Computing and Digital Literacy
Call for a Holistic Approach

1   Executive Summary

Political momentum around coding skills development is becoming increasingly strong in Europe and worldwide. Numerous initiatives to promote and teach coding are led by national governments, private and non-governmental stakeholders and academia; the European Commission also takes an active role in these endeavours. In order to ensure that these skills are developed in a consistent and high-quality manner, a standardised approach is needed. This paper consists of three key parts: first, it clarifies the terminology around coding, programming, computer science, computing and digital literacy; second, it provides an overview of various approaches to coding skills development in different countries; third, it suggests that every child should have an opportunity to learn the essentials of computing and that coding should be taught as part of computing. This paper calls for a unified approach to digital skills development that would encompass digital literacy as well as computing.

2   Defining the Terms

Coding, programming, computer science, computing and computational thinking: all of these terms are often used interchangeably to discuss digital skills development. In order to clarify these terms, we will use the existing working definitions provided in the box below.

Computer programming is the process of developing and implementing various sets of instructions to enable a computer to perform a certain task, solve problems, and provide human interactivity. These instructions (source codes which are written in a programming language) are considered computer programs and help the computer to operate smoothly[1].

Coding on a technical level is a type of computer programming that closely represents what happens at the lowest (machine) level. However, when most people talk about coding, they usually mean something at a higher, more human-readable level[2]. The terms *programming* and *coding* are usually used interchangeably (they are also used as synonyms in this paper).

Informatics is defined as the study of the representation, processing and communication of information in natural and engineered systems. It has computational, cognitive and social aspects. Informatics encompasses a number of existing academic disciplines including artificial intelligence, cognitive science and computer science[3]. Thus, in English-language texts, informatics is a broader concept than computer science. However, in other languages the term informatics is used interchangeably with computer science: in German, *Informatik*; in French, *informatique*; and in Italian, *informatica*[4].

Computer science is an academic discipline covering principles such as algorithms, data structures, programming, systems architecture, design, problem solving, etc. Computer science encompasses foundational principles (such as a theory of computation) and widely applicable ideas and concepts (such as the use of relational models to capture structure in data)[5].

Computing is the term which in digital skills debate is often used interchangeably with the term 'computer science'. In this paper, we also use these terms as synonyms (see Figure 1: Defining the terms, computer science/computing and digital literacy). In the UK, computing is defined as a broad subject area that encompasses both computer science and digital literacy[6].

Computational thinking is a problem solving process which lies at the heart of computer science. Computational thinking involves formulating problems in a way that enables the use of a computer to solve them; logically organising and analysing data, representing data through abstractions, automating solutions through algorithmic

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[1] European Schoolnet, "Computing our Future. Computer programming and coding – priorities, school curricula and initiatives across Europe", 2014.

[2] European Schoolnet, "Computing our Future. Computer programming and coding – priorities, school curricula and initiatives across Europe", 2014.

[3] The University of Edinburgh, "What is Informatics?", http://www.ed.ac.uk/files/atoms/files/what20is20informatics.pdf

[4] Christian Freksa, Matthias Jantzen, Rüdiger Valk "Foundations of Computer Science", 1997 – *"computer science or "Informatik" in Germany"'.*
 L'université Bordeaux 1 "L'informatique, c'est quoi?", http://dept-info.labri.fr/ENSEIGNEMENT/INITINFO/initinfo/supports/book/node4.html - *"L'informatique est aussi une discipline universitaire. <…> la traduction anglaise est "computer science"".*
Ca'Foscari University of Venice "Programme description", http://www.unive.it/nqcontent.cfm?a_id=73027 - *"MSc programme in Informatica – Computer Science".*

[5] The Royal Society, "Shut down or restart? The way forward for computing in UK schools", 2012, https://royalsociety.org/~/media/education/computing-in-schools/2012-01-12-computing-in-schools.pdf

[6] Simon Peyton Jones "Understanding the new programmes of study for computing", 2014, http://primary.quickstartcomputing.org/resources/pdf/understanding_pos.pdf

thinking; identifying, analysing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources; generalising and transferring this problem solving process to a wide variety of problems, etc.[7]

Digital literacy – basic set of skills required to participate in essential ICT user activities. Typical skills would include the ability to work with numbers and documents (software such as word processors and spreadsheets) and the ability to use a web browser, e-mail and internet search engines securely and effectively[8].

