

Information Science in Technical Education Process in Czech Republic

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Abstract—Information and Communication Technologies are one of the basic educations of areas in the Framework Educational Programme for Basic Education to enable students to acquire a basic level of information literacy. The aim is to equip students with elementary skills in operating of computer equipment and modern information and communication technologies, but also to navigate in the world of information, creatively work with information and use them in further education and in practical life.

The paper deals with the analysis of the situation and draws conclusions on the system of education in the Czech Republic in the context of the challenges of INDUSTRY 4.0 in response to the capture, the robotics industry and services.

Keywords—Education, technical education, curricular reform, information science in education

1 Introduction

Information and Communication Technologies are one of the basic educations of areas in the Framework Educational Programme for Basic Education to enable students to acquire a basic level of information literacy [11]. The aim is to equip students with elementary skills in operating of computer equipment and modern information and communication technologies, but also to navigate in the world of information, creatively work with information and use them in further education and in practical life [18]. In the framework curriculum for basic education, it is stated that ‘the skills acquired constitute a prerequisite for success in the labour market in an information society, and are a pre-condition for the effective development of professional and leisure activities. Mastering computer technology, particularly the ability to quickly find and process needed information using the Internet and other digital media, allows pupils to “learn anywhere and at any time”. Moreover, it takes the burden off memory while allowing for the use of a far more extensive volume of data and information than before, accelerates the updating of knowledge and appropriately complements standard textbooks and other aids.’ It is evident from the above that the emphasis is put on the applicability of computer technology, backed up by educational software and information resources in all educational areas of basic education [11]. This application level should exceed the framework of educational content of the educational field of Information

and Communication Technologies and become part of all educational areas in basic education [11].

The paper deals with the analysis of the situation and draws conclusions on the system of education in the Czech Republic in the context of the challenges of INDUSTRY 4.0 [15] in response to the capture, the robotics industry and services.

The development of information literacy, information education, information science as skills and knowledge is due to changes – development in information and communication technologies. These changes, processes are inevitable, given by the development of society, the discovery of new materials, processes and, of course, technological development.

People around the world work with the same technologies, and so the content and processes of education in information literacy – the content of information science must be the same in the US, Australia, England, the Czech Republic or Ukraine and Russia.

Different programmes that contribute to improving information literacy should be followed by students throughout their education and post-education process, starting with primary schools, through secondary schools, universities to lifelong learning [20]. Elements of information literacy at primary and secondary schools have their specific character which is mainly determined by the age of students. It is this fact that places great demands on the preparation of teachers, their approach to the didactic transformation of content [8, 19].

Primary schools have a significant position, within the formal or initial education, in the provision of information education and targeted development of relevant competencies or cognitive and operational skills and approaches necessary for the efficient use of information and communication technologies. In spite of the growing importance of informal education based on experience with the use of technology in society, in family, in leisure activities of students, it is necessary to consider the systematic educational activities at primary school leading to the foundation and development of relevant competencies as irreplaceable.

Concept of contemporary information education supported by relevant curricular documents should thus support the development of skills or competencies, enhancing adaptability of students, transfer of knowledge and skills to new contexts and ability to learn in a rapidly changing environment. The critical thinking of students, their ability to make decisions and factual arguments should also be developed. Information and algorithmic thinking, ability to solve problems, contribute to the development of students' creative thinking and support their creativity are the basis for the development of the individual, and also of society. Changing environment leads to the application of a competence approach that promotes portability of knowledge and skills in information education. Taking into account these processes and changes contributes to the effective development of specific crucial competencies [1].

Information education as standard part of the curriculum of primary schools is a feature of school systems in developed countries. In spite of technological and age similarity, its conception is not uniform and differences can be seen between systems in the organization, scale or form of relevant educational activities. Declarations of curricular materials and their implementation in practice can also differ. Teachers with

different didactic approaches and professional qualifications in the field of information science are non-negligible factors [14, 8].

