CREATING THE FUTURE

COMPUTING IN EDUCATION

CONTENTS

ECDL Foundation is a pledger of the Digital Skills and Jobs Coalition, an initiative of the European Commission

INTRODUCTION

Coding, computing, and computational thinking are terms that currently dominate the debate on digital skills development in Europe and worldwide. This is influenced by the rising demand of ICT specialists in the labour market and countries looking for ways to provide the demanded skills for the young generation. Computing is also valued as a subject that contributes to the intellectual and personal development of young people: it stimulates creativity, critical and logical thinking, problem solving, and facilitates understanding of how digital technologies function[1]. In other words, computing transforms students from consumers to creators of the digital world.

1 BCS Academy of Computing, "Excellent Computing in Every School: a Toolkit for School Leaders", http://old.computingatschool.org.uk/data/uploads/slt/pdf/excellent-computing.pdf

In October 2015, ECDL Foundation published a position paper titled, 'Computing and Digital Literacy: Call for a Holistic Approach'[2]. In the paper, we discussed the key terminology around computing and digital literacy, and we overviewed different approaches around the development of computing skills. We also suggested a balanced approach in digital skills development, which includes key elements of digital literacy and computing.

One of the key arguments of our paper published in 2015 was that coding/programming is only one element of computing[3]. Hence, when computing is introduced to children in school, teaching should begin with the basics of computational thinking and problem solving, followed by the practical implementation, such as coding. We also stated that every student should have an opportunity to learn the fundamentals of computing at school in order to be able to specialise in this discipline at later stages of education. Finally, after overviewing a variety of approaches of teaching computing, we identified a need for a standardised approach. This comprehensive approach should encompass both computing and digital literacy as two substantial elements of digital competence.

In February 2017, ECDL Foundation launched the new Computing module. This module, aimed at secondary school students, sets out essential concepts and skills relating to the use of computational thinking and coding. It will be relevant, not only for students who are interested in computing, but also for those who wish to develop transversal skills such as problem solving skills. This module can certify skills acquired either during extra-curricular activities or as part of the more formal curriculum.

In this new paper, we update the standpoint of ECDL Foundation in public debate around computing and digital literacy and position the ECDL programme against existing structures such as the DigComp framework. Firstly, this paper overviews terms and concepts related to computing. Secondly, it argues that computing is part of digital competence. Thirdly, it discusses different approaches to computing skills development in different countries. Finally, the paper presents the key elements of the new ECDL Computing module and explains how it answers the need for a consistent, high-quality approach in building and certifying computing skills.

2 ECDL Foundation "Computing and Digital Literacy. Call for a Holistic Approach", 2015, http://ecdl.org/media/position_paper_-_computing_and_digital_literacy.pdf
3 ECDL Foundation "Computing and Digital Literacy. Call for a Holistic Approach", 2015, http://ecdl.org/media/position_paper_-_computing_and_digital_literacy.pdf

The Term ‘Computing’

ECDL Foundation uses the term ‘computing’ interchangeably with ‘computer science’ – an academic discipline covering principles such as algorithms, data structures, programming, systems architecture, problem solving, etc. Computer science encompasses foundational principles (such as the theory of computation) and widely applicable ideas and concepts (such as the use of relational models to capture structure in data)[4].

At the end of 2016, the Joint Research Center (JRC) of the European Commission published a CompuThink study[5], which aimed at clarifying the term ‘computational thinking’ (CT). The researchers overviewed more than 570 sources from academic and grey literature, surveyed 19 ministries of education in Europe, and carried out 14 interviews with experts on the topic. After analysing this data, researchers concluded that there is a lack of consensus on the term of ‘computational thinking’ and that countries in Europe use different terms to describe the same subject:

> Computational thinking
> Computing
> Informatics
> Computer science
> Algorithmic thinking
> Coding, etc.

4 ECDL Foundation “Computing and Digital Literacy. Call for a Holistic Approach”, 2015, http://ecdl.org/media/position_paper_-_computing_and_digital_literacy.pdf

5 Joint Research Center, “Developing Computational Thinking in Compulsory Education”, 2016, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/developing-computational-thinking-compulsory-education-implications-policy-and-practice

When different terms are used to describe the same concept, the best approach is to name the key components of this concept in order to define it. JRC chose this strategy to define computational thinking: they outlined the key concepts and skills that repeatedly fall under this term throughout different sources[6]:

> Abstraction
> Algorithmic thinking
> Automation
> Decomposition
> Debugging
> Generalisation

In other words, no matter which term is used in different countries (computer science, computing, or computational thinking), they all refer to the same concept as long as they retain the key elements mentioned above. In order to retain consistency with ECDL Foundation's paper published in 2015[7], we continue to use the term 'computing'.