These definitions outline two different digital skills areas – computing/computer science and digital literacy. Both of them should be developed in formal education. Digital literacy skills are as important as reading and writing — it is necessary to possess them in order to access all the subjects taught across the curriculum[9]. Programming/coding is among the key elements such as algorithms and systems architecture that together form the academic discipline of computer science (see Figure 1).
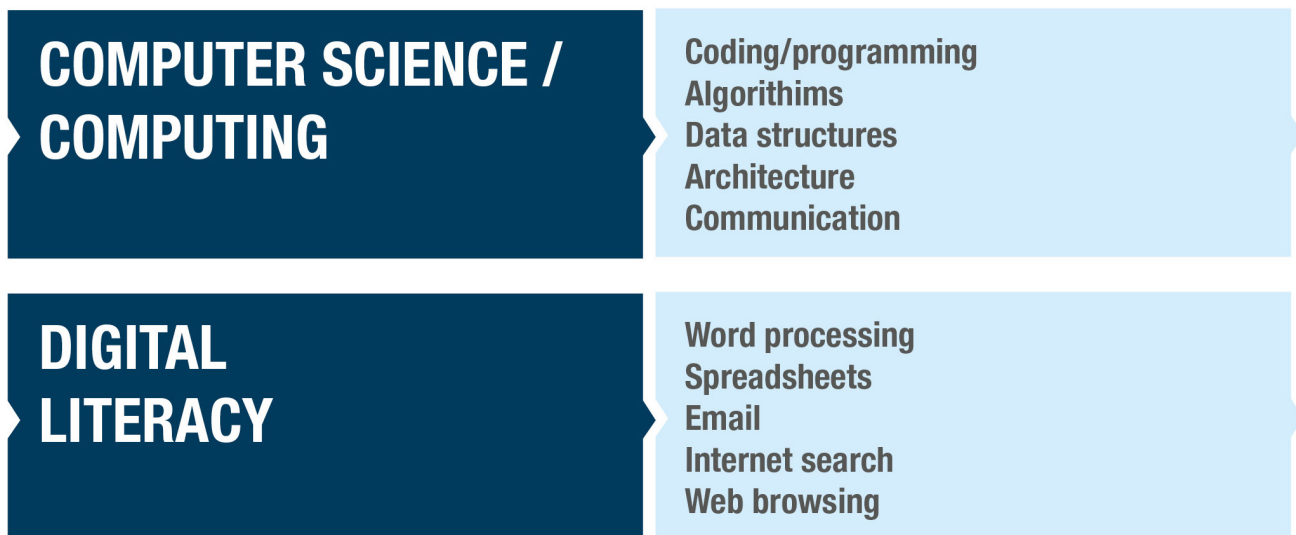
COMPUTER SCIENCE / COMPUTING	**Coding/programming Algorithims Data structures Architecture Communication**
DIGITAL LITERACY	**Word processing Spreadsheets Email Internet search Web browsing**

Figure 1: Defining the terms, computer science/computing and digital literacy

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[7] The International Society for Technology in Education (ISTE) "Operational Definition of Computational Thinking", https://www.iste.org/explore/articledetail?articleid=152

[8] ECDL Foundation "Identifying Essential ICT Skills and Building Digital Proficiency Through Appropriate Certification", http://www.ecdl.org/media/Digital_Proficiency_White_Paper1.pdf

[9] The Royal Society, "Shut down or restart? The way forward for computing in UK schools", 2012, https://royalsociety.org/~/media/education/computing-in-schools/2012-01-12-computing-in-schools.pdf

3   Different Approaches to Coding Skills Development

Discussions around digital skills development focus on coding as a key digital skill. On the one hand, this trend was stimulated by the fact that demand for ICT professionals in the labour market is rising and the absence of skilled ICT professionals is becoming more prominent. On the other hand, coding is promoted as a skill that develops logical thinking, problem solving and creativity, and constructs an understanding of principles behind digital technologies.

Following these arguments, countries inside and outside Europe have taken leadership around the development of coding skills. The European Commission has promoted coding through a number of initiatives including the Opening up Education Initiative[10], the European e-Skills for Jobs campaign[11] and the EU Code Week[12]. Former Vice-President of the European Commission, Neelie Kroes, advocated for the inclusion of coding in the school curricula of Member States[13]. The European Coding Initiative[14] was created under the auspices of the Commission, and is led by partners from the technology industry, including Microsoft, SAP, Rovio, Liberty Global and Facebook.

