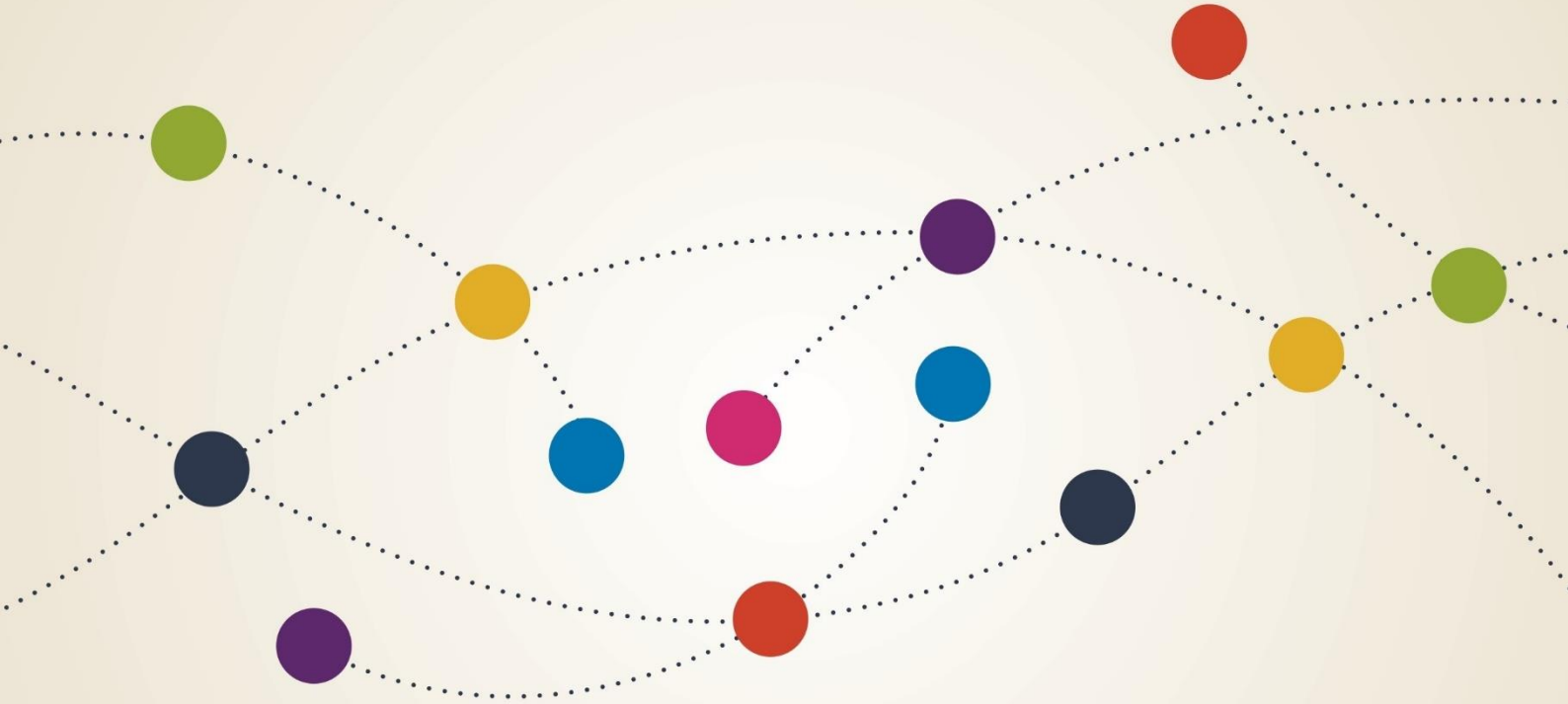

Desktop audit of coding in the primary curriculum of 22 jurisdictions

NCCA
An Chomhairle Náisiúnta Curaclaim agus Measúnachta
National Council for Curriculum and Assessment

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Desktop audit of coding in primary curriculum of 22 jurisdictions

Computer science and coding and their place in the primary curriculum is a key topic for education debate currently and, in particular, following the Minister's request to the NCCA to consider approaches to integrating coding into the primary curriculum. This short paper is a desk-top audit that takes a policy analysis approach to gathering evidence of coding in the school curricula of 22 jurisdictions. The audit aims to inform discussions about the place of coding within a primary curriculum and to identify approaches for consideration by the NCCA. Current approaches to computer science and coding in the compulsory school curricula for primary and post-primary schools are discussed, however, it is the approaches used at primary level that are of greatest interest and relevance to the paper. Developments at post-primary level are included to help locate primary developments within the overall context of curriculum policy in a particular jurisdiction.