The CompuThink study confirms ECDL Foundation's argument that computing is much more than simply programming/coding[8]. Computing is a key to problem analysis and problem decomposition, whereas coding/programming helps to implement given solutions in a particular programming language and can serve as a learning tool[9]. ECDL Foundation strongly believes that all key concepts of computing should be taught together in order to equip students with a full set of transferrable skills and knowledge. The new ECDL Computing module covers all essential concepts and skills relating to computing (see module description in Chapter 5).

6 Joint Research Center, "Developing Computational Thinking in Compulsory Education", 2016, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/developing-computational-thinking-compulsory-education-implications-policy-and-practice
7 ECDL Foundation "Computing and Digital Literacy. Call for a Holistic Approach", 2015, http://ecdl.org/media/position_paper_-_computing_and_digital_literacy.pdf
8 ECDL Foundation "Computing and Digital Literacy. Call for a Holistic Approach", 2015, http://ecdl.org/media/position_paper_-_computing_and_digital_literacy.pdf
9 Joint Research Center, "Developing Computational Thinking in Compulsory Education", 2016, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/developing-computational-thinking-compulsory-education-implications-policy-and-practice

Computing as Part of Digital Competence

ECDL Foundation believes that computing and digital literacy are two sides of the same coin and both of them should form part of compulsory education. Digital skills should be developed progressively in education, starting with the essential skills required to use a computer and get online, and then continuing with more complex skills such as computing, IT security, and web editing. Figure 1 represents an example of how to balance digital literacy skills and computing in school curricula.

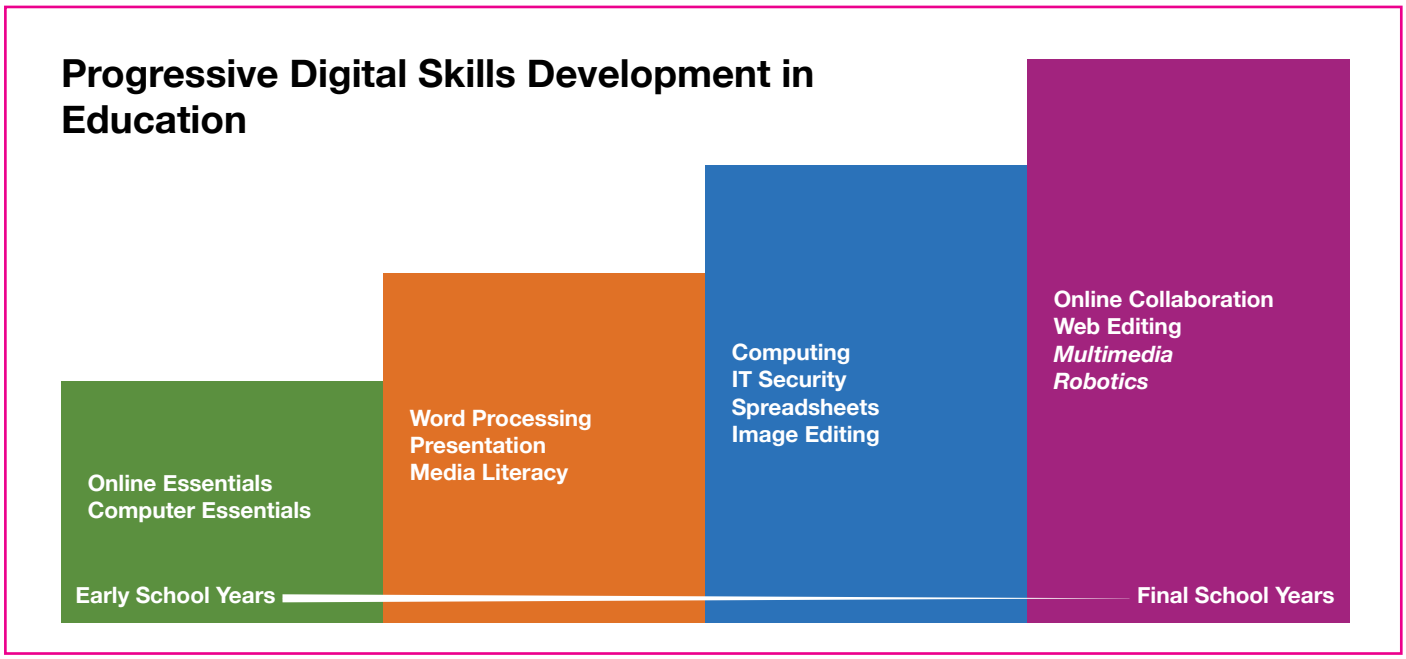

Figure 1. The concept of progressive digital skills development in education. ECDL Foundation 'Computing and Digital Literacy. Call for a Holistic Approach', 2015. These modules are already used in the education sector and modules in italics are examples of additional modules offered in some countries.