The content of courses focusing on information science is, unlike most other subjects, specific as given by the intensive development of information science. This area has been intensively perceived in the Czech Republic since the early 1990s, when information and communication technologies began to penetrate into many areas of society, and thus into education. Continuous modernisation and changes in technology, both in software and hardware, lead to completely new components, segments and platforms. These changes bring not only constant pressure on the innovation of content and concepts of subjects, but they also place considerable demands on further education or self-education of teachers. These situations are noticeably reflected in the transition from primary to secondary school, with the students having different knowledge and skills when entering secondary school. The particularity of information science is also the fact that the students learn a lot themselves as the digital world is a natural part of their life today [8]. A similar effect is reflected in other disciplines, but it is particularly extreme in case of information science and schools have to respond flexibly to it. The legislative framework of curricular documents currently in use in the Czech Republic allows for this, and primary and secondary schools can respond more flexibly to ongoing changes.

We asked ourselves how the process of education of pupils from primary to secondary school is realized? How their motivation is focused on the engineering profession of the 21st century, where information technology and digitalization will play a paramount role? What role will teachers, especially vocational subjects, play? These are some of the issues discussed in this article.

2 Legislative Definition

As with every area of human activity, it is necessary to have a legal framework and a vision of future development for its implementation. This is also the case with information science as a tool and means of education.

The National Education Development Programme was a basic curricular document at the beginning of the millennium in the Czech Republic, starting the process of fundamental changes in education. This programme was established on the basis of Government Resolution No. 277 of 7 April 1999 and sets out the main objectives of education policy. The Czech ‘White Paper’, as it is called, ‘*is conceived as a system project, formulating conceptual grounds, general intentions, and development programmes to be relevant to the development of education system in the medium term*’ [12]. In addition to internal needs, these fundamental changes were brought about by the needs of the European to global aspects of the development of society: ‘*The definition of a long-term strategy for education and training for Czech society therefore requires a deeper theoretical framework: an initial idea of the nature of man as a person and their relation to human society and the natural order. Only this broader perspective will clearly define the objectives and priorities of the education system and will also provide the main arguments for selecting the specific paths and tools for their implementation*’

[12]; this is understandable as the development of society goes hand in hand with the need to acquire an ever-increasing range of knowledge and skills that a person can develop in the developing society: *‘The higher the level of individual freedom, the more it depends on the personal maturity, responsibility and creativity of a citizen’* [12].

The Ministry of Education of the Czech Republic completed Draft ICT Development in Education Period 2009–2013 in September 2009 [13]. This document evaluates the previous period when ICT at schools was primarily funded by the National Policy for ICT in Education projects¹ and outlines a new period characterized by the implementation of projects supported by the European Social Fund.

The National Education Development Programme expired in 2014 by adopting the Education Policy Strategy of the Czech Republic until 2020 [20] which sets the educational concept in the most general way through its four main objectives:

- Personality development contributing to improving the quality of human life
- Maintaining and developing culture as a set of shared values
- Sustainable developing active citizenship, creating the conditions for a solidarity society
- Development and democratic governance
- Preparation for employment

The Education Policy Strategy sets out the basic framework for the further development of education policy and builds on the Digital Education Strategy [22] which aims to formulate the vision of information literacy: *‘The education system will ensure the skills of every individual without distinction through competences to use their experience in the information society and take advantage of open learning opportunities throughout life.’*

The Digital Education Strategy regards the development of digital technologies and, in this context, the content of pedagogical education as very dynamic. Therefore, this strategy cannot be regarded as a *‘long-term static document’*, yet it formulates three priority objectives of primary importance:

- Open education to new methods and ways of learning through digital technologies
- Improve students’ competencies in the field of information and digital technology
- Develop students’ information thinking

The Government of the Czech Republic approved the Digital Czech Republic v. 2.0 concept on 20 March 2013, [6] which states that *‘information technology should be*

¹ State Information Policy on Education was adopted on 10 April 2000 by the Government of the Czech Republic by Resolution No. 351 approving the Concept of State Information Policy in Education. With the Resolution, the Ministry of Education of the Czech Republic was obliged to prepare and annually update the timetable for the implementation of this concept by including it in individual educational support programmes for information literacy and also to reflect the implementation costs in the budgetary chapter administered by the Ministry for the following years. The concept formulated objectives in the area of information literacy of teachers, students, citizens, public and state administration staff and healthcare and library science staff. More than CZK 7 billion was earmarked from the state budget for implementation in 2001–2005. The concept was extended to 2010 in August 2004 and the government approved additional subsidies of CZK 1 billion per year for the period from 2007 to 2010. However, the Parliament of the Czech Republic did not approve this subsidy in 2006.

used everywhere in elementary school classes and not merely in subjects directly related to computer use. The government sees the full use of modern technology in classes in all subjects as essential for moving the education system forward from the simply mentoring facts to an emphasis on reader literacy, communications skills and logical thinking.’

