International Journal of Computer Science Education in Schools, March 2023, Vol. 6, No. 1

ISSN 2513-8359

A Brief History of K-12 Computer Science Education in Ireland

Roisin FAHERTY[1]
Karen NOLAN[1]
Keith QUILLE[1]
Brett A. BECKER[2]
Elizabeth OLDHAM[3]

[1]TU Dublin, Ireland
[2]University College Dublin
[3]Trinity College Dublin

DOI: 10.21585/ijcses.v6i1.148

Abstract

This paper unites the history of Computer Science (CS) Education in Ireland by plotting Ireland's roadmap leading to the implementation of formal Computer Science Education in schools. It first outlines the educational system in Ireland. The history roadmap starts in the 1970s with the first notions of introducing computing in post-primary school, and then continues up to the roll-out the CS curriculum in Ireland at the Senior Cycle level in 2018. The story is chiefly available in disparate publications and reports, so piecing together the entire story is often difficult. This paper collates the available literature, together with the authors' local knowledge of the process, into one paper that may be of interest locally and of value to other jurisdictions beginning their planning of national curricula. The paper describes the development and the current situation of the formal curricula in CS at second level. The current landscape of Computing Education at primary level, which at the time of writing is in the planning stages in Ireland, is described. Additionally, an investigation into the introduction of Computing Education in schools in the international jurisdictions that directly influenced the Irish roll-out takes place, to summarize any lessons learned that might provide insights for Ireland going forward.

Keywords: Computer Science Education, K-12, Computer Science Education Ireland

1. Introduction

The Irish K-12 education system has two levels, primary school and post-primary school. Primary school is for children aged between 4 years and 12 years approximately and is made up of eight educational years: Junior Infants, Senior Infants, and 1st to 6th Class inclusive. At the end of primary school children move into post-primary school. Post-primary schooling is six years in length divided into two sections: the Junior Cycle (1st to 3rd year) and Senior Cycle (4th, 5th and 6th Year). The 4th Year ("Transition year" or TY) is not a mandatory element of the Senior Cycle in Ireland. Schools can optionally offer this year which centres around personal growth of students (NCCA, Transition year, 2021). The Junior Cycle has terminal state assessment, until recently was called the Junior Certificate (JC). The Senior Cycle has a terminal state exam called the Leaving Certificate (LC), the results of which are used to determine university entry. These two educational levels in Ireland are the equivalent of K-12 in the US, and primary and secondary school in the UK. For a detailed comparison with other jurisdictions (see Figure 1) (Falkner, et al., 2019).

COUNTRY	AUSTRALIA (AUS)	ENGLAND (ENG)	IRELAND (IRL)	ITALY (ITA)	MALTA (MLT)	SCOTLAND (SCO)	US
AGE* (Years)							
2+				Pre-school	Kindergarten	Pre-school	Pre-school
3	Pre-school	Pre-school	Pre-school	Kindergarten	Kindergarten	Pre-school	Pre-school
4	Kindergarten	Pre-school	Junior Infants	Kindergarten	Kindergarten	Pre-school	Pre-school
4-5	Reception/ Foundation	Reception	Senior Infants	Kindergarten	Year 1	Primary 1	Pre-school
5-6	Year 1	Year 1	First Class	First class primary	Year 2	Primary 2	Kindergarten
6-7	Year 2	Year 2	Second Class	Second class primary	Year 3	Primary 3	Grade 1
7-8	Year 3	Year 3	Third Class	Third class primary	Year 4	Primary 4	Grade 2
8-9	Year 4	Year 4	Fourth Class	Fourth class primary	Year 5	Primary 5	Grade 3
9-10	Year 5	Year 5	Fifth Class	Fifth class primary	Year 6	Primary 6	Grade 4
10-11	Year 6	Year 6	Sixth Class	First class lower high school	Year 7	Primary 6	Grade 5
11-12	Year 7	Year 7	First Year	Second class lower high school	Year 8	Primary 7	Grade 6
12-13	Year 8	Year 8	Second Year	Third class lower high school	Year 9	S1	Grade 7
13-14	Year 9	Year 9	Third Year	First class higher school	Year 10	S2	Grade 8
14-15	Year 10	Year 10	Transition Yr.	Second class higher school	Year 11	S3	Grade 9
15-16	Year 11	Year 11	Fifth Year	Third class higher school	Sixth form lower	S4	Grade 10
16-17	Year 12	Year 12	Sixth Year	Fourth class higher school	Sixth form higher	S5	Grade 11
17-18		Year 13		Fifth class higher school		S6	Grade 12

Figure 1. School levels across different jurisdictions (Falkner, et al., 2019)

In Ireland, in 2020, there were 3107 primary schools (Department of Education, 2019) and 722 Secondary schools (Department of Education, 2019). The breakdown of the different types of these schools can be seen in Table 1 and Table 2.

Table 1. Primary School Breakdown

School Type	**N**
DEIS	688
Mainstream	2419
Male Only School	162
Female Only School	90
Mixed Schools	2855
Total Schools	**3107**

Table 2. Post-primary School Breakdown

School Type	**N**
DEIS	198
Mainstream	524
Male Only School	101
Female Only School	128
Mixed Schools	492
Total Schools	**722**

One of the most significant events in Ireland's formal Computer Science Education (CSEd) history was the introduction of Leaving Certificate Computer Science (LCCS) curriculum which became a reality in Ireland in September 2020, when any school could elect to offer the subject to students (NCCA, Leaving certificate computer science, 2019). The details on the specification of this subject will be covered in section 3.3. This moved Ireland a step closer to the realization of offering an education in CS to all students at all educational levels in Ireland. Phase one of the new LCCS subject was rolled out to 40 schools in 2018, completing in June 2020. It has taken almost fifty years of canvasing and effort to have this subject available formally at Senior Cycle level in Irish schools. The provision of such a subject is no small task given the changing nature of the area as well as the need to ensure teachers are well prepared to deliver such a new subject. In order to understand the landscape of CS in the Irish education system, this paper reviews the literature available to provide a single point of reference to the road taken, eventually leading to the provision of CS as a formal subject as part of the Senior Cycle in schools. It also highlights the current status of CSEd in primary schools in Ireland; while not yet formalized like the LCCS, this curriculum is progressing in a positive direction and its current situation is discussed in section 3.1. There is also an optional short coding course at Junior Cycle level which is discussed in section 3.2. The paper also includes a detailed description of the relevant international CS landscape in schools that directly influenced the Irish roll-out and collates any lessons that can be learned from these jurisdictions to aid the current Irish roll-out.

The paper has the following structure. Firstly, there is a short description of the education system in Ireland to provide context for international readers. Next follows a literature review (Section 2) which provides a summary of the literature detailing the history of Computer Science in Ireland. The paper then examines the roll-out of the 2018 LCCS pilot subject (Section 3), as well as reviewing the Junior Cycle changes to incorporate optional computer courses for students and looking at the Computer Science status quo at primary level in Ireland, as indicated above. Lessons learned from international jurisdictions (Section 4) complete this review. Finally, the paper discusses the National roll-out in 2020 of LCCS as well as what the future might hold for Computer Science in Irish education.

1.1 Primary School Education in Ireland

In Ireland, children start their formal education at the age of 4 or 5 years. Traditionally this takes the form of starting in a primary school at Junior Infants. Primary education in Ireland is an eight-year cycle after which at approximately 12 or 13 years old the children move into post-primary school. Children in primary education in Ireland follow a prescribed curriculum covering many subject areas; however, the core subjects are English, Irish and Maths. Other subject areas include Physical Education, Social Environmental and Scientific Education, Social, Personal and Health Education, Art and Religion (NCCA, Primary curriculum, 2021). Some schools and teachers just use technology in the classroom to teach the curriculum in different subjects and others expose the students to some basic IT skills; some do introduce programming and allied activities. At present there is no formal curriculum for CS for primary school children in Ireland; however, the planning for this has started.

