Development of Computational Thinking

Long program description

Introduction

Computational thinking and possibilities for its development in students is currently a frequently discussed phenomenon. In the Czech Republic, a project called *"Support for* **the Development of *Computational Thinking***" was underway until 2020. Palacký University Olomouc was also part of this project as a participating unit. As part of the project, a new ICT curriculum reform was being prepared in the Czech Republic, and new textbooks, methodologies, and interactive materials were being developed for the new concept of computer science education. Currently, the emphasis is on the development of computational thinking, among other things, for example in the revised FEP for basic education in the Czech Republic.

Although approaches to ***computational thinking*** itself still often largely differ from each other at present, the search for appropriate literature and legislative documents shows that most of the proposed sub-components coincide precisely in the fields of ***algorithmization, abstraction, debugging or evaluation, decomposition, and generalization***. Possible alternatives to these areas at the curricular level are based on specific national concepts of ***computational thinking***.

The network is focused on **the development of *computational thinking***. Each of the partner institutions allows support for the development of specific components of computational thinking through a wide range of study programs and technical backgrounds and thus contributes to the comprehensive development not only for students but also for teachers. Among the offered study areas are, for example, algorithmization and programming, automation and robotics, virtual and augmented reality, artificial intelligence, etc. Within the network, it is possible to exchange not only students at all levels of higher education but also teachers.

A key aspect is **the cooperation of individual institutions** to **exchange examples of good practice**, **experience**, **views on the issues addressed**, etc. **to achieve the most effective combinations of approaches to the development of *computational***

thinking. **The network is also fully prepared for virtual and hybrid mobility thanks to its e-learning platform.**

Planned activities

Planned mobility actions:

- Starting coordination meeting in Palacký University Olomouc, the Czech Republic within the International Week in Autumn 2024;
- participation of teachers and students from the CEEPUS network at the International Week in the Palacký University Olomouc, the Czech Republic in Autumn 2024;
- focus on the further development of our web portal "ceepusktiv.upol.cz" and e-learning system "moodle.e-zdroje.cz";
- students (undergraduate, graduate, Ph.D.) and teachers exchange;
- participation of incoming teachers and students in lessons and lectures at host universities;
- common curricula development in informatics with a focus on the development of computational thinking, dissemination of the results;
- intensive courses on selected topics (programming, robotics, virtual and augmented reality, e-learning, virtualization, 3D print, internet of things, software engineering, etc.);
- joint bachelor/master program development;
- joint research projects and paper publishing.
- development of the reciprocal exchange of knowledge, information, and cooperation on the research activities in the field of the development of computational thinking;
- participation of teachers and students from the CEEPUS network at international conferences (possibility of publishing the papers in journals and proceedings of conferences): The International Conference MIS – Modernity of Industry and Services (Autumn 2024); 11th International Conference on Customization and Personalization (MCP-CE 2024), 18–20.09.2024; International Scientific Conference MMA 2024 –

Flexible Technologies (September 2024); The Trends in Education (Spring 2025);

- **organizing courses and consultations** for incoming students with an academic staff of host universities;
- **assistance on active work in laboratories and consultations** to support **the elaborating and finishing** of bachelor, master, or doctoral **thesis** at partner universities;
- organizing **summer schools**;
- **organizing visits to the laboratories and companies** (the field of computer science) in the region of partners to improve the practice of students;
- **internships of students coming to Olomouc** at the silent partners - DRAGON solutions s.r.o. and Asociace středních a malých investorů, z.s.
- **organizing cultural and historical excursions** in the region of partners.

The special role of the partners

Palacký University Olomouc, Faculty of Education, Department of Technical Education and Information Technologies:

- **project coordinator**;
- **covered areas:** *visual programming, programming of control systems and robots, virtualization, 3D print, distance education methodology, and application of e-learning in informatics*;
- is **the only university in the Czech Republic, that provides a Ph.D. study program *"Didactics of Informatics and Digital Technologies"***;
- In 2019, **a fully equipped robotics laboratory** was opened (Robotics Center Olomouc).

Cardinal Stefan Wyszynski University, Institute of Computer Science:

- **covered areas:** *algorithms and methods of artificial intelligence, information technologies for medicine, computer graphics systems, mobile and wireless systems as well as distributed systems, cryptography, and network security*.

AGH University of Science and Technology, Faculty of Mechanical Engineering and Robotics, Department of Power Systems and Environmental Protections Facilities:

- **covered areas:** *computer methods in mechanical engineering, intelligent systems, automatic control and robotics, automatics, and robotics*.

Matej Bel University Banská Bystrica, Faculty of Natural Sciences:

- **covered areas:** *computer vision, machine learning, and robotics, high-performance computing, network technologies and the Internet of Things, virtual and augmented reality, AML systems in intelligent buildings, theoretical computer science, computer science teaching, and future teacher training informatics*;
- several laboratories are available: **IoT laboratory, mobile technologies, robots, and didactic aids and user experiences (UX) laboratory**, **High Performance Computing Center** can be used for scientific as well as educational purposes.