Another conceptual material is the Data Information Policy of the Ministry of Education 2015+ [5], which is a strategic and conceptual material the main strategic goal of which is to provide effective support to the public administration in the department through the necessary amount of structured data describing education and education system, higher education, science and research, youth, sport and physical education, operational programmes under the authority of the Ministry, etc. DIP 2015+ is based on existing national and department strategic materials, including the Digital Czech Republic v. 2.0, The Way to the Digital Economy and, of course, the basic strategic material of the Ministry of Education, Youth and Sports, the Education Policy Strategy until 2020.

Following the educational strategy, the above-mentioned Education Act introduces a system of multiple levels of educational programmes the highest level of which is the so-called ‘National Educational Programme’ or national curriculum, and the Ministry of Education of the Czech Republic is responsible for its preparation. It outlines the main principles of the national curriculum policy and generally binding requirements that reflect all the objectives of education and training. It defines the general objectives of education and general core competencies, focusing particularly on personality development, education of citizens, as well as on preparation for further education or entry into practice [12]. It is currently presented by the Education Policy Strategy of the Czech Republic until 2020 [21].

Framework Educational Programmes (FEPs) represent another level following in the National Educational Programme and the White Paper. FEPs define:

- The objectives of education for the given educational field (educational objectives).
- Competencies (defined as learning outcomes standards):
 - a) key competencies (e.g. the ability to learn, communicate, care for health), these are general education requirements universally applicable to life, part of the general education base, i.e. not tied to individual subjects);
 - b) expected competencies (more specific requirements for knowledge, skills, habits and attitudes universally applicable to normal learning, work and life situations, linked to educational areas and their fields; defined in three education periods (the first period includes 1st to 3rd year, the second period includes the 4th and 5th year, the third period includes the 6th to 9th year of elementary education)).
- Basic curriculum (defined as a binding standard of the offer of primary and secondary school education, i.e. the list of subjects that each school must offer to their students to acquire in the achievement of the expected competencies).
- Framework curricula.
- Conditions for the implementation of education.

- Principles for creating school educational programmes and other rules for introducing these programmes into schools.

FEPs are set for preschool, elementary, grammar school and secondary vocational education:

- a) The Framework Educational Programme for Preschool Education was approved by the Ministry of Education of the Czech Republic in May 2001 with effect from 1 September 2003.
- b) Framework Educational Programme for Basic Education defines the national concepts of the objectives, content and results of elementary (primary and lower secondary) education, valid from 1 September 2005.
- c) The Framework Educational Programme for Secondary General Education (grammar schools), approved by the Ministry of Education of the Czech Republic on 24 July 2007 with effect from 1 September 2009.
- d) The Framework Educational Programme for Secondary Technical and Vocational Education is designed for individual educational fields, which are divided into J, E, H, L0, M, conservatoire and follow-up study. The Ministry of Education, Youth and Sports of the Czech Republic issued a separate educational programme for each of the educational fields mentioned in the Government Regulation on a system of education in primary, secondary and tertiary education (281 programmes were issued in total). These programmes were released in 4 waves from June 2007 to November 2015 with effect from 1 September 2009 to 1 September 2015.

The last, lowest level of curricular documents is School Educational Programmes; these are documents governing education in a particular school or school facility. They are processed by individual schools for their specific conditions and intentions. All this provides schools with space for greater autonomy, use of the potential and creativity of teachers, greater flexibility and greater efficiency. Emphasis is put primarily on some areas of education, such as foreign languages, use of practical life and work experiences, European integration, multicultural education, environmental education or healthy lifestyle. It also includes the inclusion of requirements for new forms of teaching, cross-curricular relationships, integrated group teaching, project teaching and, in particular, the use of information technology.