1.2 Junior Cycle

Typically, at the age of 12 or 13, an Irish child begins post-primary school, with the JC occupying the first three years, concluding with the exams that form part of the state assessment at this stage. Students normally sit these exams around the age of 15 (Citizens information, 2020). Students typically take a minimum of eight to a maximum of ten subjects for final examination/assessment and reporting in the JC (Department of Education, 2021), choosing from a range of subjects (see Figure 2). Ireland's JC is similar to the GCSE in the UK. A reform of the JC began in 2011 with the publishing by the DES of the document "Towards a framework for Junior Cycle" (NCCA, Towards a framework for junior cycle, 2011). This was followed by "A Framework for Junior Cycle" (Department of Education, 2015), published in October 2012. Prior to this point the JC was made up of discrete subjects which were offered by the schools, chosen by the students, and examined as part of the state exams. In 2012 there was a move towards introducing a group of subjects which while assessed are not examinable, allowed the student to acquire a level 3 qualification on the National Qualifications of Framework (NQF), through what was called a short course. Short courses were first offered in 2014 by schools and this was followed by the publication of the 2015 Framework for JC (Department of Education, 2015). This built on the 2012 publication, aiming to:

"set out a clear vision of how teaching, learning and assessment practices will evolve in the first three years of post-primary education to ensure a learning experience for our young people that is appropriate to the needs of the 21st century."

A JC short course is a 100-hour course (rather than one occupying 200 to 240 hours) and can be delivered at varying stages across the three years of the JC. The main JC short course that falls under the umbrella of CS is the Coding short course (NCCA, 2016). This has an emphasis on active learning where students provide evidence of their learning in a variety of ways, including digital media, audio recordings and written pieces. It is made up of three strands: CS Introduction; Let's get connected; and Coding at the next level. Thus, the JC offers opportunities for students to learn about CS through coding, but the course is optional and so is not taken by all students. In a report published by Lero in 2019 (Fleming & McInerney, JCCiA - interim report, 2019), some of the challenges faced by this short course included timetabling of the subject in schools, lack of necessary resources and time required to ensure teachers were up to date on the teaching methodologies needed.

1.3. Senior Cycle

Ireland's Leaving Certificate (LC) state exams are held at the end of the Senior Cycle (equivalent to the end of US grade 12) where typical students are 17-18 years of age. These are comparable to the UK A levels, more specifically the LCCS is comparable to the US AP (Advanced Placement) Computer Science A and Computer Science Principles exams, and the UK A level Computer Science subject. Students sitting the LC have a range of subjects to choose from (see Figure 3), but for university entrance purposes a minimum of six subjects is taken. While the only mandatory subject is Irish – compulsory except for students who have an exemption for some reason, such as recent arrival in the country – many schools require their students to take English and Maths (and indeed students would opt for them in any case) because they are required for entry to many third-level courses and for employment purposes. The standard is for students to sit seven subjects and count six of these towards the points for their university entrance (CAO, 2021). There are typically around 65,000 students who sit the LC each year, and for whom the results of this exam determine their university course. In 2018, three new LC subjects were added to the offering: Physical Education, Politics and Society and Computer Science. These new subject offerings also herald a move, albeit a small one, to a combination of exam and coursework assessment as opposed to just terminal examination which was the case for the majority of LC subjects. The top subjects sat by students for the LC in Ireland in 2019 (this year was chosen as it is prior to any effect of the COVID pandemic) were Irish, English and Maths (State Examinations Commission, 2021); however, apart from these, the top three choice subjects in 2019 were Biology (~34,000), Geography(~24,000) and French(~23,000) (State Examinations Commission, 2021).

SUBJECT	LEVEL
Irish	Higher, Ordinary and Foundation
English	Higher and Ordinary
Mathematics	Higher, Ordinary and Foundation
History	Higher and Ordinary
Geography	Higher and Ordinary
French	Higher and Ordinary
German	Higher and Ordinary
Spanish	Higher and Ordinary
Italian	Higher and Ordinary
Art, Craft & Design	Higher and Ordinary
Music	Higher and Ordinary
Science (Revised Syllabus)	Higher and Ordinary
Home Economics	Higher and Ordinary
Materials Technology (Wood)	Higher and Ordinary
Metalwork	Higher and Ordinary
Technical Graphics	Higher and Ordinary
Business Studies	Higher and Ordinary
Environmental and Social Studies (ESS)	Higher and Ordinary
Technology	Higher and Ordinary
Latin	Higher and Ordinary
Ancient Greek	Higher and Ordinary
Classical Studies	Higher and Ordinary
Jewish Studies	Higher and Ordinary
Religious Education	Higher and Ordinary
Civic, Social and Political Education (CSPE)	Common

Figure 2. Junior Cycle Subjects

SUBJECT	LEVEL
Irish	Higher, Ordinary and Foundation
English	Higher and Ordinary
Latin	Higher and Ordinary
Ancient Greek	Higher and Ordinary
Classical Studies	Higher and Ordinary
Hebrew Studies	Higher and Ordinary
Arabic	Higher and Ordinary
French	Higher and Ordinary
German	Higher and Ordinary
Italian	Higher and Ordinary
Spanish	Higher and Ordinary
History	Higher and Ordinary
Geography	Higher and Ordinary
Mathematics	Higher, Ordinary and Foundation
Applied Mathematics	Higher and Ordinary
Physics	Higher and Ordinary
Chemistry	Higher and Ordinary
Physics and Chemistry	Higher and Ordinary
Agricultural Science	Higher and Ordinary
Biology	Higher and Ordinary
Agricultural Economics	Higher and Ordinary
Engineering	Higher and Ordinary
Construction Studies	Higher and Ordinary
Technology	Higher and Ordinary
Design and Communication Graphics	Higher and Ordinary
Home Economics	Higher and Ordinary
Accounting	Higher and Ordinary
Business	Higher and Ordinary
Economics	Higher and Ordinary
Religious Education	Higher and Ordinary
Art (including crafts)	Higher and Ordinary
Music	Higher and Ordinary
Russian	Higher and Ordinary
Japanese	Higher and Ordinary

Figure 3. Senior Cycle Subjects

- Coding
- Civic, Social and Political Education (CSPE)
- Physical Education (PE)
- Digital Media Literacy (DML)
- A Personal Project: Caring for Animals (Level 2)
- Social, Personal and Health Education (SPHE)
- Artistic Performance
- CSI: Exploring Forensic Science (Level 2)
- Chinese Language and Culture
- Philosophy

Figure 4. Short Courses

2. The History of the Irish Landscape

This section will review available literature on the history of CSEd in Ireland: a long history, with computing in education dating back to the 1970s. The aim here is not to detail each step along this journey, but to provide an overview of the journey itself, where the focus will be on the main key turning points through the last 50 years. The history timeline, from the early 1970s to 2020, is summarised in Figure 5 which shows the main events that

have defined the landscape today as nodes that are discussed in detail later in this section. This timeline will be broken into three phases, as defined by McGarr (McGarr O. , 2008), for discussion: Phase 1 - The Early Technophiles Stage (1971:1984), Phase 2 - The Keyboarding Phase (1985:1996) and Phase 3 - The Integration Stage (1997:2008).

In 2009 McGarr compiled a comprehensive history of information technology use in education in Ireland (McGarr O. , 2008). This report detailed the how the Irish educational system responded to changes in various ICT initiatives and policy changes from 1975 to 2008. Other documents covering parts of the story include that by Moynihan (Moynihan, 1986) (to the mid-1980s), Oldham (Oldham, 2015) (up to 1997) and McGarr and Johnston (from 1997 to 2017) (McGarr & Johnston, 2021), while Connolly et al. (Connolly, Byrne, & Oldham, 2022) give an overview of the whole period. We begin by summarising McGarr's three distinct phases of this history before detailing developments in CSEd from 2009 to present day.