A broad range of jurisdictions were included in the audit: neighbouring UK systems due to their obvious cultural similarities, Scandinavian and other European jurisdictions which appear to be leading developments in this area, United States owing to their strong emphasis on research-driven approaches, and finally Pacific and Asian countries which have emerged as leading trends in technology and ICT within curriculum policy.

1. Australia
2. Austria
3. Canada
4. Estonia
5. Finland
6. France
7. Germany
8. Hong Kong
9. Italy
10. Japan
11. Lithuania
12. Netherlands
13. New Zealand
14. Poland
15. Portugal
16. Scotland
17. Slovakia
18. South Korea
19. Spain
20. UK (England)
21. United States
22. Wales

While it is beyond the scope of this audit to explore what lies exactly behind this emerging trend, the rationale and impetus for the increased integration of computer science across school curriculum offered by the jurisdictions audited tend to stem from both an educational and economic agenda. The majority of the jurisdictions that have integrated or plan to integrate computing into their curricula aim to develop core educational skills such as logical thinking skills, coding skills or core competencies, e.g., problem-solving. However, for many jurisdictions, the decision to introduce computing was also linked to a desire to encourage students to study further in computer science as well as a direct response to the needs of the job market (European Schoolnet, 2015). For example, the Computer Science for All (CSfA) initiative in the US has an outright aim of *offering ever student the hands-on computer science that make them job-ready on day one*[1].

Relevant curriculum developments in Ireland

In the Irish primary curriculum (DES, 1999), ICT is subject neutral; there is no separate curriculum for ICT or its equivalent. The curriculum acknowledges the role of technology in enriching teaching and learning and provides practical suggestions for how schools might use technology in their work with children. Further support was provided to schools in 2004 with the publication of *Information and Communications Technology (ICT) in the Primary School Curriculum: Guidelines for Teachers*. The guidelines provide teachers with supports on planning for ICT in the school and in the classroom, and include a range of exemplars based on classroom practice showing how to use ICT to add value to teaching and learning across the curriculum. Building on these guidelines, further support was given to schools in 2007 with the launch of the *Framework for ICT in Curriculum and Assessment* which outlines the kinds of learning experiences with ICT (knowledge, skills, and attitudes) a student should be afforded through their primary and post-primary education. Since then, there has been a number of developments at post-primary level. In 2007, a Design and Communication Graphics (DCG) course was made available at senior cycle intending to develop the creative

[1] Stated by US President Barack Obama in his 2016 State of Union Address. For more see https://www.whitehouse.gov/blog/2016/01/30/computer-science-all

thinking and problem solving abilities of students. This course promotes skills such as graphicacy/graphic communication, creative problem solving, spatial abilities/visualisation, design capabilities, computer graphics and CAD modelling. Furthermore, in 2014, an optional short course on coding for the new junior cycle (12-15 year-olds) was introduced. Plans are also underway to develop a curriculum specification for computer science for senior cycle. Recently, interest for including elements of computer science in the primary curriculum has focused on 'coding' and the uses of and development of programming, together with the foundational skills of computational, flexible and creative thinking and problem-solving.

Key findings emerging from the audit

- Computer science and coding are increasingly integrated within curriculum policy at primary education level in other jurisdictions. The degree of integration varies across jurisdictions.
- In some countries, for e.g. Italy and the US[2], national initiatives have been introduced to address the computer science and coding agenda. These initiatives aim to filter down to school systems through investment in training teachers, expanding access to high-quality infrastructure and instructional materials and building regional partnerships.
- In 2014, the UK was the first country to introduce coding as a mandatory component of the (computing) curriculum at primary level[3]. Since then, Slovakia, Poland, Finland and France have also introduced coding as a mandatory component in the primary curriculum.
- The location of coding within the curriculum varies across jurisdictions. In Finland and France, coding is a cross-curricular activity. While in England, Slovakia and Poland, coding is part of a broader computer science subject[4].
- With the exception of Finland where coding is a purely cross-curricular activity, coding is typically located within a computer science curriculum (or an equivalent). Where this particular curriculum is not yet part of curriculum policy in a jurisdiction, coding is mostly integrated within mathematics or science curricula.
- In some jurisdictions, e.g., England and Finland, coding is introduced to children from an early age (5+ years). While other jurisdictions, e.g., France and Spain (Navarra) do not introduce coding until later in the primary years (10+ years).