3 Framework Educational Programme for Basic Education

Basic education is intended to help students ‘to shape and gradually develop key competences and to provide a solid foundation for general education oriented to close-to-life situations and practical conduct’. Basic education should therefore strive to achieve the following objectives [11, 18, 20]:

- Enable students to acquire learning strategies and motivate them for lifelong learning
- Encourage students to creative thinking, logical thinking and problem solving
- Lead students to a versatile, efficient and open communication

- Develop students' ability to cooperate and respect the work and achievements of others as well as their own
- Prepare students to manifest themselves as free, independent and responsible individuals, to exercise their rights and to fulfil their duties
- Create the need in students to show positive feelings in behaviour and experiencing of life situations; develop sensitivity and sensitive relationships with people, the environment and nature
- Teach students to actively develop and protect physical, mental and social health and to be responsible for them
- Lead students to tolerance and respect for other people, their cultures and spiritual values, to teach them to live together with other people
- Help students learn and develop their own abilities in line with real possibilities and apply them together with the acquired knowledge and skills in decision making about their own life and professional orientation.

These objectives should lead to the creation and development of key competencies [3], representing a set of knowledge, skills, abilities, attitudes and values important for the personal development and employment of each member of society. Their selection and concept is based on the values generally accepted in society and generally shared ideas about the competencies of an individual contributing to their education, satisfied and successful life and strengthening of civil society functions [7].

Educational areas are defined in the Framework Educational Programme for Basic Education by their characteristics describing the position and importance of the given field, including the educational content of individual educational fields of the given educational area. There is also a link between the educational content of first school and lower secondary school of basic education. This part is followed by the objectives of the educational area, i.e. what the student is led to through the educational content to gradually achieve key competencies [11].

Within the School Educational Programme, the school is obliged to divide the educational content of the individual educational fields into subjects with a guarantee of being aimed for the development of key competencies. One or more subjects may be created from one educational field or the subject can be created by integrating the educational content of multiple educational fields (integrated subject). The Framework Educational Programme allows for the integration of educational content on the level of topics, thematic areas and/or educational fields [18]. A qualified teacher is defined as the basic condition for functional integration in the Framework Educational Programme.

4 Educational Area: Information and Communication Technologies

Information and Communication Technologies are one of the basic educational areas of the Framework Educational Programme for Basic Education enabling students to acquire the basic level of information literacy. The aim is to equip the students with

elementary skills in the control of computer technology and modern information and communication technologies, as well as to orient themselves in the world of information, creatively work with information and use it in further education and in practical life [18]. The Framework Educational Programme for Basic Education states that ‘*the skills acquired constitute a prerequisite for success in the labour market in an information society, and are a pre-condition for the effective development of professional and leisure activities. Mastering computer technology, particularly the ability to quickly find and process needed information using the Internet and other digital media, allows pupils to “learn anywhere and at any time”. Moreover, it takes the burden off memory while allowing for the use of a far more extensive volume of data and information than before, accelerates the updating of knowledge and appropriately complements standard textbooks and other aids.*’ This shows the emphasis on the applicability of computer technology based on educational software and information resources in all educational areas of basic education. Therefore, this application level should exceed the educational content of Information and Communication Technologies and become part of all educational areas in basic education.

Table 1. Framework curriculum

Educational Area	Educational Field	Stage 1	Stage 2
		Grades 1–5	Grades 6–9
<i>Minimum Time Allotment</i>			
<ul style="list-style-type: none"> • Information and Communication basic concepts for working with information – information, information sources, information institutions • Structure, functioning and description of a computer and peripheral equipment • Operating systems and their basic functions • Introduction Technologies 		45 min.	45 min.

(Framework Educational Programme for Basic Education, 2015)

Time allotment of the educational field and educational area of Information and Communication Technologies proposed in the Framework Educational Programme for Basic Education is a minimum time allotment providing sufficient room for school orientation – see Table 1.

In addition to this time allotment, the school has the so-called available time allotment for strengthening the subjects as selected by the school (the so-called school specialization), for optional educational activities, for cross-curricular subjects and complementary educational fields, etc.