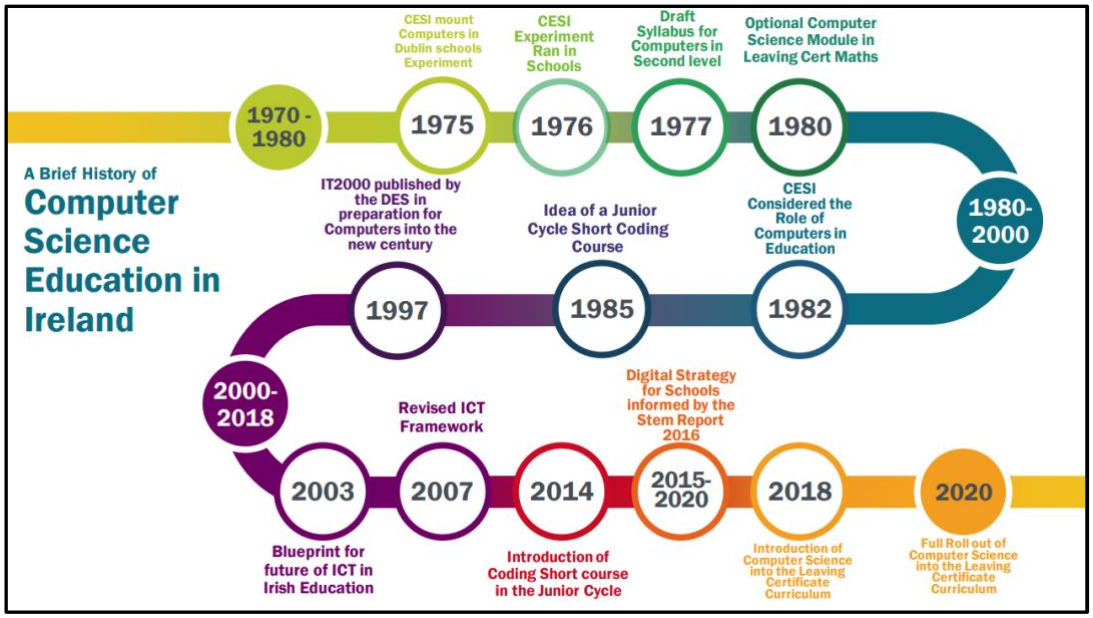

Figure 5. A Timeline of Computer Science in Ireland

2.1 Phase 1 - The Early Technophiles Stage (1971:1984)

In order to get a full picture of the history behind the introduction of CS into primary and post-primary schools in Ireland it is necessary to consider the landscape as far back as the 1970's (see Figure 6). The Computer Education Society of Ireland (CESI, now the Computers in Education Society of Ireland) – which is the official Teachers' Professional Network for CS in Ireland, while also advocating for the use of information technology in teaching and learning across the curriculum (Oldham, 2015) – was established in 1973 and the first chairman Jim Roche published a paper in 1975 detailing the CS training provision for teachers in Ireland (McGarr O. , 2008). Despite these training sessions being open to all teachers they were attended mainly by Maths teachers (Breathnach, 1987) and (McGarr O. , 2008). In 1973, Trinity College Dublin introduced a one-year, part-time diploma course on Computers in Education. This course, in addition to programming, covered a wide range of computer-related topics including the history of computers, problem solving & flow charting, modern computing, hardware, logic and computers in education (Moynihan, 1986). The aim of the course was to grow the base of teacher knowledge in computing. In July 1975, International Computers Ltd. approached CESI to run a trial course of CS in Dublin schools, and from January to April 1976 this course ran in seven Dublin schools (Moynihan, 1986). Moynihan (Moynihan, 1986) concludes that while this experiment was successful there was a requirement to increase the time given to this subject in order to fully embed it into the curriculum.

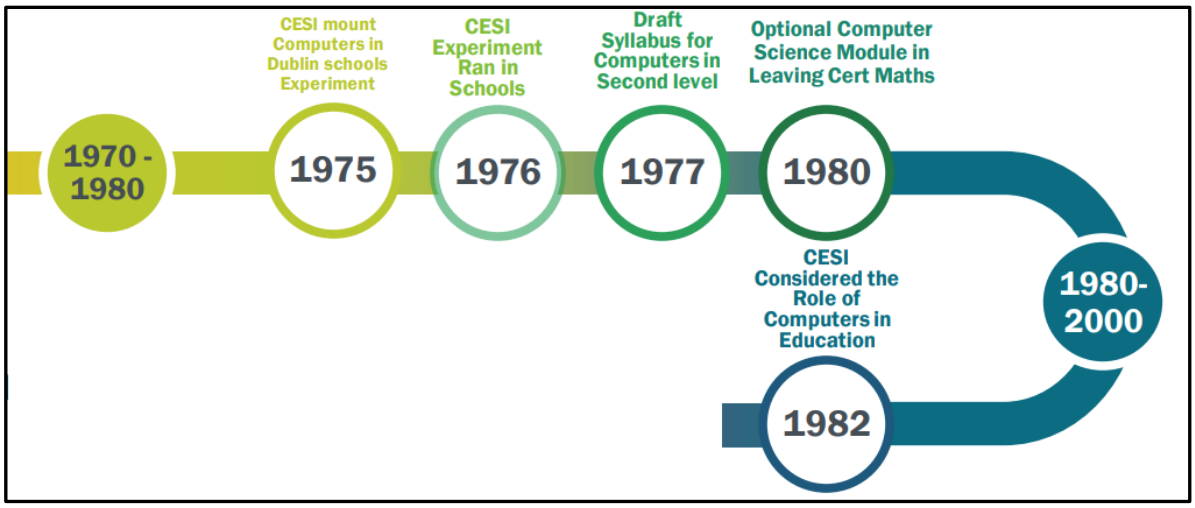

Figure 6. Phase 1 - The Early Technophiles Stage (1971:1984)

The state Department of Education released a white paper in 1980 on educational development. This paper is referred to by Professor John Coolahan in his report "A Review Paper on Thinking and Policies Relating to Teacher Education in Ireland" (Coolahan, 2007). Coolahan determines that the paper failed to focus enough on teacher training – general teacher training / education in Ireland. The lack of any mention of CS teacher training by Coolahan indicates its insignificance in Teacher Continuous Professional Development (CPD) during this time. There was however sustained pressure, mainly through CESI, for the development of a CS curriculum for the Senior Cycle at second level, and 1980 saw the introduction of computing to the Senior Cycle as part of the Maths programme. However, the computing element was not mandatory, and it was not examined as part of the LC state exam (Oldham, 2015) and (Connolly, Byrne, & Oldham, 2022). In addition to this, the syllabus was not set in stone by the Department; instead, schools applying to run the subject submitted their proposed syllabus to the Department as part of their application, allowing for changes over time (McGarr, The development of ICT across the curriculum in Irish schools: A historical perspective, 2008) and (Oldham, 2015). McGarr explains (though "chiefly" would be more accurate than "exclusively" (Oldham, 2015):

"The syllabus required the inclusion of issues such as: Careers in computing, structured diagrams, problem analysis and programming languages. This type of content was typical of the computer use in schools in the early years of the decade as the focus, at that time, was exclusively on learning about the new developing technology."

In 1984 the Department of Education sanctioned a subject on computer studies at Junior Cycle and a syllabus committee was set up to devise the content for this subject, which was introduced in 1985. However, it is worth noting that this subject, again, was not going to be assessed in the state exams (Oldham, 2015) and (Connolly, Byrne, & Oldham, 2022). It was also around this time that a survey by the Association of Secondary Teachers, Ireland (ASTI, one of two post-primary teachers' unions) noted that a wide range of computer applications were being used in schools and by teachers. While organisations such as CESI were advocating both for a CS curriculum and for the use of computers in teaching and learning (Oldham, 2015), the practice on the ground seemed to be less CS-focused.