ECDL Foundation believes that computing skills and digital literacy skills are essential elements of digital competence. As defined by JRC, digital competence is a "confident, critical and creative use of ICT to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society"[10]. The key elements of digital competence are outlined by the DigComp Framework for citizens (DigComp)[11], which was developed by the JRC in order to facilitate the development and understanding of digital competences in Europe. This Framework outlines five digital competence areas: information and data literacy, communication and collaboration, digital content creation, safety and problem solving. The ECDL programme covers all digital competence areas outlined by DigComp[12]. The ECDL Computing module, in particular, covers competences under the DigComp competence areas, 'Digital content creation' and 'Problem solving'.

Computing Skills Development in Europe and Worldwide

For several years, computing has been high on the political agenda both in Europe and worldwide. The European Commission calls coding the literacy of today, which is fundamental in understanding how digital technologies work

10 JRC "Digital Competence in Practice: An Analysis of Frameworks", 2012, http://ftp.jrc.es/EURdoc/JRC68116.pdf
11 JRC, DigComp, https://ec.europa.eu/jrc/en/digcomp/digital-competence-framework
12 JRC, DigComp Gallery of Implementations, https://ec.europa.eu/jrc/en/digcomp/implementation

and serves in developing 21st century skills such as problem solving and analytical thinking[13]. Moreover, the European Commission considers teaching computing as a promising solution to satisfy the rising demand for ICT professionals in Europe. The New Skills Agenda for Europe invites Member States to invest more into digital skills development, including coding and computer science[14].

European countries are increasingly implementing computing into their school curricula. The CompuThink report[15] reveals that eleven countries have recently included computing in their compulsory education: Denmark, France, Finland, Croatia, Italy, Malta, Poland, Turkey, England and Scotland. Seven countries specified that they have plans to introduce computing into their school curriculum: the Czech Republic, Greece, Ireland, the Netherlands, Norway, Sweden and Wales. Finally, seven countries have already had computing as part of their school curriculum (mainly upper secondary level) for a number of years: Austria, Portugal, Cyprus, Israel, Lithuania, Hungary and Slovakia. Some of these countries are planning to include computing in lower secondary and primary schools.

There is a trend of introducing computing into compulsory education all around the globe. The CompuThink study provides examples from Australia, British Columbia (Canada), Japan, New Zealand, Singapore and South Korea[16]. In Australia, since 2015, digital technologies are addressed as a whole discipline with the curriculum focussed mainly on algorithms and problem solving. In Singapore, the new subject of 'Computing' will start in 2017 at the Secondary 3 level. In British Columbia, Canada, from the school-year 2016-17, computing is integrated from grades 6 to 8 as part of the subject, 'Applied Design, Skills and Technologies'[17]. In early 2016, the former President of the USA, Barack Obama, launched the 'Computer Science for All' initiative aiming to provide an opportunity for all American students to learn computer science[18]. The key rationale for all of these countries to introduce computing into school curriculum is to foster 21st century skills such as logical thinking and problem solving[19].

All of these examples from Europe and worldwide show that many countries are willing to integrate computing into their compulsory education. In addition to these efforts, multiple extra-curricular activities such as volunteer-led Code Clubs[20] and Coder Dojos[21] are mushrooming worldwide. They are supported by international campaigns such as the Hour of Code[22], Code Week[23] and the Africa Code Week[24].

In this large variety of different approaches and teaching practices for computing skills, ECDL Foundation suggests a well thought-out and thoroughly developed approach to computing skills development – the ECDL Computing Module.