5 Framework Educational Programme for Secondary Technical and Vocational Education

The concept of FEPs for Secondary Technical and Vocational Education differs fundamentally from the FEPs for Basic and Secondary General Education. It is distinguished by the fact that it seeks to create an educational environment based on pedagogical autonomy of schools or focusing on the graduates finding employment, as well as by being designed for the educational fields included in a new system of educational fields than it was until the time of the curricular reform. Thus, there is one FEP for each educational field, emphasizing vocational training requirements and graduates' competencies based on labour market requirements described in professional profiles and qualification standards. Unlike existing curricular documents defining the general objectives of education and particularly the content of education, these Framework Educational Programmes primarily define learning outcomes (what the student should learn and be able to demonstrate at a certain level according to their prerequisites).

In addition to technical and vocational education, the emphasis is put on the importance of general education for pupils' development as a prerequisite for understanding current social phenomena and the rapid development of science and technology and adapting to changing life and work conditions [17]. General education includes ICT education as one of the cross-curricular themes (Citizen in a Democratic Society, Man and the Environment, Man and the World of Work, Information and Communication Technologies) fulfilling competencies to use information and communication technologies and to work with information. Education is aimed at graduates working with a personal computer and its basic and application software, but also with other means of information and communication technologies, and using adequate sources of information including effective work with them, i.e. the graduates should [17]:

- Work with a personal computer and other means of information and communication technologies
- Work with common basic and application software
- Learn to use new applications
- Communicate via email and use other means of online and offline communication;
- Obtain information from open sources, particularly through the use of a global Internet network
- Work with information from various sources carried on different media (printed, electronic, audiovisual), including the use of information and communication technologies
- Recognize the need to judge the different credibility of different information sources and to critically approach the information obtained; be media literate

6 Framework Educational Programme for Education Field of Information Technologies

The Framework Educational Programme for the Educational Field of Information Technology was issued by the Ministry of Education, Youth and Sports on 29 May 2008 and includes the following professional competencies [17]:

- Design, build and maintain HW, i.e. the graduates should
- Work with basic software, i.e. the graduates should
- Work with application software, i.e. the graduates should
- Design, implement and manage computer networks, i.e. the graduates should
- Program and develop user, database and web solutions, i.e. the graduates should
- Take care of occupational safety and health, i.e. the graduates should [23]
- Strive for the top quality of their work, products or services, i.e. the graduates should
- Act economically and in accordance with sustainable development strategy, i.e. the graduates should.

Graduates in Information Technologies can find employment in the areas of HW design and implementation, IT maintenance in terms of HW, programming and development of user, database and web solutions, application software installation and administration, OS installation and administration, design, implementation and administration of networks, qualified IT sales, including consultancy, and general and specialized support for IT users. Possible jobs for graduates include IT technician, user support, programmer, application manager, operating system manager, network administrator, IT sales representative, etc.

Specialized part of education in the educational field of Information Technologies is divided into 5 educational areas, the framework division of which is described in Table 2 [17]:

- **Hardware** – Focused on computer architecture, principles of operation of each computer component and their interconnection. The student will thus be able to design and assemble personal computers for the intended purpose of their use, will be able to connect peripherals to a computer, maintain them functional, add consumables, service equipment and do minor repairs. It also includes diagnostics of hardware components and devices.
- **Basic software** – Focused on operating systems. Emphasis is put on acquiring knowledge and skills to use in practice when installing, configuring and managing OS, including connecting a computer to the network.
- **Application software** – Includes advanced use of application programs, their installation and configuration, including the provision of related user support. Emphasis is put on office software, communication software and multimedia software. The student learns to transfer data between applications, use different data formats and convert them.
- **Computer networks** – It leads to an introduction to network topology and network communication principles. The student learns how to design and implement a simple

computer network using active and passive elements, configure and connect the computer to a local network and the Internet. The student masters the principles of addressing and routing in computer networks and learns to use wireless technologies. It includes identifying and removing common network failures.