Technical University in Košice, Department of Computers and Informatics:

- **covered areas:** *functional programming, compilers, parallel programming, object-oriented programming, virtual reality, computer graphics, and systems supporting software engineering*.
- operates **a fully equipped virtual reality laboratory** and **OpenLab laboratory**, which is focused on **the development and research of modern digital technologies** such as **the Internet of Things (IoT)** or **Artificial Intelligence (AI)**, OpenLab is designed primarily for students to develop their practical skills and implement their projects.

University of Novi Sad, Department of Mathematics and Informatics:

- **covered areas:** *introduction to programming, Programming languages, Data structures and algorithms, Object-oriented programming, Operating systems, Compiler Construction, Software engineering, Requirements engineering, Software testing, Design patterns, Machine learning, Parallel*

programming, High-performance computing, Big data analysis, Computer Graphics;

- has also several labs, which can be used in solving some problematic areas in the development of computational thinking – for example, **SQLab – Software Quality Laboratory, RIS – Information Systems Development Laboratory**;
- a new master's study field focused on artificial intelligence was created (https://www.pmf.uns.ac.rs/en/studies/study-programs/msc-artificial-intelligence-2022/).

University of Ljubljana, Faculty of Computer and Information Science:

- **covered areas:** *computer science and systems, algorithms, programming languages, system software, parallel programming, pattern recognition, data science, artificial intelligence, and information technology*.

J. Selye University, Faculty of Economics and Informatics, Department of Informatics:

- **covered areas:** *robotics; design, implementation, and transformation of digital IT systems*;
- is equipped with **the Intelligent Robotics Centre with its supercomputer**.

Canadian Institute of Technology:

- **covered areas:** *software engineering, computer engineering, telecommunication, business administration, business and administration, and IT, finance, and accounting*.

Budapest University of Technology and Economics, Faculty of Electrical Engineering and Informatics, Department of Network Systems and Services:

- **covered areas:** *networking and networked systems: analysis and design of wired and wireless networks, new network architectures and protocols, mobile communication systems and services, multimedia networking*

and media distribution systems and services, cryptography, and network security; quantum computing and communications, acoustics and studio technologies, signal processing, financial information systems.

- a new course entitled "Network and Traffic Management" – the course provides not only theoretical knowledge and practical skills in network and traffic management, but also insights into the latest research and developments; students will learn how to manage complex networks and the services that run on them, and how AI can be used to create the highest quality and most reliable networks; they will become familiar with the different types of network traffic and the challenges that they face, and will then master the AI-based solutions that can be applied to them.

University of Debrecen, Faculty of Informatics:

- **covered areas:** *3D printing and modeling, data visualization, geo-visualization and geographic information systems.*
- regular course (every semester) on 3D printing and modelling.

University of Belgrade, Faculty of Organizational Sciences:

- **covered areas:** *management and information systems and technologies.*

Josip Juraj Strossmayer University of Osijek, Faculty of Education:

- **covered areas:** *modern teaching strategies, methods, procedures, and techniques based on an interdisciplinary approach to education; programming in primary education.*

University of Rijeka, Faculty of Informatics and Digital Technologies:

- **covered areas:** *implementation of the latest information technologies and up-to-date knowledge into the business sector and the local community, to ensure the transition of the region into a knowledge-based society.*

University of Tokaj:

- **covered areas:** *computer architectures, data structures and algorithms, object-oriented programming, and operating systems*.

University of Novi Sad, Faculty of Technical Sciences, Department of Industrial Engineering and Management:

- **covered areas:** *mechatronics (automation of work processes, intelligent systems, system modeling and simulation modern biosystems, mechatronics of drive systems, electro pneumatics in mechanization); industrial engineering and management (development, implementation, and management of technical solutions, operations management, supply chain management, innovation management, project management); data management (storing, organizing and maintaining the data created and collected by an organization, providing analytical information to help drive operational decision-making and strategic planning)*.

Silesian University of Technology, Faculty of Organization and Management, Department of Economics and Computer Science:

- **covered areas:** *business analytics, smart cities, and modern energy, industrial economics and finance, business simulations, econometrics and statistics in business, machine learning in the energy sector, sustainable development, quality management, and investments.*

University of Kragujevac, Faculty of Engineering:

- **covered areas:** *informatics in engineering, industrial engineering, applied mechanics and automatic control, production engineering, etc.*

Slovak University of Technology in Bratislava, Faculty of Materials Science and Technology in Trnava, Department of Production Devices and Systems:

- **covered areas:** *2D/3D simulation of manufacturing and logistic instances, creation of digital twins or emulation models, virtual commissioning of manufacturing and logistic instances or parts of these, e.g.: control codes;*

robotization and automation of production systems, logistics and logistic technologies; industry and logistics 4.0, statistical validation of industrial experiments.

