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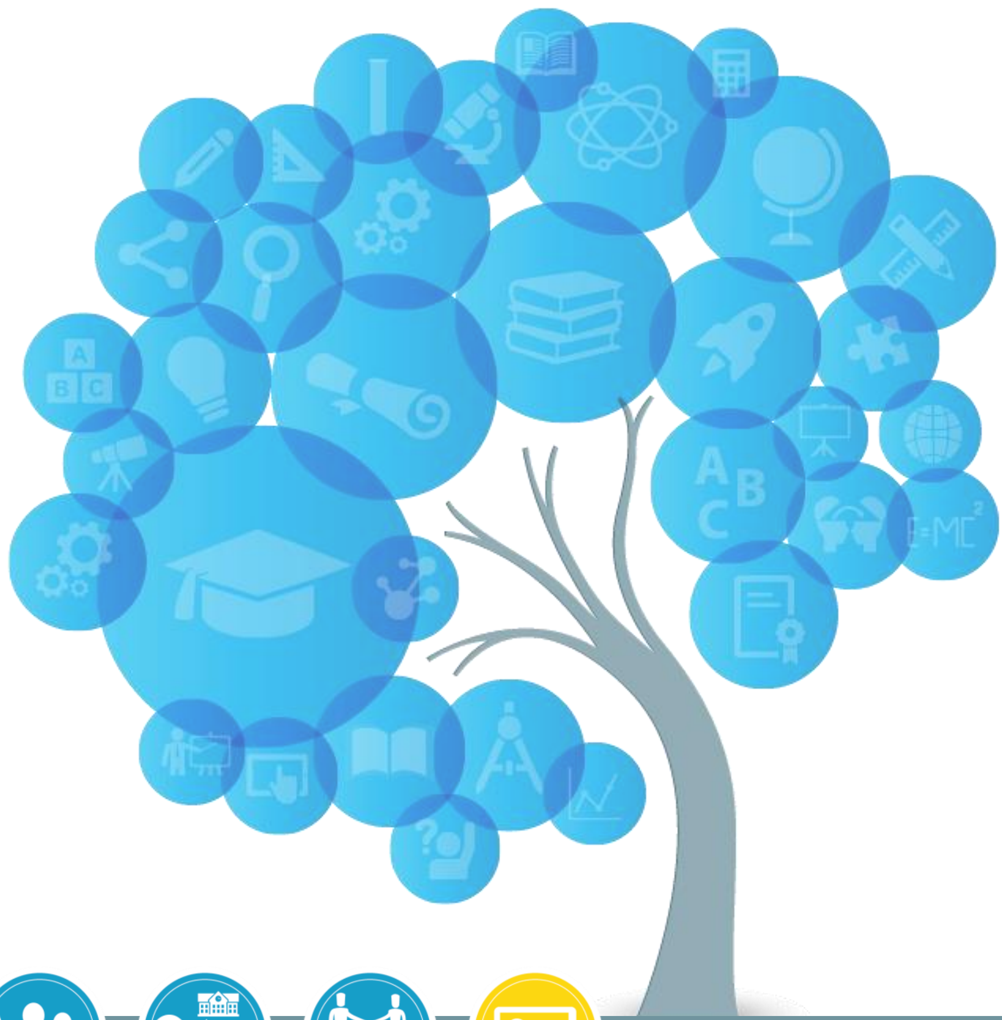

EEA Strategic Framework Working Group on Digital Education: Learning, Teaching and Assessment

Online plenary meeting
10 May 2022

Education and Training

Working Group Digital Education: Learning, Teaching and Assessment
Online Plenary
10 May 2022

Plenary meeting #3

Input paper: Digital skills in primary and secondary education

Introduction

Within the framework of the Digital Education Action Plan 2021-2027, the Commission will propose a Council Recommendation on improving the provision of digital skills[1] in education and training (Q1 2023). The proposal will articulate the steps needed to promote digital competence development from early on and at all stages of education and training and have a specific focus on the role that informatics can play.

This paper sets out some background for a discussion of the links between informatics and digital skills development and provides some preliminary observations to the members of the working group to allow them to reflect on the issues that arise from the current provision of digital skills.