- **Application programming and development** – Focused on creating algorithms and writing program source code using programming language. The student understands the algorithm properties and the basic concepts of object-oriented programming, learns how to write algorithms, data types, program control structures, simple objects and basic SQL commands. Creation of simple applications, static and dynamic websites is a substantial part of education in application programming and development.

Table 2. Framework curriculum

Educational Areas and Content Ranges	Minimum Number of Lessons for the Whole Period Education	
	Weekly	Total/4 years
ITC education	4	128
Hardware	5	160
Operating systems	6	192
Application software	8	256
Computer networks	4	128
Application programming and development	8	256

(Framework Educational Programme for Secondary Technical and Vocational Education, 2008)

7 Use of Information and Communication Technologies in Educating Students with Physical Disabilities

The use of information and communication technologies in the context of the education of students with health disabilities includes, in particular, the individual needs of the student, both in terms of the type of products used and the extent of their application. The basis is therefore based on the reflection of individual educational needs, including an individual educational plan [10].

There are currently efforts of manufacturers of information and communication technologies to offer technological solutions that make life easier for people with disabilities and adjust the means to their specific needs. A wide range of hardware and software products are available for the physically and visually impaired to make the use of personal computer easier to communicate with the world, to help them learn and work. Tools for easier use of keyboards are developed in the area of hardware, as well as replacing part of the keyboard with mouse movement, adjusting monitor controls and printer settings, and many devices are configured remotely via network connectivity. For example, solutions have been developed for blind and purblind people that enable data input and output to be made using an external Braille-type device in combination with a voice output.

In addition to hardware solution, a wide range of software can be used, with most operating systems already having built-in features. The appearance and behaviour of

operating system environments can also be customized by control panels and other built-in features with regard to various user disabilities. These include, for example, the colour and size settings of icons and fonts, volume and mouse/keyboard behaviour settings.

8 Conclusion

The teacher at a 21st Century School is as important as in the past, but there is an apparent change in concept. According to K. Černý [4], the teacher should be a guide in the knowledge of the modern world. Traditional teaching and school, which were previously focused on the transfer of facts and knowledge, are changing. Facts can now be found on the Internet, and memorizing the subject matter is thus replaced by learning in context.

In 2014 the Ministry of Education, Youth and Sports elaborated the Digital Education Strategy until 2020 [20]. The strategy outlines the direction of 21st century education in the Czech Republic. The apparent digitization, which enters many industries, is also processed in the Industry 4.0 initiative, a document issued by the Ministry of Industry and Trade of the Czech Republic in August 2016 [15]. The initiative aims to strengthen and maintain the competitiveness of the Czech Republic during the so-called Fourth Industrial Revolution.

According to the Digital Education Strategy until 2020, education should prepare the students with greater emphasis on information technology. Introduction of new subjects and study fields is expected. All schools, regardless of their specialization, should teach about the system functioning of the Internet, the possibilities of its use at work, and the benefits of applying new Industry 4.0 technologies to future employment opportunities development. School graduates should acquire the ability to adapt and active attitude to the world, creativity and the desire to keep learning.

According to the Assessment and Teaching of 21st Century Skills (2012), the importance of cognitive skills in the modern labour market is increasing. The students should be able to solve non-routine problems and learn to think systemically and non-systemically. Other skills may include intrapersonal skills (such as the ability to set goals and reflect their achievement or single-mindedness) and interpersonal skills (the ability to work together, to communicate and to talk with people not only from one's own cultural and linguistic background).

Industry 4.0 aims to better prepare the students to assert themselves in their personal life, community and society. The Ministry of Industry and Trade perceives that society's diversification will increase. The task of the schools will be to ensure social cohesion, as well as targeted compensation for students' disadvantages [15].

It is necessary to inform all students of the possibilities of Industry 4.0 at secondary technical schools as soon as possible. The possibilities of professional internships in companies where production is already automated would facilitate the introduction of Industry 4.0 into practice. Changes in education brought by Industry 4.0 will be great. Schools must intensively prepare their students for this idea transformation, which will

greatly affect the economy and society of the Czech Republic. Everyone must be prepared for the changes brought by the fourth-generation industry. And the schools will be the institution that will prepare future generations for this technological revolution.

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