At the moment, three countries in Europe have integrated, or are planning to integrate, coding as an obligatory part of their primary school curriculum: England, Belgium (Flanders) and Finland[15]. Six European countries have indicated that coding is compulsory at upper secondary school level: Bulgaria, Cyprus, Czech Republic, Greece, Poland and Portugal[16]. However, in most of the countries, children can only learn how to code in afterschool activities led by volunteers, such as Coder Dojos (in May 2015, there were more than 675 Coder Dojo clubs in 57 countries), Code Clubs (over 3150 Code Clubs worldwide) or Rails Girls (227 events worldwide)[17].

Coding competitions are also organised in different countries. For example, in 2004, a computing competition for school students called Bebras took place in Lithuania. The initiative was soon picked up by different countries and in 2012, more than 500,000 students from 26 countries participated in it[18]. In October 2015, BBC Learning will hand out a million credit-card sized BBC Micro:bit computers to students in Year 7 (11- and 12-year-olds)[19]. These devices have a number of different features such as programmable buttons, LEDs, a Bluetooth connection, compass, temperature and moisture sensors, etc. The purpose of this initiative is to get children excited about digital technologies.

Initiatives around coding are also evident outside Europe. In the United States, the 'Hour of Code' campaign has been led by large technology companies such as Facebook, Google and Apple. The website of the campaign,

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[10] Communication COM(2013)654 final from the European Commission of 25 September 2013, 'Opening up Education: Innovative teaching and learning for all through new technologies and Open Educational Resources'.

[11] European e-Skills for Jobs campaign, http://eskills-week.ec.europa.eu/

[12] European Code Week, http://codeweek.eu/

[13] Neelie Kroes, Androulla Vassiliou, Open letter to the EU's education ministers, Brussels, 25 July 2014, Ares (2014).

[14] 'All you need is code' website, http://www.allyouneediscode.eu/

[15] European Schoolnet, "Computing our Future. Computer programming and coding – priorities, school curricula and initiatives across Europe", 2014.

[16] European Schoolnet, "Computing our Future. Computer programming and coding – priorities, school curricula and initiatives across Europe", 2014.

[17] https://coderdojo.com/, http://codeclubworld.org/, http://railsgirls.com/, http://map.railsgirls.com

[18] http://www.bebras.org/?q=about

[19] Margaret Rhodes "A Million Kids in the UK Will Get This Tiny Computer", http://www.wired.com/2015/07/bbc-microbit-computer/

Code.org, offers free beginner's tutorials for visitors to learn how to code and educational resources for teachers[20]. Similar materials are provided by another American website, Code Academy[21]. In Hong Kong, coding is available in some schools as part of the formal curriculum and it is offered by private learning centres as an after-school activity[22]. In Japan, the Information Processing Society has organised the 'SamurAI Coding' competitions for young people since 2012[23]. In the Middle East, the ArabCode.org initiative took off in 2015[24]. It seeks to teach coding and computer science skills to youth in the Middle East and North Africa through an interactive, game-based approach. The goal of the campaign is to provide the fundamentals of programming to 1 million young people from 8 years of age.

There are two points to make regarding these initiatives. First, different stakeholders (governments, the private sector, academia and NGOs) around the world recognise the importance of coding skills and are willing to support initiatives in this area. Second, there is no consistent approach across countries. Coding skills development varies from formal education to after-school activities and the promotion of on-line learning materials for independent learning. In order to ensure that these skills are developed in a consistent and high-quality manner, a standardised approach is needed.

England is the only country that has a consistent approach to teaching computer science as a discipline from the primary school level. Coding is delivered as one of the elements of the discipline and not as a separate subject. Digital literacy skills are developed as a part of the Computing curriculum so as to provide the basis for all other subjects. This approach distinguishes England as a country that has a holistic approach towards digital skills development.

One of the key problems in teaching computer science as part of the school curriculum is insufficiently skilled teachers. For example, at the beginning of the new school year, 60% of teachers in England did not feel comfortable with delivering the new curriculum[25]. Christine Gregory, the spokesperson of the Association of Teachers and Lecturers (ATL) in the UK declared that, "There just aren't the people in the schools at the moment with these skills. [Schools] can't just magic teachers out of the air."[26] A survey carried out by the European Schoolnet in 2014 revealed that this problem is prominent in all European countries[27]. It is strengthened by the fact that, due to the high demand for ICT professionals in the labour market, well-qualified ICT teachers are often lured away by ICT companies that offer better-paid jobs.