2.2 Phase 2 - The Keyboarding Phase (1985:1996)

McGarr notes that, during the keyboarding phase (see Figure 7), while there was investment in the technology for schools by the Department of Education, teachers seemed to be teaching a broad course in computer literacy rather than CS (Brady, 1987), and (McGarr, The development of ICT across the curriculum in Irish schools: A historical perspective, 2008). Notably, the JC Computer Studies course focused on use of applications packages as well as programming (Oldham, 2015). This is also addressed by Moynihan in his MSc. thesis titled "Computer Education in Ireland: A Case Study" (Moynihan, 1986). Moynihan had been part of CESI since 1976 and had been the chairman since 1978. He had advocated strongly for the introduction of CS into the school curriculum; however, this document (Moynihan, 1986) details the issues that arose as part of his campaign to introduce CS into the "rigid centralised Irish Educational System". The issues are summarised by Moynihan (Moynihan, 1986) as follows:

"The DES has not got the personnel, the structures or the expertise to provide the framework for the proper introduction of Computer Education into schools. The wider concept of Information Technology is simply not understood at official level."

During this time the Curriculum and Examinations Board was established. Their role was to oversee the design of new school curricula (McGarr O. , 2008). This board favoured the integration of ICT across the curriculum but mainly focused on Business and Technology subjects. In 1993 an EU evaluation on the use of computing at second level was undertaken. This report highlighted some of the inadequacies around the teaching of computing in Irish schools (McGarr O. , 2008). These inadequacies included: the use of standard applications such as word processing, little emphasis on CS and a lack of explicitly stated policy. This was followed by another large-scale study by Drury which backed the initial inadequacies, and further discovered that in the absence of national strategy, schools had developed informatics courses focused on computer applications software (Drury, 1995), and (McKenna, Brady, Bates, Brick, & Drury, 1993).

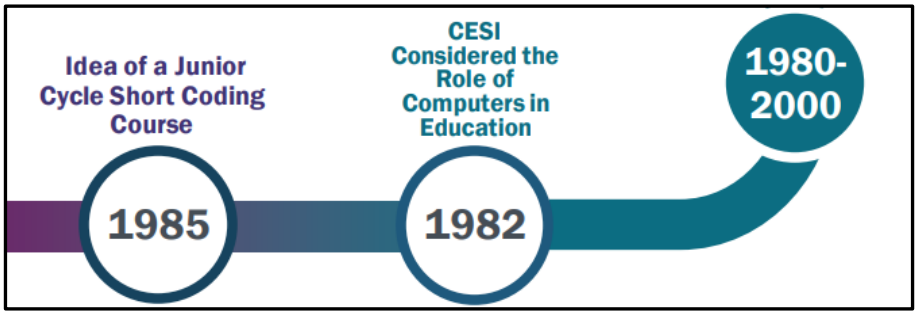

Figure 7. Phase 2 - The Keyboarding Phase (1985:1996)

These reviews through the 1990s shows that the lack of policy from the Department of Education in relation to computing in schools had led to a situation where computing in schools were largely being used for informatics classes (McGarr O. , 2008) and (Oldham, 2015) rather than CS. Bearing in mind that the initial stages of computer education of teachers was chiefly based around computer programming and CS, this was disappointing.

2.3 Phase 3 - The Integration Stage (1997:2008)

In 1996 an International Data Corporation (IDC) report ranked Ireland in the third division in relation to its state of preparedness for the Information Age. This sparked renewed efforts to incorporate ICT into schools in a meaningful way. McGarr states that this, the third phase (see Figure 8), is marked by the launch of the Schools IT2000 Initiative. The aim of this initiative was to increase student literacy in computing and to support teachers in developing the skills needed to support their students. This initiative improved the uptake of ICT across Ireland (McGarr O. , 2008). In 2001 an evaluation of the Schools IT2000 Initiative (Department of Education, 1997) found increased IT infrastructure in schools as well as increased uptake in teacher training, however it also found that a more defined policy was needed and that basic informatics type classes were still predominant in schools. McGarr notes that the absence of a clearly defined national CS policy for schools has been an ongoing problem in Irish schools over the past 30 years and this is also corroborated by Rinn, 1984, Kelly 1985, NCCA 1993, and Mulkeen 2002 according to McGarr's report (McGarr O. , 2008).

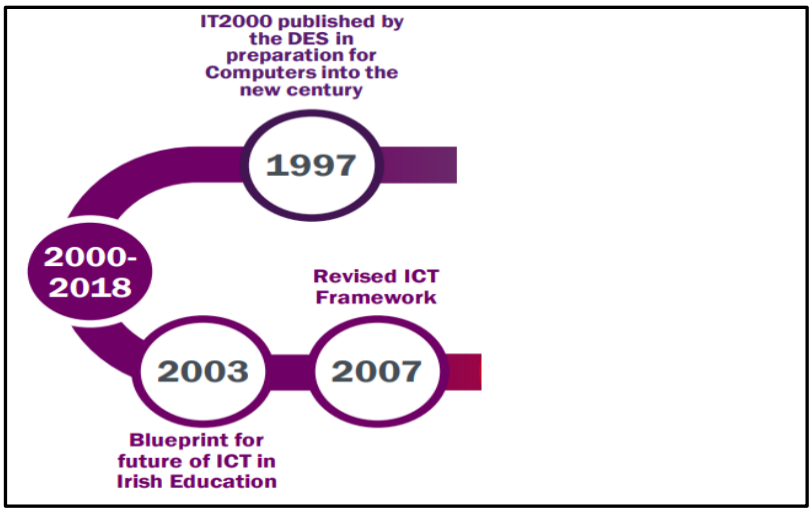

Figure 8. Phase 3 - The Integration Stage (1997:2008)

McGarr also notes the effect of a cabinet re-shuffle within three years of the Schools IT2000 Initiative where the appointment of a new Minister for Education, with different priorities, resulted in an ICT decline at this critical time. Having devised the three phases, as summarised above, McGarr concludes that CS at second level evolved rather than was developed. McGarr also states that in order for Ireland to continue to improve, lessons should be learnt from the past, whereby ICT initiatives and policies need to be presented as integrated teaching and learning with relevance for all teachers.

2.4 Developments mainly since 2008

The Schools IT2000 Initiative was the start of real change in the landscape of Ireland's approach to CS. McGarr and Johnston reviewed educational policy and how it has framed the CSEd in Ireland in a paper in 2017 entitled "Exploring the Evolution of Educational Technology Policy in Ireland: From Catching up to Pedagogical Maturity" (McGarr & Johnston, 2021). That paper reviewed a number of educational policy documents including:

- Schools IT2000 - A policy Framework for the New Millennium (Department of Education, 1997)
- Investing effectively in Information and Communication Technologies in Schools 2008 (Department of Education, 2013)
- The report of the Minister's Strategy Group (Department of Education, 2008)
- Smart Schools = Smart Economy: Report of the ICT in Schools Joint Advisory Group to the Minister for Education and Science (ICT Ireland, 2009)
- Digital Strategy for Schools 2015 - 2020: Enhancing Teaching, Learning and Assessment (Department of Education, 2016)
- Digital Strategy for Schools: Action Plan 2015 - 2020 (Department of Education, 2017)

McGarr and Johnston also explain four possible rationale categories for including technology education in schools. These are:

1. Educational - this justification for technology inclusion is based on enhanced learning for students.
2. Economic/Vocational - this justification for technology inclusion is to prepare students for roles is Science, Technology, Engineering and Maths (STEM) fields in order to advance the economic competitiveness of the country by producing more technically skills graduates (McGarr O. , 2008).

3. Social - this justification for technology inclusion is based on the issue if inequality and therefore looks at ensuring all students have access to adequate digital skills.

4. Catalytic - this justification for technology inclusion is based on the effect it can have on changing educational practices from teacher-led to student-led learning.

In examining these policy documents McGarr and Johnston (McGarr & Johnston, 2021) drew several conclusions. During the 20-year period examined in this paper the nature of computing in schools has changed significantly and the educational policy has responded to these changes bringing Ireland to a point where the educational system realised the need to facilitate the more independent, student centred learning for technology to be capitalised on effectively. The study also found that the impetus for these changes over the 20-year period were mainly Economic (McGarr & Johnston, 2021), where there is a body of data identified that would support this in the OECD reports from 2004, 2012 and 2015 suggesting that the trends in Irish schools in relation to technology was average or below average by international comparison. This drove the desire to use technology effectively rather than having it as a stand-alone subject in schools. Ireland was not alone in this Economic driving factor in Educational policy, as Canada and Northern Ireland also found that economic and political forces shaped educational policy (McGarr & Johnston, 2021) and (Connolly, Byrne, & Oldham, 2022).