Table 1 provides an overview of approaches to coding within the primary curriculum of the 22 jurisdictions. Table 2 provides additional contextual information for the jurisdictions.

2 In support of the initiatives Computer Science for All (CSfA) in the US, $4 billion has been allocated in funding for states and $100 million directly for school districts to expand K-12 computer science education.

3 Computing is mandatory in state masintained schools but not in academies, free schools and independent schools, although many will teach it.

4 Computing (England), Informatics (Poland & Slovakia)

Table 1: An overview of approaches to coding across 22 jurisdictions

Jurisdiction	Mandatory	Currently integrated	Plan to integrate	Age
Australia		Depends on regional or school curricula	Yes *No date announced*	
Austria		Depends on regional or social curricula		
Canada (British Columbia)			Yes *From 2019*	Age 5+
Estonia		On voluntary basis		
Finland	Yes *From 2016* (Cross-Curricular)	As cross curriculum activity		Age 5+
France	Yes *From 2016 (*Cross-Curricular)	As cross curriculum activity		Age 12 +
Germany		Piloted in some states		Age 12+
Hong Kong		Elective course in some schools		
Italy			Yes *From 2015*	
Japan			Yes *From 2020*	
Lithuania			Yes *No date announced* (algorithms only)	

Jurisdiction	Mandatory	Currently integrated	Plan to integrate	Age
Netherlands		On voluntary basis		
New Zealand				
Poland	Yes *From 2016* (within 'Informatics')			
Portugal		Piloted in 3rd & 4th grade *From 2016* (Extra-curricular activity)		Age 9-10
Scotland				
Slovakia	Yes *From 2015* (within 'Informatics')			
South Korea			Yes *From 2019*	
Spain (Navarra)		Yes (within 'mathematics')		Age 10-12
UK (England)	Yes *From 2014* (within 'computing')			Age 5+
United States			Yes *No date announced* (within 'computer science')	
Wales		On voluntary basis	Yes *From 2016* (as part of digital competency framework)	

Table 2: Additional contextual information

Country	Approaches to coding in primary curricula across 22 jurisdictions
Australia	At primary school level, the teaching of computer science or informatics is not mandated in any jurisdiction presently. Each State offers students a subject in IT/ICT[5] in their final years' of schooling (Years 11 and 12). As part of the 'Advancing Education Plan', Queensland plan to make coding and robotics compulsory in schools from Pre to Year 10 (age 5-16). Every state school will have access to specialist science, technology, engineering and maths teachers, and a Queensland coding academy will be set up to assist with the teaching of the skill (Sadler, 2015) The State of Victoria has committed to delivering a Digital Technologies Curriculum in 2016 to all levels of schooling. It is likely that this curriculum will be initially introduced as an elective subject in lower secondary (Year 9), a date for introduction at primary has not been announced (Reynolds, 2015)
Austria	No mandatory programme at primary level. Mandatory ICT/Informatics Education is only in grade 9 (age 14 years) (Futschek, 2015)

5 In 2015, Victoria implemented a suite of final years of schooling (Years 11 and 12) in computing, algorithmics and informatics

Country	Approaches to coding in primary curricula across 22 jurisdictions
	Coding is integrated in some schools in the form of school trials. It depends on regional or social curricula, whether coding is compulsory or not.
Canada	British Columbia – Currently rewriting k-12 curriculum to include coding courses and computational thinking. Developments will take place over the next three years.
	Ontario - There are no mandatory computer science programs in the Ontario curriculum, and no elective computer courses until Grade 10. There have been no public claims made about plans for introducing this.
Estonia	No mandatory programme at primary level. In 2012, launched a pilot programme, ProgeTiiger, to teach programming to all students from grades 1 to 12 (From age 5+). Funded by the state-backed Tiger Leap Foundation, this is a voluntary education programme for schools, taught by teacher enthusiasts
Finland	From 2016, Finland will be the first country to introduce coding as a mandatory, purely cross-curricular activity. It is not a specific course or separate subject area. ICT competency is one core competency of the Finnish curriculum. The curriculum does not use the word code but rather computational thinking and programming.