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[20] http://code.org/
[21] http://www.codecademy.com/
[22] http://www.bbc.com/news/business-32880185
[23] http://samuraicoding.info/
[24] http://www.arabcode.org/
[25] UK Digital Skills Taskforce "Digital Skills for Tomorrow's World", 2014, http://policy.bcs.org/sites/policy.bcs.org/files/Interim%20report.pdf.
[26] Roland Moore-Colyer, "Coding curriculum shake-up could solve looming skills gap but key concerns remain", 2 September 2014, http://www.v3.co.uk/v3-uk/analysis/2363062/coding-curriculum-shake-up-could-solve-looming-skills-gap-but-key-concerns-remain.
[27] European Schoolnet, "Computing our Future. Computer programming and coding – priorities, school curricula and initiatives across Europe", 2014.

4   Maintaining a Balance between Computing and Digital Literacy

ECDL Foundation believes that every child should have an opportunity to be exposed to the fundamentals of computing to the same extent that they learn Biology or Physics. The aim is not to transform all children into biologists, physicists or ICT professionals, but to provide them with the essential concepts of these disciplines. At later stages of education, children should be able to specialise in more complex disciplines of their choice.

Coding (or programming) should be taught as an element of computing and not as a separate subject. It encompasses the theory of computation, as well as various concepts that range from programming to data structures and architecture. In order to equip children with a full set of transferable skills and knowledge, all of these areas should be covered in formal education.

Computing should be taught together with digital literacy skills. Two misconceptions exist around digital literacy: the first is that young people are already skilled in using 'traditional' computer programmes, such as working with text documents and spreadsheets; and the second is the misconception that computer science is more important for employability than digital literacy skills.

The first misconception is based on the concept of 'digital natives', which implies that young people who grow up surrounded by digital technologies intuitively gain digital literacy skills, and therefore they do not need digital education or training. In fact, extensive research indicates that this is not the case. For example, the International Computer and Information Literacy Study (ICILS)[28], which assesses computer and information literacy skills of 60,000 eighth graders from 21 education systems all over the world, discovered that, on average, 17% of students do not reach the lowest level of their scale (e.g. performing basic communication tasks and adding simple content to information products) and only 2% score at the highest level, which requires the application of critical thinking while searching for information online. Moreover, the results of ICILS show that in 7 out of 9 participating EU countries, 25% of students demonstrated low levels of computer and information literacy[29] (more research on this topic can be found in ECDL Foundation's position paper on the Fallacy of the 'Digital Native'[30]). Therefore, it is crucial to ensure that the development of digital literacy skills is not replaced by computer science.

The second argument relies on the forecast of the European Commission that by 2020, Europe might face a shortage of up to 825,000 ICT professionals[31]. However, statistics show that ICT professionals form only around 5% of the total labour force in Europe[32]. In contrast, 90% of jobs will require at least basic digital skills by 2020[33] but 40% of

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[28] International Computer and Information Literacy Study (ICILS), "Preparing for Life in a Digital Age. The IEA International Computer and Information Literacy Study. International report". Springer Open, 2014.

[29] Ibid.

[30] ECDL Foundation, "The Fallacy of the 'Digital Native': Why Young People Need to Develop their Digital Skills", 2014, http://www.ecdl.org/digitalnativemyth.

[31] European Commission, 'Grand Coalition for Digital Jobs', http://ec.europa.eu/digital-agenda/en/grand-coalition-digital-jobs

[32] Tobias Hüsing "e-Leadership in Europe. Demand and Supply forecasts (2015-2020)", Brussels, 2 June 2015, http://leadership2015.eu/fileadmin/leadership2015/Presentations/07_Tobias_Huesing_empirica__FOR_WEB_PUBLICATION.pdf