3. Present Day Computer Science Education in Ireland

This section will review CSEd in Ireland from 2017 up to the introduction of the formal LCCS subject in 2018 (see Figure 9).

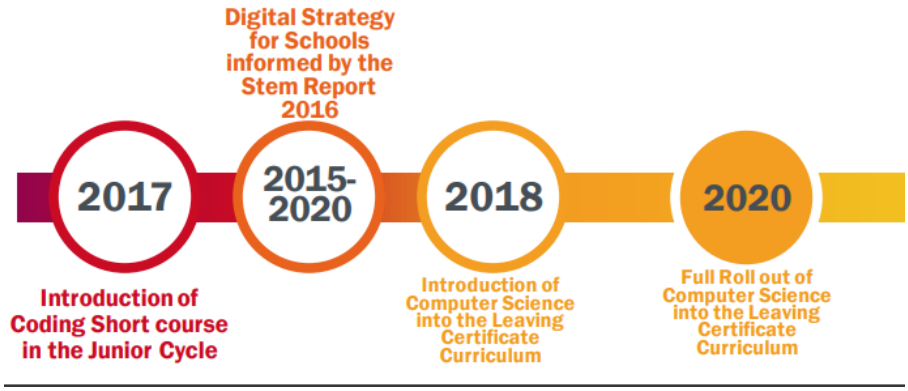

Figure 9. Current Phase

3.1 Primary Computer Science

In July 2016 the NCCA was asked by the then Minister for Education and Skills, Mr Richard Bruton TD, to consider approaches to integrating coding and computational thinking into the primary curriculum. The NCCA implemented several phases to help inform the development of the curriculum, before any work was done on the curriculum document itself, thus inverting the common approach of the developing the curriculum first (with multiple stakeholders) and investigating its suitability after the specification has been rolled nationally. This resulted in initial research into coding in primary schools in other jurisdictions (NCCA, 2019). From this the "Coding in Primary Schools Initiative" began with phase one in September 2017. This involved 15 primary schools, which were attained through an open call process (47 schools applied). The focus of phase one was to document coding practices in these 15 schools, all 15 schools had prior knowledge and teachers with experience of teaching coding and computational thinking in a primary classroom. The findings from this were then used to inform the development of materials for phase two. Phase two took place between May 2018 and February 2019, and consisted of 25 additional schools (153 schools applied), in addition to the 15 phase one schools. As there are 3107 primary schools in Ireland (Department of Education, 2019), ~1.3% of primary schools participated in phase two. The additional phase two schools did not have the prior knowledge and practices in place like phase one schools. Phase two focused on developing learning outcomes to use from Junior Infants to Sixth Class, that would

allow for potential progression to the JC Coding short course and the LCCS course. The learning outcomes focused on physical computing and play-based pedagogical approaches to coding and computational thinking and were split into two separate groups: Junior Infants - Second Class, and Third - Sixth Class. Most teachers from phase two felt that the language used in the outcomes was too technical and that there needed to be clearer explanation of some of the terms. Some teachers also stated that they did not see a clear progression from the early years outcomes through to the senior years. When teachers were asked what the main challenges might be, they identified curriculum overload, teacher confidence, CPD, and school infrastructure as being the most pressing issues (NCCA, 2019).

As of June 2019, approximately 3,180 primary teachers have participated in coding and computational thinking face-to-face workshops and, from 2014 - June 2019, a total of 3,463 teachers completed the online "Scratch for Learning" course, both facilitated by the PDST. The feedback from the teachers participating in phase two is that time will be needed to embed the concepts of coding and computational thinking in classrooms. This is part of a larger review of the entire curriculum planning (NCCA, 2019) to include the development of the final primary school curriculum, which at present, due to the COVID pandemic, is postponed.

3.2 Junior Cycle Computer Science

In 2014 the NCCA produced nine short courses which schools could include in their JC curriculum (Fleming & McInerney, 2019) one of which was the short Coding course for the Junior Cycle (NCCA, 2016). This course, which was part of the JC reform (NCCA, 2021), had three strands of learning associated with it: CS Introduction, Let's Get Connected and Coding at the Next Level. This course was piloted in 2016 with 22 schools taking part and released in 2017 with 52 schools taking part (Fleming & McInerney, 2019), and (NCCA, 2016). The aims of these strands were to introduce the learners to coding and the broader view of CS including algorithms, problem solving and testing code (NCCA, 2016). The purpose of this pilot was to examine the current provision and opportunities within schools for Information and Communications Technology. Its goal was to support and document the experiences of a small number of schools as they incorporate aspects of the Coding short course within their JC programme and to explore further options for support of schools and teachers offering the Coding short course. Lero, the Science Foundation Ireland Research Centre for Software, which brings together expert software teams from universities and institutes of technology across Ireland in a co-ordinated centre of research excellence with a strong industry focus, was chosen to conduct this research and create the report.

The study found that there was little difference in the gender breakdown of teachers teaching this course at 55%:45% male:female respectively. Expertise of the teachers delivering this course was predominately in Technology and Maths at a combined total of 45%. However, what was also discovered was the diverse time allocations across the surveyed schools to this course where 27% were seen to be allocating the required time but as high as 21% were not meeting the required time for the short course, which is 100 hours. This was compounded in the latter years as students drew closer to the formal JC state exams (Fleming & McInerney, 2019).

The statistics around student engagement, which was reviewed as part of a report by the NCCA (NCCA, 2019), in the short course showed very little gap between the male and female uptake at 51% and 49% respectively, where 48% of the students had some previous exposure to coding. The previous exposure differed greatly from student to student with some students experiencing this at home and others attending summer camps. Perhaps the most interesting indicator from students was their enjoyment of the course. Given the concerning lack of female uptake in CS at third level, the breakdown of enjoyment is best looked at in this context. Here the NCCA report stated (NCCA, 2019) that 62% of males reported enjoying it while 48% of females did. Disappointingly, of the students who studied the Coding short course, only 20% of them said they would consider CS as an option at third level, with 47% saying they would not consider it.

There were a number of successes and challenges identified in the Lero report (Fleming & McInerney, 2019) from the introduction of short courses into the JC curriculum. The successes included the student interest and engagement, the development of student skills and the new teaching methodologies learned. Some of the challenges faced were timetabling of the subject, access to resources and the additional time requirement from teachers. Despite the challenges there was a large interest in delivering the Coding short course, in particular the continued interest of participating schools at 75% saying they planned to continue delivery in the 2017/2018 academic year. The introduction of the LCCS subject in 2018 has also had a positive effect on the acknowledgment across the educational sector of the need for these types of offerings at JC level. Continuing efforts need to be

made by the initial cohort of schools from resourcing the course, supporting teachers and expanding communities of practice to allow for flexibility in order to ensure the sustainability of a coding for all approach.

3.3 Leaving Certificate Computer Science

In January 2017 the NCCA announced the new Leaving Certificate Computer Science subject. The Minister at the time, Mr. Richard Bruton TD, said.

"The introduction of Computer Science as a Leaving Certificate subject is part of the Government's overall commitment to embed digital technology in teaching and learning. The society our children will grow up in, will be one which has been fundamentally transformed by new technology. Our education system must prepare our children to thrive in such an environment by equipping them with skills in creativity, adaptability and problem solving."