DRAGON solutions s.r.o.:

- **silent partner**;
- **covered areas:** *web development, programming, e-learning systems, etc.*

Asociace středních a malých investorů, z.s.:

- **silent partner**;
- **covered areas:** *financial literacy, connection to business and production, interdisciplinary networking, etc.*

Selection criteria for mobility

Student mobility:

- proficiency in the language of instruction at the host institution or students **have to understand and speak English fluently (minimal is B2 level)** to follow the courses and pass the exams;
- quality of study/research plan of the visit;
- the students **have to write a cover letter** to attend courses at the university of this network, which has to be reviewed and accepted or rejected by the local CEEPUS coordinator at the institution;
- **priority is given to full semester stays and Ph.D. students**;
- **if the number of students is too large, a cover letter will be decided**.

Short-term student mobility:

- proficiency in the language of instruction at the host institution or students **have to understand and speak English fluently (minimal is B2 level)** to follow the courses and pass the exams;
- quality of study/research plan of the visit;

- the students **have to write a cover letter** to attend courses at the university of this network, which has to be reviewed and accepted or rejected by the local CEEPUS coordinator at the institution;
- **priority is given to Ph.D. students**;
- **if the number of students is too large, a cover letter will be decided**.

Teacher mobility:

- **priority is given to visiting teachers to give lectures about the uncovered areas at the host institution**;
- interest in common curricula development in the field of **the development of *computational thinking***;
- **valid teaching position** at the home institution;
- **priority is given to teachers who want to stay for more than one week** (minimum is 6 teaching or supervising hours/week);
- subject offered by the teacher fits the curriculum of the host institution or is related to **the development of *computational thinking***.

Coordination of the network

We will organize **regular coordination meetings**. The coordination meeting **will be held at the beginning and the end of the academic year with every partner involved in the project**.

Meetings **will be held also online by e-mail, social networks, telephone**, etc.

Monitoring of the performance of the network

We **will organize personal and online meetings to obtain feedback** from all the partners, **to analyze the results**, or if there are some problems, **to find solutions, and to plan the next steps**. We will try **to optimize the performance of our network** this way.

Coordinating the network is **very important for good and efficient communication to the NCO**. Every partner (local CEEPUS coordinators) should get to know the person in charge to ensure **smooth operation in case of exchange within the network**.

At the end of each academic year, **the participating units write partial reports based on which the network coordinator shall write a final report**. The network coordinator will also **establish performance indicators regarding the mobilities and at the end of the year, he will check the results**.

We will also **constantly develop and update** a **web portal of the network**, where **the main aspects of network activity, an overview of planned activities**, etc. **are presented**.

Organizing the international conferences (organized by partner units) and **publishing the main results** here will give a **good opportunity to meet, discuss, monitor the performance of the network, and solve problems in a variety of areas**.

We will encourage **the exchange of experience, good practice, and focus on avoiding and solving eventually problems**.

Academic recognition

Students who **complete** their studies at a participating institution **will receive full academic recognition**.

Cooperation with representatives of ***the Foreign Relations Department*** and ***ECTS Coordinators***, who are an integral part of mutual recognition, **is important**.

Regular **online communication** will be established **between the supervisors of the visiting students at the sending and receiving institutions**. **Evaluation of cooperation quality** will take the form of regular **online meetings**.

In the case of **student exchange**, their curriculum is **discussed by contact persons from both institutions** (host and home).

All participating institutions recognize the credits obtained by their students at the host institutions. **Each of them applies** the **ECTS credit system**.

This is how we ensure **mutual recognition for student mobility**.

More information on the credit systems of each partner university **can be found on their website**.

Network and other activities

This CEEPUS network **contributes to programs like Erasmus+ and other bilateral and multilateral collaborations**.

We also **combine our CEEPUS network with research activities focused on the development of *computational thinking*** or related to it.

University of Novi Sad, Department of Mathematics and Informatics currently preparing materials for **a project application in the context of the Erasmus+ program** with **Palacký University in Olomouc**.

