skills are a prerequisite for the application of technology, but also for the presentation of its functionality and use value, here we particularly mean advanced programming, python programming, parallel programming, artificial intelligence, deep learning, data science, machine learning, etc.);
2. Project management competences (this type of competences constitutes a whole set of knowledge, some of them are repeated in relation to the listed competences of the first type, executive knowledge, decision making, strategic development, team management, etc.);

3. Dissemination and implementation competencies (In the implementation of the entire set of HPC technology application, training and education, the process of dissemination and therefore the competence of the people who are the bearers of that process is very important).

With the knowledge, which we have already pointed out, that competencies are a dynamic category, we are fully aware that competencies must be further expanded, as well as modeled with specific subcategories for each of the seven categories that we have listed. In accordance with the necessary categories, we have developed an education system that supports their development. When it comes to type I competencies, although they may not all be directly visible in the programs, the curricula of each of the programs are incorporated. For example, one of the training programs, called Open Mind Academy [12], which was intended for university students and high school students, in its program, because through the team projects that the participants worked on, directly targeted the development of innovation and creativity, problem solving orientation, openness to modern technologies, gathering and working in multidisciplinary teams, in addition to the curriculum, which included the development of professional competences, e.g. python programming. In order to develop these competencies, a system of education and training was developed, which includes formal and informal aspects and is shown in Fig. 4, prepared by the author. What we remain consistent with throughout the further process of realizing the EUROCC project is that the development of competences represents a continuous and extremely dedicated process, which we have systematized in the picture through formal and informal forms of education.

5. Conclusions and recommendations

This paper provides an overview of the concepts and systems needed to develop the competencies needed to implement modern technology such as HPC. The work sublimated the insights that the authors had from the academic and research side, but also the practical ones gained during the implementation of the EuroCC project in Montenegro, hoping that adequate input was provided for other researchers and participants, who deal with this extremely relevant issue for successful implementation project. Although it is a sophisticated technology, which speeds up and automates processes, the quality of human capital "gathered" around it will be decisive for further expansion and development. In connection with everything mentioned in the previous work, it is concluded that there must be a systemic approach and sustainable, dynamic projects and tools for the development of human resources in the development of competences. By using the developed and set competencies as guidelines or standards, organizations can more effectively set and organize education, training and development in order to improve the capabilities of individuals at the organizational and national level.

Funding

This research was carried out within the EuroCC project – National Competence Centres in the framework of EuroHPC realized under the Horizon 2020 (H2020) through EuroHPC Joint Undertaking (JU).

Conflict of interest

The authors declare that they have no conflict of interest.

Availability of data and materials

Not applicable.

Ethics statement

Due to the nature of the study, formal consent and ethical approval were not required.

References

[1] EUROCC – National Competence Centres in the framework of EuroHPC: https://www.eurocc-access.eu/.
[2] Vukotic V, Drakic-Grgur M. Competence Oriented Education System, Proceedings from the 2013 International Conference on Advances in Social Science, Humanities, and Management, Atlantis Press (part of Springer Nature), 2013, pp. 153–158. ISSN 1951-6851, ISBN 978-90-78677-93-2, doi: 10.2991/asshm-13.2013.28.
[3] Athey T, Orth M. Emerging Comptency Methods for the future. Human Resource Management. 1999; 38(3): 216.
[4] Spencer LM, Spencer SM. Competence at work: Models for superior performance. New York: John Wiley & Sons, Inc 1993; 4.
[5] Government of Montenegro, S3 Smart Specialization Strategy Montenegro 2019–2024, p 30–31 table 2: https://wapi.gov.me/download-preview/ea1d661e-922a-4d42-af8d-ae55bc53988e?version=1.0.
[6] Government of Montenegro, S3 Smart Specialization Strategy Montenegro 2019–2024, p 30–31 table 2: https://wapi.gov.me/download-preview/ea1d661e-922a-4d42-af8d-ae55bc53988e?version=1.0.
[7] Kutlaca Dj, Tinaj S. National Innovation Capacity of Montenegro, Faculty for International Economics, Finance and Business, University of Donja Gorica, 2016; 79. ISBN: 978-9940-597-01-6.
[8] World Intellectual Property Organization (WIPO). 2022. Global Innovation Index 2022: What is the future of innovation-driven growth? Geneva: WIPO. doi: 10.34667/tind.46596.
[9] Partner within NCC Slovenia is Arctur company Arctur – high performance computing, cloud computing, mobile and web design, 4PM: https://arctur.si/.
[10] Wong S-C. Competency Definitions, Development and Assessment: A Brief Review. International Journal of Academic Research in Progressive Education and Development. 9(3): 95–114. According to quote De Vos A, De Hauw S, Willemse I. 2011. Competency development in organizations: Building an integrative model through a qualitative study. Vlerick Leuven Gent Management School. 2020: 10.
[11] Spencer LM, Spencer SM. Competence at work: Models for superior performance. New York: John Wiley & Sons, Inc 1993; 4.
[12] Open Mind Academy – EuroCC Montenegro – https://www.udg.edu.me/en/open-mind-academy/.
[13] EuroCC Montenegro – National Competence Centre for High-Performance Computing: https://eurocc.udg.edu.me/.