In 2018, the LCCS subject was rolled out in a pilot phase to 40 schools around Ireland (phase one) (NCCA, 2019). The geographical spread of the phase one schools can be seen in Figure 10, where data was obtained from the LERO Interim report 2019 (McGarr, McInerney, Exton, & Power, 2019). These schools were selected based on an application submitted to the DES. The selection represented both a good geographical spread as well as being balanced in terms of gender numbers and DEIS School representation (McGarr, McInerney, Exton, & Power, 2019). Of the chosen schools, 31% were already offering the JC Coding Short course (NCCA, 2016), with another 21% of schools selected offering the JC Digital Media Literacy course (NCCA, 2021). Of the participating schools, 38% of teachers were female. The teachers prior experience of this new subject area varied from teaching IT in the school previously and supporting IT in the school, to having CS industry experience (McGarr, McInerney, Exton, & Power, 2019).

Figure 10. Geographical Spread Phase One Schools (Fleming & McInerney, 2019)

The specification of the LCCS curriculum was designed assuming no previous experience in the area and prescribes 180 contact hours for the subject. The content is based around three interwoven strands consisting of: Practices and principles; Core concepts; and Computer science in practice (see Figure 11). Strand three is a group of applied learning tasks (ALTs) that provide an opportunity for skills based practical learning in the classroom. These practical skills are then further enhanced through the coursework part of the LC assessment.

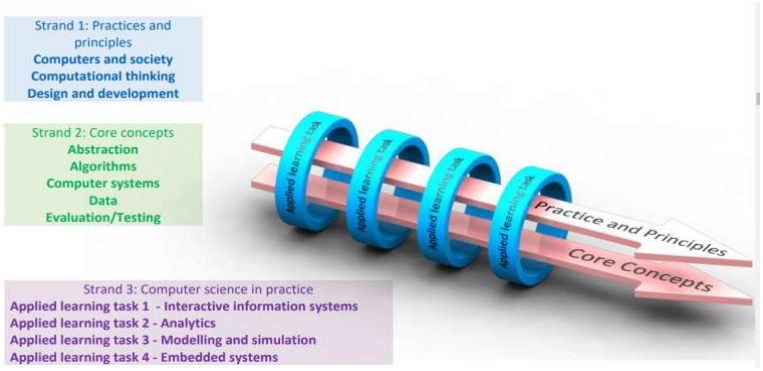

Figure 11. Leaving Certificate Strands

The aim of these strands is to enhance the learners' creativity and problem solving as well as facilitating independent and collaborative work. The strands can be completed in any order. In terms of assessing the students there is a piece of continuous work (coursework), worth 30% of their marks, and one terminal exam in the subject, worth the remaining 70% of marks. The coding part of the course is taught using Python and JavaScript, although the aim is to regularly review this in line with industry developments (McGarr, McInerney, Exton, & Power, 2019).

Teachers were offered CPD training and continued support in the delivery of this subject from the NCCA. The training offered consists of a mix between National workshops, Skills workshops, Regional clusters and Webinars. The Lero report 2020 determined that both the National workshops and the Skills workshops were by far the most valued by the teachers (McGarr, McInerney, Exton, & Power, 2020). The feedback from the teachers while positive was diverse; several teachers felt that these training opportunities should focus more on content or practical skills to bring back to the classroom rather than pedagogical approaches (McGarr, McInerney, Exton, & Power, 2020), while others valued the pedagogical content more. This highlighted the different needs of teachers with some requiring content knowledge (CK) rather than pedagogical content knowledge (PCK). This emphases the requirement for teachers to feel confident in the CK before they feel confident to approach PCK.

Phase one completed in 2020, where students (739) that were due to sit the first ever LCCS exam in June 2020 received so-called "calculated grades" due the COVID pandemic (Department of Education, 2020). Students in this initial cohort were offered the opportunity to sit an exam in LCCS in November 2020, where a very small group of approximately 12 students completed this formal sitting. The NCCA continued with the national roll-out in September 2020 for this subject. The figure for the additional schools who started phase two in September 2020 was 52; this was lower than expected, perhaps due to COVID, where some schools might have decided to postpone the roll-out. This resulted in 92 schools offering LCCS in the 2020-21 academic year. Phase three commenced in September 2021 and there is expected to be approximately another 50 schools who opt to offer LCCS as part of this phase. Uptake for the first three phases is positive despite the setbacks that schools have faced due to the COVID pandemic, given that some 20% of post-primary schools in Ireland are offering LCCS. In terms of the student uptake in these schools at the end of phase one, 1.4% of senior cycle students were taking LCCS. If the same level of students take the subject in the phase two and phase three, Ireland will be on the right path to attempt to match the uptake for A Level Computer Science which was at 10.8% in 2019 (Ofqual, 2019).

The next section examines the international jurisdictions that specifically informed the Irish LCCS subject. It will observe their current CS landscape and how the roll-out of their CS in schools has progressed, with a specific focus on any lessons learned that might provide insights for Ireland going forward.

4. Lessons Learned from International Jurisdictions

The 2017 Irish commissioned report, the "Report on the Provision of Courses in Computer Science at the Senior Cycle level of Education Internationally" (Keane & McInerney, 2017) investigated the international provisioning of CS in five jurisdictions: England, Scotland, New Zealand, Ontario, and Israel across areas such are rationale and motivation, curriculum, assessment, participation, and teacher CPD, with the aim to help inform the provisioning of the LCCS roll-out. Given that these specific countries informed the current Irish Senior Cycle LCCS, their entire primary and second level CS initiatives would perhaps be noteworthy to readers interested in

the Irish story. With the aim to summarize any common lessons learned that could provide insights for Ireland as it moves forward with its CS roll-out. Table 3 gives an overview of their CS offerings across primary and second level, which will be summarised and discussed in the following sections.

Table 3. Jurisdictions of Interest to Ireland Delivering CS in schools, compiled from (Keane & McInerney, 2017)

Country List			
Country Name	Primary	Lower Secondary	Upper Secondary
England	Mandatory	Optional	Optional
Ireland	No	Optional Short Course	Optional
Israel	No	Mandatory and Optional Modules	Optional
New Zealand	Mandatory	Mandatory	Optional
Ontario	Integrated with Maths	No	Optional
Scotland	Mandatory	Mandatory	Optional

England

Interest groups such as Computing At School (CAS) led to England, in 2014, being the first country to introduce CS (which included coding) as a curriculum at primary level through a subject titled Computing. At second level, since September 2015, students in England can choose to continue to study CS through elective subjects at GCSE and A-Levels (both of which are named Computer Science). In 2017, the UK commissioned and produced a report titled "After the reboot: computing education in UK schools" (The Royal Society, 2017) which details CS curriculum and initiatives in schools across the UK. In summary the report stated that a majority of teachers felt they were delivering a subject they were inexperienced with, and that typically they might be the only teacher in their school tasked with delivering the subject.

In 2018, it was reported that 70% of students in England attend schools offering GCSE CS, but only 11% of all students take GCSE CS. With 10.8% of A-Level students taking CS (Ofqual, 2019), which would imply that although there is a reduction in the overall number students who take the A-Levels (Department for Education, 2012), the ratio of students electing to take CS at this level remains at ~11% of the student population. However, a concern is that data shows that only 9.8% of the A-Level CS students were female (Keane & McInerney, 2017). The previous statistics initially suggest that delivery of CS to all primary school students has not yet dramatically increased the percentage of students, or the number females, opting to take this subject in senior years. However, it will be necessary to wait until a full cycle of primary students have been exposed to CS from entry to exit, for the final data to be analysed and adequate conclusions drawn.

Scotland

One of the four constituent nations in the UK is Scotland, where computing has been a subject delivered since the 1980s at second level (Jones, et al., 2011), although it was not delivered at primary school until 2010. While CS was available at primary school in Scotland before England (2014), it was introduced with the requirement only to ensure all students must at the very least be "exposed" to CS by the age of 14 (Keane & McInerney, 2017). In 2014, Scotland introduced Computing Science into the Junior Cycle curriculum, which leads to a National 5 (N5) qualification, the Scottish equivalent of England's GCSE, or Ireland's JC. While the number of entrants to the N5 CS subject from 2014 to 2017 was 7,000 students (Scottish Qualifications Authority, 2021), more recent years show a slow decline in the uptake at N5 (Scottish Qualifications Authority, 2021). The 6,221 students that elected to take the subject represented only just over 7.5% of the number of students who took the N5s in 2020, with only 1,256 (~20%) females. Additionally in 2020, just under half the number of students that elected to take the N5 exams elected to take CS at the Senior Cycle level, indicating a drop away of students (with only 17% females) (Scottish Qualifications Authority, 2021).