13 European Commission "Coding – the 21st Century Skill", https://ec.europa.eu/digital-single-market/en/coding-21st-century-skill
14 European Commission "A New Skills Agenda for Europe. Working together to strengthen human capital, employability and competitiveness", 10.06.2016, http://ec.europa.eu/social/BlobServlet?docId=15621&langId=en
15 Joint Research Center, "Developing Computational Thinking in Compulsory Education", 2016, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/developing-computational-thinking-compulsory-education-implications-policy-and-practice
16 Ibid.
17 Ibid.
18 Megan Smith "Computer Science for All", https://www.whitehouse.gov/blog/2016/01/30/computer-science-all; "Fact Sheet: a Year of Action Supporting Computer Science for All", https://www.whitehouse.gov/the-press-office/2016/12/05/fact-sheet-year-action-supporting-computer-science-all; https://www.whitehouse.gov/blog/2016/10/27/call-new-csforall-actions-during-computer-science-education-week
19 Joint Research Center, "Developing Computational Thinking in Compulsory Education", 2016, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/developing-computational-thinking-compulsory-education-implications-policy-and-practice
20 https://www.codeclubworld.org/
21 https://coderdojo.com/
22 https://hourofcode.com/us
23 http://codeweek.eu/
24 http://africacodeweek.org/

ECDL Computing Module

The new ECDL Computing module, which was developed with input from experts in the field, sets out the essential concepts and skills relating to the use of computational thinking and coding to create simple computer programs. This module introduces concepts and skills that are essential for anyone interested in developing specialised IT skills and it also assists in developing generic problem solving skills that are useful for everyone. The outline of the Computing module is provided in Table 1.

ECDL Computing Module

Category	Skill Set
Computing Terms	> Key Concepts
Computational Thinking Methods	> Problem Analysis > Algorithms
Starting to Code	> Getting Started > Variables and Data Types
Building Using Code	> Logic > Iteration > Conditionality > Procedures and Functions > Events and Commands
Test, Debug and Release	> Run, Test and Debug > Release

Table 1. Syllabus outline of ECDL Computing Module

Different Approaches to Computing Skills Development

For countries that are on the way to introducing coding as part of their education systems, it is important to answer several key questions: first, should computing be taught as part of the school curriculum or as an extra-curricular activity; second, at which education level should it be integrated (primary or secondary); and third, how to support teachers who will be teaching computing.

Computing as Part of the School Curriculum or an Extra-Curricular Activity?

Curriculum overload is a relevant issue in many countries. Education systems are pressured to integrate numerous subjects in already tight schedules and teachers have to rapidly adapt to the changing needs. In this context, offering a new subject as an after-school activity seems like an attractive idea, especially since numerous volunteer-based activities already take place in different countries. However, only by integrating computing into compulsory education, can we make sure that it is taught in a structured, comprehensive and inclusive way.

First, the interest in participating in coding clubs substantially exceeds the supply[25]. It means that only the most motivated children (or children with motivated parents) can participate in these activities.

25 See for example, http://www.irishtimes.com/news/education/know-the-code-the-rise-and-rise-of-the-coderdojo-movement-1.1774135

Second, there are some stereotypes that exist about computing (it is for boys, 'geeks', etc.)[26]. As a consequence, many children who could potentially get interested in this subject, lack an incentive to try it.

Third, some after-school activities are organised with the principle of 'bring your own device'. Children from disadvantaged backgrounds who do not posses digital devices, might be excluded from coding activities.

In comparison, when computing is part of the school curriculum, all children have access to this subject. BCS stresses that computing is a rigorous and demanding subject, thus all means should be taken to ensure that young people from disadvantaged backgrounds have no barriers to achieve the highest results[27].

Finally, most of the after-school activities teach children the basics of coding, but not the other essential elements of computing (such as problem analysis, algorithms, etc.). In order to ensure that every child learns the fundamentals of computing starting with problem analysis and problem decomposition and finishing with practical implementation such as coding, computing should be introduced in compulsory school curricula. The fact of introducing a subject into the school curriculum ensures that it is taught in a systematic and structured manner.

Children who have already acquired computing skills through extra-curricular activities, should have an opportunity to certify these skills based on a recognised standard. In this case, the ECDL Computing module could serve as a practical solution.

26 Allison Master, "Researchers explain how stereotypes keep girls out of computer science classes", https://www.washingtonpost.com/news/education/wp/2016/04/26/researchers-explain-how-stereotypes-keep-girls-out-of-computer-science-classes/?utm_term=.d6aa16baf48b

27 BCS Academy of Computing, "Excellent Computing in Every School: a Toolkit for School Leaders", http://old.computingatschool.org.uk/data/uploads/slt/pdf/excellent-computing.pdf

Which Education Level?

Most European countries have integrated computing at secondary education[28]. There is also a growing trend to introduce this subject from primary school (for example, in Finland, England (UK) and France). This trend is driven by the idea that, in order for students to better grasp the concepts of computing, they should be integrated into the early years of education. However, the CompuThink study states that, at the moment, there is not enough evidence to clearly define the optimal age to start learning computing[29]. Some authors call for more research about what is the earliest stage from which students can understand and work with abstraction[30].