During the WG meeting on the 10 May, members will hear three presentations:

1) Updates of the DigComp 2.2 framework, to include elements of AI and disinformation;
2) A recent study on computational thinking in compulsory education
3) A forthcoming report on informatics[2] in primary and secondary education across member states.

This input paper does not seek to repeat this content, but rather to highlight some aspects related to the links between them and to pose some questions that could steer the discussion.

Digital skills and competence

The European Commission proposed a definition of digital skills in the Council Recommendation on Key Competences for Life-long Learning[3]:

> Digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (including digital well-being and competences related to cybersecurity), intellectual property related questions, problem solving and critical thinking.

The European Commission published in 2013 the Digital Competence Framework for Citizens, which aims to provide a common reference framework of what it means to be digitally savvy in an increasingly globalised and digital world. The version 2.2[4] of the Digital Competence Framework has been recently published to include a wider array of examples of knowledge, skills and attitudes, also covering emerging digital technologies and practices.

The development of digital competence is included in the vast majority of Member States at all three education levels. The development of this competence (which touches upon several domains) is addressed in different ways in formal education in the member states. Digital skills can be inserted in the curricula as a transversal key competence (which entails that every subject in the curriculum shall include some aspects of digital skills development) or as a separate subject, as informatics or other.

[1] The expressions 'digital skills' and 'digital competence' are here used interchangeably as synonyms.
[2] The term informatics is used here as a synonym of computer science.
[3] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01)&rid=7#:~:text=Digital%20competence%20involves%20the%20confident,and%20for%20participation%20in%20society.)
[4] JRC Publications Repository - DigComp 2.2: The Digital Competence Framework for Citizens - With new examples of knowledge, skills and attitudes (europa.eu)

Informatics and digital competence

Informatics is often defined as the scientific discipline that underpins the competences needed to understand the digital world. As a discipline, it has evolved mainly in higher education settings. However, the need to boost students' digital competence development has led to recent reforms in many member states aiming to insert informatics in curricula in schools at both primary and secondary level.

A recent example of the argument for a greater concentration on informatics in schools is given in the 'Informatics Reference Framework for School'[5]:

> Informatics is the scientific discipline that underpins the digital world. Given its pervasiveness, it is essential to all disciplines and professions and has increasing importance as a school subject. Just as pupils learn about the living and the physical world in the natural sciences in school, all pupils should learn informatics in school so that they can flourish in the digital world. Informatics brings understanding to processes of modelling and manipulating real-world objects as well as their digital counterparts. The new way of thinking about problems and their solutions is of key importance for understanding our contemporary and future society, but informatics has limitations and dangers to be aware of.

Whilst digital technology is indeed pervasive, the value of informatics is not always recognised. This is perhaps because informatics is seen as focussing on advanced digital skills and as being only for ICT professionals. However, informatics can bring important new ways of thinking about and tackling problems to all students.

In order to understand the role that informatics can play in promoting digital competence development Table 1 maps the different areas of the 'Informatics Reference Framework for School' with the areas of the Digital Competence Framework.

Informatics Reference Framework	**Digital Competence Framework**
At the end of upper secondary education, pupils will:	
1. Use digital tools in a conscious, responsible, confident, competent and creative way.	Competence Area 1 1. Information and Digital Literacy
2. Understand the phenomena, concepts, principles and practices of informatics and the multifaceted ways of applying them to model, interpret, and operate on reality.	This is core informatics content, and is not clearly reflected in the Digital Competence Framework
3. Analyse, design, frame and solve problems by devising representations, designing algorithmic solutions and implementing these in a programming language.	Whilst informatics may well extend and deepen the discussion in these areas, much of this is already reflected in: Competence Area 3 Digital Content Creation – specifically - Competence 3.4 Programming • Competence Area 5 Problem Solving
4. Develop computational models to creatively investigate, understand and communicate about natural and artificial phenomena and systems.	This is core informatics content, and is not clearly reflected in the Digital Competence Framework
5. Identify, analyse and discuss ethical and social issues associated with computational systems and their use as well as their potential benefits and risks.	Ethical and social issues are mentioned specifically in: • Competence Area 1 Information and Data Literacy • Competence Area 3 Digital Content Creation • Competence Area 4 Safety. These topics are included in definitions of informatics as a subject, and informatics as an academic discipline clearly has an important role in these discussions, these topics have strong dependencies on other academic disciplines (e.g. psychology, sociology and ethics). Discussion of these topics are likely to benefit from being embedded in other subject areas, and also related to work on, for example, information literacy and media literacy.