Country	Approaches to coding in primary curricula across 22 jurisdictions
	For example - ICT competences in grades 1-2: “Pupils receive and share experiences in working with digital media as well as age-suitable programming.” (OPS 2016, 101). In post-primary schools, there are ICT driving license courses and quite a number of specialised courses like programming or numerical mathematics (Koivisto, 2015). Robotics has been introduced more recently.
France	Computer science has been an elective subject for students in the scientific stream in general high schools (Year 10+) for a number of years (Grandbastien, 2015) From the beginning of the 2016 academic year, coding will be implemented as part of the primary school curriculum from Year 8 (aged 12). At lower primary level, there is no mandated programme, rather teachers are encouraged to offer extra-curricular activities that pave the way for ‘IT Thinking’ (Terosier, 2016). This may include optional programming courses teaching the basics of programming and simple applications
Germany	Federal Government has recently recommended for improvement of the implementation of ICT-education in school curricula. The curriculum is the responsibility of States.

Country	Approaches to coding in primary curricula across 22 jurisdictions
	Neither computer science nor coding are mandatory school subjects, however most states offer computer science programmes as elective courses from 5 éme to Términale (Ages 12 – 18) 'Informatics' as a primary level subject is being piloted in some states though there is no mandatory programme for this (Magenheim, 2015).
Hong Kong	No mandatory programme at primary level. Computer literacy is commonly taught but programming/ coding receives less attention. A syllabus from the Education Bureau that sets out requirements for junior secondary school students in computer literacy was last updated in 1999. Coding is an option available in some schools (most private) as part of the formal curriculum and it is offered by some private learning centres as an after-school activity in out-of-school private study centres e.g. First Code (ECDL, 2015)
Italy	For computer science education, a policy is present for specialised education (e.g. upper secondary technical schools). A national optional initiative 'coding the future"' has been launched with the aim of introducing primary school pupils to basic computer science concepts through coding. Italy plan to introduce digital education at the primary level with aims to have "computing logic" in 40% of primary schools by 2017 (Bottino, 2015)

Country	Approaches to coding in primary curricula across 22 jurisdictions
Japan	Currently, no special course for learning informatics or ICT is stated officially at the elementary stage. Lower secondary schools have informatics and programming curricula as a part of 'Technology and Home Economics', which is one of the compulsory subjects determined by the Ministry. (Saita, 2015) The Ministry for Education plans to make computer programming a compulsory subject in primary schools by 2020, middle schools by 2021, and high schools by 2022 (Japan News, 2016) In the interim, it is likely programming will be integrated in 'science' or 'integrated study' curricula.
Lithuania	The tradition of coding in national curriculum dates back to 1986. Coding is part of secondary school curriculum, provided through general ICT/ Technology courses. A large number of ICT learning objectives are included in central steering documents, which include less common objectives such as programming skills and knowledge of computer hardware. (Dagiené, 20015) It is planned to integrate the teaching of algorithms at primary school level (European Schoolnet, 2015)
Netherlands	At K-12 level, there is no mandatory teaching in digital literacy. Most schools, however, expect pupils to have basic knowledge by the end of primary school. The Dutch department of education recently launched 'Onderwijs 2032' to start a national dialogue on the very basics of what education should provide for pupils by the end of schooling.

Country	Approaches to coding in primary curricula across 22 jurisdictions
	As an aside, the Dutch NGO CodeUur has provided 635 schools with coding lessons for kids and teachers and is looking at new ways to integrate coding into the national curriculum.
New Zealand	Currently, a review of the curriculum is taking place. This review aims to look at whether the inclusion of digital technologies in the curriculum is explicit, whether it should remain as part of the technology learning area or become a separate learning area, at what level students should begin learning in digital technologies.
Poland	From 2016, programming (coding) will be integrated within subject 'Informatics' at all school levels. Previously informatics was offered by some schools as a taught option. 'Extended informatics' was available as an optional course in secondary education (age 15+).
Portugal	No mandatory programme at primary level. Last year, a pilot was launched that introduced coding to students of the 3rd and 4th grade (Age 9-10) in the 2015/16 school year as an extra-curricular activity.
Scotland	No mandatory programme at primary level.