The new ECDL Computing Module was developed for secondary and vocational school students around 12-16 years old who wish to start learning about computational thinking and coding. This age group is typically ready to engage in relatively complex concepts relating to problem solving and is also ready to use flexible, easily readable programming languages such as Python. The module is likely to be of interest not only to students who are interested in IT and computing, but also to those who wish to develop transversal skills relating to problem solving.

How to Support Teachers?

In order to ensure high-quality computing education, it is necessary to provide substantial support for teachers. According to BCS, the most challenging task for teachers is to develop the required subject knowledge in parallel to pedagogical practice in order to teach computing in an engaging way[31]. Support for teachers should involve both technical skills and pedagogical aspects, as well as useful tips on how to make computing classes engaging and attractive.

With the launch of the new Computing Module, ECDL Foundation has prepared supporting materials for teachers who will teach computing. These materials give additional information, exercises, and references relating to the specific content set out in the students' learning materials, and act as an important additional resource to support module delivery.

28 Joint Research Center, "Developing Computational Thinking in Compulsory Education", 2016, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/developing-computational-thinking-compulsory-education-implications-policy-and-practice

29 Joint Research Center, "Developing Computational Thinking in Compulsory Education", 2016, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/developing-computational-thinking-compulsory-education-implications-policy-and-practice

30 Ibid.

31 BCS Academy of Computing "Teaching, Learning and Assessment", http://old.computingatschool.org.uk/data/uploads/slt/pdf/teaching-learning-assessment.pdf

CONCLUSIONS

Computing, computational thinking and computer science are terms that are often used to define the same concept, which encompasses the following elements: abstraction, algorithmic thinking, automation, decomposition, debugging and generalisation. ECDL Foundation uses the term computing to maintain consistency with our previous position paper, “Computing and Digital Literacy: Call for a Holistic Approach”.

ECDL Foundation believes that computing skills and digital literacy skills are essential elements of digital competence and should form part of compulsory education. The ECDL programme covers all digital competence areas outlined by DigComp, the digital competence framework for citizens.

Computing is being integrated into compulsory education in a number of countries in Europe and worldwide. These activities are complemented by volunteer-led after-school activities such as Code Clubs. In this large variety of different approaches and teaching practices, ECDL Foundation provides a high-quality solution to computing skills development.

The recently launched ECDL Computing Module was developed to rigorously high standards with the input of subject matter experts and practicing computing professionals from around the world, ensuring that it is both relevant and comprehensive. This module is likely to be of interest, not only to students who are inclined towards computing, but also to those who wish to develop their transversal skills, such as problem solving.

The ECDL Computing module could be used as a basis for computing skills development in compulsory education as well as a solution to certify skills acquired through extra-curricular activities. The key target audience of this module is secondary school students, around 12-16 years old, because they are ready to engage with the relatively complex concepts related to problem solving. The module is complemented with additional materials, which were developed specifically to support teachers in teaching computing.

The ECDL Computing module was developed to help empower young people to build key skills for the future.

ABOUT ECDL FOUNDATION

ECDL Foundation is an international organisation dedicated to raising digital competence standards in the workforce, education and society. Our certification programmes, delivered through an active network in more than 100 countries, enable individuals and organisations to assess, build and certify their competence in the use of computers and digital tools to the globally-recognised ECDL standard, known as ICDL outside of Europe.

As a nonprofit social enterprise, ECDL Foundation benefits from the unique support of experts from national computer societies and partners worldwide to develop vendor-independent standards which define the skills and knowledge required to use digital technology effectively. We work with education and training partners, local and regional authorities, national governments, international development organisations, as well as public and private sector employers in all sectors, in the delivery of our programmes.

The quality and reputation of ECDL is built on almost twenty years of experience in delivering our certification programmes to over 14 million people and in more than 40 languages worldwide, with more than 2.5 million ECDL tests taken annually. Our success is maintained by our ongoing innovation in certification programme development, our commitment to rigorous test design methodologies, and consistent adherence to our quality assurance standards.

ECDL Foundation supports the initiatives of National Operators of the programme in Europe and the Arab States from our headquarters in Dublin, Ireland and our European office in Brussels, Belgium. We have also established three regional operations – ICDL Africa (based in Rwanda), ICDL Asia (based in Singapore) and ICDL Americas (based in Panama). All ECDL Foundation operations work closely with regional, national and local partners to develop the global network of ICDL Accredited Test Centres.

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