Table 1

As is shown in Table 1, incorporating informatics into school education could help to support some aspects of digital competence[6]: There are areas where the informatics content

[5] The Informatics Reference Framework for School (release February 2022) (informaticsforall.org)

[6] One interesting and potentially useful new direction in teaching informatics is outlined in Hromkovič, J., Lacher, R. (2017). The Computer Science Way of Thinking in Human History and Consequences for the Design of Computer Science Curricula. In: Dagienė, V., Hellas, A. (eds) Informatics in Schools: Focus on Learning Programming. ISSEP 2017. Lecture Notes in Computer Science, vol 10696. Springer, Cham. https://doi.org/10.1007/978-3-319-71483-7_1

incorporates ideas, which go beyond digital competence as defined in the digital competence framework, particularly in the more academic aspects set out in items 2, 3 and 4. There are also areas where the digital competence framework goes beyond the informatics curriculum, especially in the competence areas related to use, critical use, and use in a personal context, which are closely related to information literacy and media literacy and perhaps better discussed within areas of actual application across the curriculum. Competence Area 3 Digital Content Creation may often be best taught, at least in part, in language, music, art, and media classes where digital content creation takes place.

Computational thinking

There are many contesting definitions of the term computational thinking. Grover & Pea, 2018)[7] define it in this way: "Computational thinking is the thought processes involved in formulating a problem and expressing its solution(s) so that a computer-human or machine can effectively carry it out", to which definition the authors add "Computational thinking is NOT «thinking like a computer»; rather, it is about thinking like a computer scientist".
Jeannette M. Wing's 2006 paper[8] sparked much of the present-day interest in the topic, and in an era when there was declining interest in computer science in universities, she proposed the teaching of computational thinking as a way of incorporating computer science thinking into other subjects. Thinking along similar lines Fessakis and Prountsoundi (2019)[9] argue that the term computational thinking is a "conceptual vehicle to facilitate the dialogue on the role of Computer Science in general education". So, computational thinking is closely connected with informatics, and might be seen as a gateway to informatics more generally. Whilst computational thinking is not specifically mentioned in the Digital Competence Framework similar ideas are reflected in part in Competence Area 3.4 Digital Competence Creation, most specifically in Competence 3.4 Programming, and in Competence Area 5 Problem Solving. However, though computational thinking is sometimes equated with teaching coding, most authors resist this equation. For example, Andreas Schleicher at OECD specifically argues against this equation:

> In today's technology-rich world, many schools have begun teaching coding, the language we use to instruct today's computers. It's a skill that is in high demand, and there are intriguing examples of schools across the world teaching it in ways that are relevant and engaging for students. But the risk is that we will again be teaching students today's techniques to solve tomorrow's problems; by the time today's students graduate, these techniques might already be obsolete. We should instead focus on the computational thinking that underpins these techniques – and that students can use to shape the technologies of tomorrow[10].

Teachers

If there is to be increased emphasis on teaching informatics and computational thinking in schools, then member states will need to address the issue of teacher supply. There is difficulty recruiting and keeping teachers in general in most countries, and, further, very few people trained in informatics are going into teaching.
A Royal Society report highlighted the cycle of factors which negatively impact on computing teaching[11],arguing that interventions are required at more that one point to break this cycle.