Scotland is further along in their CS curriculum roll-out than England, with the availability of CS as an optional subject at second level in some form since 1980s. This demonstrates it has not had the long-running issues with its development as Ireland and England seem to have had with the change in focus from CS to ICT usage. However, statistics show its uptake is still low and is decreasing at second level. Also a concern for Scotland is the 25% decrease in the number of computing teachers available compared to the previous ten years, with 17% of second level schools having no computing specialist to deliver the subject (The Royal Society, 2017). The number of first-year students on computing initial teacher training courses dropped by 80% from 2007 to 2016, resulting in a number of universities dropping their Postgraduate Certificate in Education in CS (The Royal Society, 2017).

Israel

CS is not incorporated as a stand-alone subject at primary school. At secondary school in 2012, they introduced a new CS programme for the Junior Cycle in schools (Zur Bargury, et al., 2012, October). However, at Senior Cycle, Israel has offered an optional CS subject for the past five decades, where it has maintained and developed its current curriculum since 1998, but it has been an optional subject since the mid-1970s (Gal-Ezer, Beeri, Harel, & Yehudai, 1995). Its major principle is the ”zipper principle” that describes interweaving conceptual and experimental topics - essentially ensuring theory is delivered alongside hands on practical work. This closely mirrors the interweaving theme also seen in the Irish LCCS curriculum, which may be in part due to the fact the zipper principle was discussed and investigated as part of the Lero report (Keane & McInerney, 2017).

The average percentage of students who took CS at Senior Cycle level over a sixteen-year period was 18% of the total exam population (Keane & McInerney, 2017). Its long-standing implementation may also contribute to its sustained female participation rate of over 40% between 1995 and 2011 (Keane & McInerney, 2017). The fact that since 1998 individuals wishing to teach CS in high schools had to obtain a degree in CS coupled with formal teacher training, has been acknowledged as part of its success (Keane & McInerney, 2017).

New Zealand

In 2011, New Zealand, through the Digital Technologies curriculum introduced a number of optional Programming and CS modules for Senior Cycle level students (Keane & McInerney, 2017). These are part of The National Certificate in Educational Achievement (NCEA), the New Zealand equivalent of the Irish LC. These modules which became available in 2012 are assessed 100% on the students’ course work, with no terminal examination paper which the majority of other NCEA subjects include. The sign-up initially has been low for the Programming and CS modules but there has been an upward trend in students taking the modules (Keane & McInerney, 2017). The New Zealand government updated the curriculum in 2017, where from January 2020 it is mandatory for all students in Years 1-10. However, a report titled “It’s early days for the new digital technologies curriculum” from 2019 reported that only 7% of all the schools had a quite good understanding and enough knowledge and skills to start to implement the Digital Technologies curriculum. The majority of schools (88%) felt somewhat prepared (Education Review Office, 2019). The initial new Digital Standards that were introduced quickly over a two-year period from 2009-2011 resulted in teachers having little time to prepare, which may have impacted on the feeling of unpreparedness of teachers. This same issue might be replicated or - worse - dilated for the Year 1-10 mandatory roll-out. In the coming years it will be easier to assess New Zealand’s approach with its mandatory roll-out of CS to all students and preparing their teachers to deliver the new modules, but at the moment it is too early to draw conclusions.

Ontario

In September 2020 Ontario released a new maths curriculum at primary school for grades one through eight that integrates coding into the algebra strand of the curriculum, with clear coding expectations specified in the curriculum at each grade level. On entering grade nine, students can elect to take one introductory broad-based technology course called Exploring Technologies. This is followed by a subject called Computer Studies at the senior level, which has been in place since 2009, across grades 10-12. New entrant teachers teaching the subject are required to have an Ontario teaching licence and also a third level qualification in CS, software engineering or equivalent professional experience. Although the programme has been running for many years, the absence of publicly available data makes it difficult to conduct analysis of student uptake (Keane & McInerney, 2017).

4.1 International CS Rollout Discussion

CSEd at primary and secondary levels is expanding around the globe, and is being formalised and integrated into school curricula internationally, with many schools moving in recent years to incorporating core CS subjects across their primary schools either as a mandatory stand-alone subject, or integrated with Maths as is in the case in Ontario, or as a set of modules in a wider programme, like New Zealand (see table 4 for summary). On examination of the current status of the international jurisdictions that informed the Irish LCCS, it is clear there needs to be a growing sense of urgency about progressing CS in Irish schools, not only at LCCS, but also as an examined subject in the JC, and integrated throughout primary school level. This is to ensure Ireland keeps abreast, and to ensure success and uptake of this subject by students in participating schools.

Table 4. Countries Delivering CS in schools that Informed Ireland

	Pre-University CS Offerings														
	Primary					Lower Secondary					Upper Secondary				
Country Name	Mandatory	Formal Curriculum	Standalone Subjects(s)	Module(s) within a wider programme	Integrated Subject	Mandatory	Formal Curriculum	Standalone Subjects(s)	Module(s) within a wider programme	Integrated Subject	Mandatory	Formal Curriculum	Standalone Subject(s)	Module(s) within a wider programme	Integrated Subject
England	*	*	*				*	*				*	*		
Ireland							*	*				*	*		
Israel						*	*		*			*	*		
New Zealand	*	*		*		*	*		*			*		*	
Ontario	*	*			*		*	*				*	*		
Scotland	*	*		*			*	*				*	*		

The 2017 Irish report entitled "Computer Science in Upper Second Level Education Internationally" (Keane & McInerney, 2017) looked in detail at the provision of CS in Israel, England, Scotland, Ontario and New Zealand. The report examined challenges faced, course content, learning outcomes and teacher CPD in each of these countries. It highlighted that other countries, such as England and New Zealand, also like Ireland had a long road to ensuring the curriculum is grounded in CS rather than on the use of computers. In particular, the English curriculum within the UK has informed the Irish curriculum, so their story is of interest and closely related to the Irish one as an insight of how another country rolled out CS to all. Specifically, their roll-out along with its success and/or failures can help guide Ireland as it progresses through its own roll-out.

Recent revisions in the English and New Zealand curriculum are taking place to ensure the core concepts of CS are now the foundations of their programmes. The report (Keane & McInerney, 2017) provided a pathway for the formal introduction of CS at the Senior Cycle in Ireland. Along with England and New Zealand, Scotland also recently revised their CS curriculum, the collective aim with these revisions was not only to ensure the curricula were grounded in CS, but also to ensure that they supported student learning and scaffolding of the subject through all school years.

However, two key challenges stand out in all the international research, which Ireland needs to understand and learn from:

1. Low uptake, and in particular low female uptake of CS across countries, with the exception of Israel. Of particular note, Scotland, which has an established track record of CS in schools, has had notable decline in uptake over the past number of years.

2. Teacher Continuous Professional Development (CPD) to ensure teachers are supported is vital to the success of the subject's integration. In all countries where the uptake of the subject was low, the main prohibiting factor seemed to relate to the lack of teacher CPD and support. For example, New Zealand's short lead-in left teachers and schools unprepared and ill equipped to successfully deliver the CS subject. Also, in England teachers stated they felt they were delivering a subject they were inexperienced with, and that typically they might be the only teacher in their school tasked with delivering the subject. Where in Scotland there has been a 25% decrease in the number of computing teachers available compared to the previous ten years. To further support this theory, Israel who do not seem to suffer the same uptake issues, provide high quality teacher CPD and support.

Ireland needs to ensure it does not encounter these same issues faced by other countries as it integrates CS into primary level and cements its establishment at second level.