Objectives of the network

Objectives:

- Focus on the further **development of our e-learning system** "moodle.e-zdroje.cz" and **web portal** "ceepusktiv.upol.cz", which enables mutual publication of all news, communication, and above all allows potential applicants for mobility, to obtain all important information in one place, not only in English but also in their native language.
- **students** (undergraduate, graduate, Ph.D.) and **teachers exchange**;
- **participation** of incoming teachers and students **in lessons and lectures** at host universities;
- **common curricula development** in computer science with a **focus on the development of *computational thinking***, dissemination of the results;
- **intensive courses on selected topics** (*programming, robotics, virtual and augmented reality, e-learning, virtualization, 3D print, internet of things, software engineering,* etc.);
- **joint bachelor/master program development**;
- **joint research projects and paper publishing**;
- **development of the reciprocal exchange of knowledge, information, examples of good practice, and cooperation on the research activities** in the field of **the development of *computational thinking***;

- **organizing courses and consultations** for incoming students with an academic staff of host universities;
- **assistance on active work in laboratories** and consultations **to support the elaborating and finishing** of bachelor, master, or doctoral **thesis** at partner universities;
- **organizing summer schools**;
- **internships at our silent partners**.

Biggest achievement:

- In the Czech Republic, **our network won the "Award of the House of Foreign Cooperation" in the field of "Digitalization"** for the year 2021. In connection with this award, **the CEEPUS network was promoted on social networks, and various articles were published** (see https://www.zurnal.upol.cz/nc/zprava/clanek/nejuspesnejsi-pociny-mezinarodniho-vzdelavani-patri-i-univerzite-palackeho/) and even a publication was published for the mentioned awards, where our CEEPUS network is also mentioned and presented (see https://www.dzs.cz/sites/default/files/2022-04/Publikace-Ceny-DZS-2021_1.pdf). In the previous academic year, **we managed to establish a scientific cooperation** between the Technical University of Košice (Slovakia) and the Faculty of Education in Olomouc (Czech Republic) **on a research project related to virtual and augmented reality**. Another achievement is, that **our network is every year more and more known in the academic environment** and many universities directly contact us themselves because of connecting their unit to our network.
- We have established cooperation with new partner universities and a new silent partner. We also managed to publish several joint articles.

Biggest challenge:

- Make a common agreement between partner institutions on **creating the possibility for preparation of joint programs of study** (bachelor, master) and **creating the appropriate framework**

for the implementation of the ECTS credit system at the undergraduate and postgraduate levels.

- Create a collaborative online course in the context of computational thinking and digital education. Increased involvement of our silent partners in CEEPUS.

Biggest obstacle:

- The biggest obstacle was motivating students and teachers to use the mobility opportunities – we started arranging regular annual face-to-face meetings at the beginning of the academic year between local coordinators and their students at each university to introduce CEEPUS network possibilities.

E-learning system, web portal, and digitalization

In cooperation with our silent partner – "DRAGON solutions s.r.o." – we prepared our e-learning platform (see https://moodle.e-zdroje.cz/). Each network partner has many virtual rooms available. **The system is fully functional** and can be conveniently used for the **implementation of virtual/hybrid mobilities**, but also the **e-learning itself**, which is part of full-time study/mobility. The platform is widely used and since we have unlimited access to it, it is possible to modify individual modules/components based on the feedback obtained to achieve maximum work efficiency and automate some key processes. Not only practitioners/companies can implement e-learning courses through this system, which **will lead to higher availability and faster dissemination of specific knowledge among all network partners. The study can be carried out virtually anywhere.**

In addition to the above, a **web portal** (see https://ceepusktiv.upol.cz/) focused specifically on our network was created.

Its key features are as follows:

- the **possibility to publish all news related to the network**,
- clear calendar of events,

- **mutual communication between mobility participants and partners** (discussion forum),
- **multilingualism** – key information is always available in English, and if the partner is interested in localizing to their mother tongue, the portal is ready for it;
- all information about the network, mobilities, events, all-important contacts, forms, instructions, and links in one place – **simply, clearly, understandably**;
- **each coordinator can create web content independently of the others** - specific parts of the website can be tailored to the specific requirements of the audience (potential mobility participants) in each country.

All of the above are still **gradually updated and developed**.

The network itself focuses on the development of computational thinking, which is closely related to digital literacy and ICT. Our aim is, among other things, to combine the knowledge, experience, and approaches of individual partners/universities to the mentioned issue to develop the most comprehensive key competencies in the mobility participants and individual CEEPUS coordinators.

We believe that not only the content focus of the entire network but also our activities and the established web platforms **positively support the digitization process and innovative practices in the area**.

Conclusion

Universities prepare students to pursue a career in **an IT area that is constantly evolving** and **needs to respond to change**. Currently, the emphasis is on **the development of *computational thinking***. **Thinking like an IT engineer can be beneficial** in many ways. For example, **be able to create your algorithm for solving any problem** (we consider everyday problems) and in this way **make life easier**. **Future absolvents should prepare for changes** increase their *knowledge*, and *skills,* and *focus* on developing their thinking. **The development of *computational thinking*** does **not only start with the student but also with his teacher**, who should give the student **the right direction**.

All of the above can be very helpful in **the development of *computational thinking*** not only for incoming students but also for teachers.

Olomouc, 14.01.2024
Mgr. Tomáš Dragon
Network coordinator