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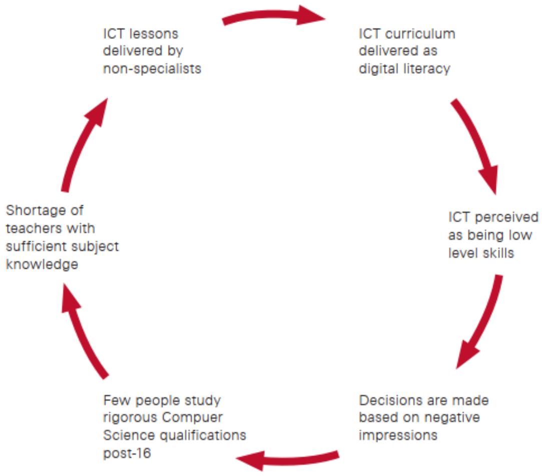
[7] Grover, S., & Pea, R. (2018). Computational Thinking: A competency whose time has come. In S. Sentance, E. Barendsen, & S. Carsten (Eds.), Computer Science Education: Perspectives on Teaching and Learning in School (pp. 19–38). Bloomsbury Publishing.
[8] Wing, J. M. (2006). Computational thinking. Communications of the ACM, 49(3), 33–35. https://doi.org/10.1145/1118178.1118215
[9] Fessakis, G., & Prantsoudi, S. (2019). Computer Science Teachers' Perceptions, Beliefs and Attitudes on Computational Thinking in Greece. Informatics in Education, 18(2), 227–258. https://doi.org/10.15388/infedu.2019.11
[10] Should schools teach coding? | LinkedIn
[11] Royal Society (Great Britain). (2012). Shut down or restart? https://royalsociety.org/-/media/education/computing-in-schools/2012-01-12-computing-in-schools.pdf



Since the supply of teachers with good informatics background is likely to be limited, and yet crucial to the implementation of informatics in schools, it may be appropriate to identify the most effective use of the teaching resource that is available.

Teaching Informatics

Even where informatics is taught by a teacher with a good knowledge of informatics, there is a sometimes a perception that it is poorly taught. It is arguable that yet have an adequate pedagogy for informatics. For example, in a blog post looking back on 10 years since the publication of her paper on computational thinking Jeanette M. Wing comments[12]:

> There also are interesting research questions that I would encourage computer scientists to pursue, working with the cognitive and learning sciences communities. First, what computer science concepts should be taught, when, and how?
>
> What is that progression in computer science? For example, when is it best to teach recursion?

In examining the curriculum for computing in schools a UNESCO/IFIP TC3 meeting in 2018 also reported that:

> The development of Computer Science/Informatics school curricula is impeded by insufficient empirical evidence of student learning in order to support content definition and sequencing[13]

Historical note: the case of UK

In the UK, computer science (or computer studies) was quite widely taught in schools in the 1980s (Appendix J of the Royal Society report[14] and Brown et al (2014)[15]). These early computer science courses in schools were not always well received because lack of teacher expertise led to poor teaching and university computer science departments found that students who studied computer science at school acquired poor programming habits. An example of this argument at the time from the USA is this comment by Stallard, C. K. (1987)[16]:

> Many professors of computer science wish schools would leave alone such matters as computer programming for college-bound students. They feel that students are taught improperly and, as a result, develop bad habits of thought and of programming style. Much of the college-level effort must be to unteach what was improperly taught earlier. Many professors say that those who enter computer science programs in college with no prior experience have an advantage.

[12] Computational thinking, 10 years later (phys.org)
[13] https://wcce2022.org/pubs/UNESCO%20meeting%20at%20OCCE%202018%20report%20final.pdf
[14] https://royalsociety.org/-/media/education/computing-in-schools/2012-01-12-computing-in-schools.pdf
[15] Brown, N. C., Sentance, S., Crick, T., & Humphreys, S. (2014). Restart: The resurgence of computer science in UK schools. ACM Transactions on Computing Education (TOCE), 14(2), 1-22. Restart: The Resurgence of Computer Science in UK Schools: ACM Transactions on Computing Education: Vol 14, No 2
[16] Stallard, C. K. (1987). Computers for Education: On What Basis Do We Proceed?. The Clearing House, 61(4), 154-156. https://doi.org/10.1080/00098655.1987.10113928

As computers became more commonly available there was a desire to see them used to support education more widely and not just to support teaching programming in computer science, and this resulted in the dropping of computer programming and the incorporation of teaching of computer applications in the UK National Curriculum from 1988 onwards[17] under the umbrella of Information and Communication Technology (ICT). In 2016, after some 20+ years of teaching ICT, there was much expressed dissatisfaction with this curriculum[18] as being a poor preparation for living and working in more digital times, and there was a switch back in the UK to a more computer science-oriented approach and 'Computing' became a compulsory subject in the UK National Curriculum.