[33] European Commission, 'Commission launches 'Opening Up Education' to boost innovation and digital skills in schools and universities', 25 September 2013, http://europa.eu/rapid/press-release_IP-13-859_en.htm

the European population has insufficient digital skills and 22% has none at all[34]. These numbers confirm that digital literacy skills development is as relevant as computing.
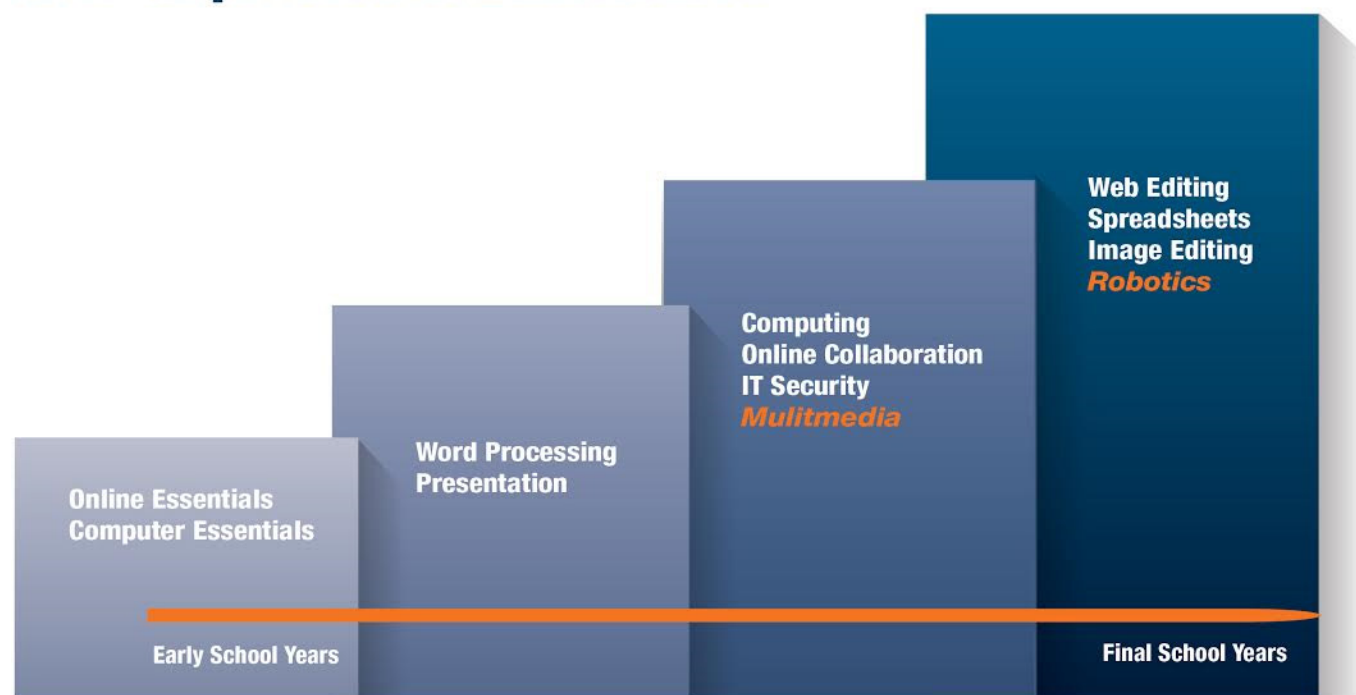

Figure 2: The concept of progressive digital skills development in education, ECDL Foundation

Figure 2 provides an example of how to balance digital literacy skills with computing from early to final school years. It includes the whole range of skills, from essential skills required to use a computer and get online, to computing and web editing. It is a representation of ECDL modules within the education space, but implementations of this model can vary from country to country. Modules marked in white are already commonly used in the education sector (the Computing module is currently under development) whereas modules marked in orange are examples of additional national modules that are offered in some countries.

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[34] Digital Agenda Scoreboard, "Digital Inclusion and Skills", 2014, https://ec.europa.eu/digital-agenda/en/news/scoreboard-2014-digital-inclusion-and-skills-eu-2014

5 Conclusions

- The definition of computing/computer science indicates that coding is merely one of the many elements of this discipline. Computing, when introduced to children in school, should begin with a broad focus on computational thinking and problem solving.

- Every child should have an opportunity to learn the fundamentals of computing at school. At later stages of education, they should be able to specialise in this discipline.

- Digital literacy skills are relevant for and support all other subjects. These skills should be developed together with, and be complementary to, computing.

- Teaching coding and computing varies substantially among different countries. In order to ensure that these skills are developed in a consistent and high-quality manner, a standardised approach is needed. It should encompass both computing and digital literacy as two substantial areas of digital skills. The standardised approach should serve as a guidance to develop teachers' digital competences in computer science that are scarce at the moment.

- ECDL Foundation provides a solution to standardised digital literacy skills training and certification in many schools across Europe. At the moment ECDL Foundation is actively engaged in exploring how to define the relevant essential skills and knowledge in the area of computing in a way that complements the acquisition of digital literacy.