Country	Approaches to coding in primary curricula across 22 jurisdictions
	Education in Scotland is currently going through the final phase of a long-term redesign process -Curriculum for Excellence CfE. They are also in the process of developing a strategy for digital learning[6]. Part of the new curriculum (CfE) for the first three years of secondary includes specific outcomes for Computing Science. After the 'S3' (third year of secondary) stage, students can study Computing Science on an optional basis.
Slovakia	Algorithmic thinking and computer programming (coding) is developed in the compulsory school curriculum subject 'Informatics' at both primary and secondary level. The focus is on algorithmic problem solving and thinking, programming, creation of instructions and programmes. At primary level, children learn to programme and control robots, design model toys and skils, programming steps and phases and children's programming language. In some gymnasiums (advanced secondary school), coding is offered as a separate subject (European Schoolnet, 2015)
South Korea	South Korea has a highly digital society and a long tradition of teaching computing in schools. At all levels of school in South Korea the curriculum contains a substantial amount on the use of computers (ICT)

6 For more information see http://www.gov.scot/Publications/2016/03/9409

Country	Approaches to coding in primary curricula across 22 jurisdictions
	Since the revised curriculum in 2009, Computer basics and how to use algorithms, programming, problem solving, representing information, computer networks and computer ethics are taught as an elective course within the middle and high school curriculum (Kimn, 2015) Coding as a compulsory subject is set to become part of the primary school curriculum in 2019, and in middle school grind from 2017.
Spain	In 2015, the Madrid Regional Government introduced the CODE Madrid programme to teach programming and robotics at secondary level (Kloos, 2015) Coding has been introduced in the 'Tecnologías de la Información y la Comunicación I' curriculum from the 2016 school year (for the whole country) as an optional subject in upper secondary education.
	*** In the autonomous Community of Navarra (region of Spain), curriculum content connected to algorithmic and coding has been included in the mathematics curriculum (for the final two years of primary school, 10-12 years) (European Schoolnet, 2015)

Country	Approaches to coding in primary curricula across 22 jurisdictions
UK (England)	Introduced as a mandatory component of the computing curriculum in 2014, currently the only country to mandate coding as a curriculum subject at primary level[7]. Computing is a distinct subject in primary school curricula but schools are free to teach it as an integrated subject or stand-alone. Teaching as an integrated subject is more common at primary than secondary level, where cross-curricular work is less common. The UK 'Computing' curriculum defines the core of computing as part of computer science. Children are taught the principles of information and computation, how digital systems work and how to put this knowledge to use through programming/coding (Berry, 2013) Computing Curriculum objectives at Key Stage 1 (5-6 year-olds): Children will be learning what algorithms are, which will not always involve computers. When explained as "a set of instructions" teachers may illustrate the idea using recipes, or by breaking down the steps of children's morning routines. But they will also be creating and debugging simple programs of their own, developing logical reasoning skills and taking their first steps in using devices to "create, organise, store, manipulate and retrieve digital content".

7 Computing is mandatory in state maintained schools but not in academies, free schools and independent schools, although many will teach it.

Country	Approaches to coding in primary curricula across 22 jurisdictions
United States	In January 2016, President Obama announced plans to invest $4billion in computer science education through initiative Computer Science for All (CSforAll). Google and other information-related business are currently setting up websites to promote CS education programmes free of charge. Following this announcement - a group of state and territory leaders who belong to the Expanding Computing Education Pathways (ECEP) Alliance from Alabama, California, Connecticut, Georgia, New Hampshire, South Carolina, Maryland, Massachusetts, Puerto Rico, Texas, and Utah have developed five-year plans to grow CS, broaden participation in computing, and develop teachers. ***Researchers in California have compiled research into the integration of CS into math and science curriculum[8].
Wales	No mandatory programme at primary level. Similar to Ireland, in primary schools, coding activities are incorporated into the timetable informally by teacher enthusiasts. Coding clubs and competitions e.g. Coderdojo, Google Call to Code and Decoded are popular.

8For more information see: https://edsource.org/2016/teaching-math-with-computer-programming-can-help-narrow-achievement-gap/563371

Country	Approaches to coding in primary curricula across 22 jurisdictions
	The Welsh Government who, as part of the development of a new curriculum for Wales, will be making a Digital Competency Framework available in September 2016. It is expected that coding and programming will feature as part of this framework.

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