However, whilst this curriculum change in the UK has certainly had had some successes it has also faced serious challenges in implementation[19] and a study by Laura Larke at the Oxford Internet Institute in 2019 identified aspects of teachers' resistance to the new curriculum, concluding:

> Policymakers and others directly involved in the creation of this curriculum did not adequately account for how state schools and their teachers would interpret this new policy, the impact it might realistically have on young people's relationship with modern digital technologies, and whether there might be a mismatch between the pro-technology narratives represented in this curriculum and the everyday beliefs and experiences of today's teachers. The teachers in this study were using their professional judgement to modify or reject outright England's National Curriculum computing standards by minimizing or ignoring subject content that they saw as redundant or less than critical to their students' success, or that they felt they did not have the training, experience, resources, or time necessary to teach.[20]

Two other perspectives on the future of teaching digital skills

To put the discussion of the place of informatics in relation to digital competence into a wider context, it may be valuable to highlight some other perspectives about ways of in which teaching digital skills in schools should be further developed. The most important discipline, alongside informatics, which underpins the development of digital skills is, arguably, **media literacy**. The following quote from David Buckingham provides a taste of what media literacy sees as the fundamental issues in relation to digital media:

> What we study are forms of representation and communication that are socially organized and distributed. With social media, these forms of representation and communication – written, visual, aural, audio-visual, musical – are generated, and then shared and circulated, in rather different ways. All media are social; but these new platforms would perhaps be better termed sociable media – they offer opportunities for circulation between individuals, not just distribution by large corporations. What makes these media social or sociable are the social practices they make possible, which depend upon particular forms of connection or connectivity.[21]

Neil Selwyn provides another perspective, calling for development beyond digital literacy towards 'algorithmic literacy' in the context of AI and data-driven systems[22] focussing on the need for the citizen's awareness of these issues, rather than on the IT specialist's skills in developing such systems. He references Frank Pasquale who talks about the importance of public education in order to counter the emergence of a 'black box society', where automated decisions are made that citizens are certainly not part of, and usually not aware of.

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[17] the arguments for this are perhaps most clearly expressed in the McKinsey report of 1997 https://rubble.heppell.net/stevenson/McKinsey.pdf

[18] https://royalsociety.org/-/media/education/computing-in-schools/2012-01-12-computing-in-schools.pdf

[19] https://royalsociety.org/~/media/events/2018/11/computing-education-1-year-on/after-the-reboot-report.pdf

[20] Larke, L. R. (2019). Agentic neglect: Teachers as gatekeepers of England's national computing curriculum. British Journal of Educational Technology, 50(3), 1137-1150.

[21] Teaching social media: a critical media education approach | David Buckingham

[22] What should 'digital literacy' look like in an age of algorithms and AI? – Parenting for a Digital Future (lse.ac.uk)

Questions for reflection

What and why

- How is your country/organisation approaching the different aspects that relate to digital skills? Is there a specific aspect that is privileged? Why?
- What are the underlying reasons and rationale for 'teaching' digital skills in your country/organisation? What are the expected benefits?
- What are the objectives related to digital skills development? Why do we want to achieve this?
- What are the benefits of informatics on school education? What are the shortcomings?

Where

- What is the place of digital skills in the curriculum?
- How are digital skills taught or developed in primary and secondary education in your country? What discipline/subject are they related to? Are the following approaches pursued (*Informatics; Digital /Media Literacy; Computational Thinking*)?
- What choices are made in relation to curricula? Are digital skills taught as
    - A cross-curricular theme?
    - A separate subject (compulsory or elective)?
    - A theme within another subject?

When

- How are those choices unfolding in the different levels of education (and training)? At what age is this starting? What is the rationale for the progression?
- What would be a good school level to incorporate informatics (primary/lower secondary/upper secondary)?
- How are learning outcomes of secondary schools related to the study of informatics in Higher Education or Vocational Education?

Whom?

- What choices are made in terms of teachers that support the development of digital skills? Are there issues related to recruitment/retention?
- Is the supply of teachers with good Informatics backgrounds limited?
- What is the teacher training provision for supporting teachers in developing their students' digital skills?