5. Discussion and Future Work

ICT in schools in Ireland has come full circle with the introduction of the LCCS in 2018, to focusing on CS rather than computer use which was in part due to lessons learned from the reviewed international countries. At this stage the only results that have been released from the SEC in this subject in Ireland are for those who sat the exam in November 2020. These results indicate that one third of students got in the top three grade bands (CAO, 2021) and other two thirds were in the next three grade bands with no one receiving grades lower than a H6 (CAO, 2021). Given the fact that in 2020 all LC results were predicted grades, the students who sat the exam in November are very low at 12 students and without public availability of the overall results including the predicted grades there are no conclusions, based on results, to be drawn at this stage. The introduction of the JC Coding short course is another positive step. This short course can help in a number of ways: It can prepare students for the LCCS course; it can educate students about CS; and it can also allow students realise that CS might not be for them. The NCCA are currently reviewing and redeveloping the primary school curriculum, and this work provides a timely opportunity to integrate coding and computational thinking skills in the curriculum that aligns with progression into the JC short course and the LCCS. The possible introduction of formal CS at primary level, which will align with the JC short course and the LCCS will help ensure the success of CS at both primary and second level in Ireland. At a minimum the continuation of CS at second level is really important and the combination of the JC short course as well as the LCCS subject provides for this.

It is clear that CS at Senior Cycle level has taken many years to become a reality in Ireland and was greatly informed by the Irish report entitled "Computer Science in Upper Second Level Education Internationally" (Keane & McInerney, 2017) and the international countries this report reviewed. Ireland is on par with these international jurisdictions at Senior Cycle, and while it has an offering at Junior Cycle, this needs to progress to an examinable subject at JC to ensure its uptake by students. At Primary school, Ireland is lagging behind and needs to push forward with integrating CS at Primary level. All the while ensuring it does not encounter the same issues as the jurisdictions that informed Ireland did. From investigation into these jurisdictions, there are commonalities with their CS roll-out having been impacted with regards to participation levels, including low female participation levels and teacher CPD. Ireland is in such an early stage with their roll-out that it cannot be determined as of yet as to whether it will also suffer from these issues. Moving forward, Ireland needs to ensure that it not only increases its CS offerings at K-12 to keep on par internationally, but it also needs to ensure it does not encounter issues around participation rates and teacher CPD as it introduces formal CS into primary level and cements its establishment at second level.

The next number of years will see the national roll-out of the LCCS subject. The uptake of this will be interesting to watch and of course the output i.e., the student results, will also be important. Combined with the ongoing work looking at how to introduce computing concepts at primary level, the landscape of CS in schools in Ireland will be a rapidly evolving scene over the coming years. Ireland needs to also complete their CS offerings at primary school and in the enhance the offering at Junior Cycle of secondary school to ensure the same scaffolding for CS exists from entry to exit in the Irish school system.

The first two authors are involved in a body of work to help assist these goals and are conducting interventions and longitudinal studies with both students and teachers (over the coming years), where their wider team plan to share all of this work, founded on research nationally and internationally. Part of the future work will be to detail if Ireland's CS roll-out was successful and if it did encounter participation and teacher CPD issues.

6. Conclusion

In conclusion, the introduction of Leaving Certificate Computer Science (LCCS) in Ireland in 2018 marked a significant milestone in the country's formal Computer Science education history. The roll-out of this subject followed many years of effort to offer Computer Science education at the Senior Cycle level in Irish schools. Although Computer Science education is not yet formalized at the primary school level, it is making positive progress. Additionally, there is an optional coding course offered at the Junior Cycle level. This paper reviewed the literature on the history of Computer Science education in Ireland and examined the 2018 LCCS pilot subject, the Junior Cycle changes, and the current status of Computer Science education at the primary school level. The paper also looked at international Computer Science education landscapes and drew lessons from these jurisdictions to aid the current Irish roll-out. The future of Computer Science education in Ireland is promising, as the national roll-out of LCCS in 2018 has opened opportunities for students to gain a formal education in this subject. The paper is an important contribution to the field of CS education and provides valuable insights for educators and policy makers.

References

Brady, M. (1987). Computers in secondary schools. *COMPASS—Journal of the Irish Association for Curriculum Development, 16*(1), 46-53.

Breathnach, P. (1987). Computer studies survey. *ASTI journal*, 14-18.

CAO. (2021, September 14). *Common points scale and grading system.* Retrieved from CAO: http://www2.cao.ie/downloads/documents/CommonPointsGradingSystem.pdf

CAO. (2021, September 31). *Irish leaving certificate examination points calculation grid.* Retrieved from CAO: https://www.cao.ie/index.php?page=scoring&s=lcepointsgrid

Citizens information. (2020, August 20). *Senior cycle and junior cycle*. Retrieved from Citizens information: https://www.citizensinformation.ie/en/education/primary_and_post_primary_education/going_to_post_primary_school/

Connolly, C., Byrne, J., & Oldham, E. (2022). The trajectory of computer science education policy in Ireland: A document analysis narrative. *European Journal of Education, 57*(3), 512-529.

Coolahan, J. (2007). *A review paper on thinking and policies relating to teacher education in Ireland.* Ireland: Teaching Council. Retrieved October 31, 2022, from https://www.teachingcouncil.ie/en/publications/research/documents/a-review-paper-on-thinking-and-policies-relating-to-teacher-education-in-ireland.pdf

Department for Education. (2012). *Subject progression from gcse to as level and continuation to a level.* United Kingdom: Department for Education. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/183942/DFE-RR195.pdf

Department of Education. (1997). *Schools IT 2000: full report.* Ireland: Department of Education. Retrieved September 13, 2021, from https://assets.gov.ie/24665/6bb0ea96e5944d12a39a0fe44ef14c61.pdf

Department of Education. (2008, March 26). *Department of education and science statement of strategy.* Ireland: Department of Education. Retrieved September 21, 2021, from Department of Education:

https://www.gov.ie/en/organisation-information/dc5b86-department-of-education-and-science-statement-of-strategy-2008-2010/

Department of Education. (2013). *Investing effectively in information and communication technology in schools, 2008-2013.* Ireland: Department of Education. Retrieved October 31, 2022, from https://www.gov.ie/en/publication/4598cc-investing-effectively-in-information-and-communication-technology-in/

Department of Education. (2015). *A framework for junior cycle.* Ireland: Department of Education. Retrieved August 20, 2020, from https://www.documentcloud.org/documents/453392-a-framework-for-junior-cycle-full-report

Department of Education. (2016, November 2). *Digital strategy for schools 2015-2020: Enhancing teaching, learning and assessment.* Ireland: Department of Education. Retrieved October 31, 2022, from Department of Education: https://assets.gov.ie/25151/52d007db333c42f4a6ad542b5acca53a.pdf

Department of Education. (2017). *Digital strategy for schools 2015-2020: Action plan 2017.* Ireland: Department of Education. Retrieved October 31, 2022, from https://assets.gov.ie/24382/7b035ddc424946fd87858275e1f9c50e.pdf

Department of Education. (2019, November 1). *National school annual census 2019/2020*. Retrieved from Department of Education: https://www.gov.ie/en/collection/63363b-data-on-individual-schools/

Department of Education. (2020, September 1). *Leaving certificate 2020: Your questions answered - October 2020.* Retrieved September 14, 2021, from Department of Education: https://www.gov.ie/en/publication/ad9de-leaving-certificate-2020-your-questions-answered-september-2020/

Department of Education. (2021, November 29). *Department of education – circular cl0059_2021. Arrangements for the implementation of the framework for junior cycle with particular reference to the school year 2021/22.* Retrieved from Department of Education: https://assets.gov.ie/205684/b02e0580-53a8-406a-b8fa-c0487865cb4c.pdf

Drury, C. (1995). *Implementing change in education: The integration of information technology into Irish post-primary schools.* University of Leicester: Unpublished M. Sc. Thesis.

Education Review Office. (2019). *It's early days for the new digital technologies curriculum content.* New Zealand: Education Review Office. Retrieved January 20, 2021, from https://ero.govt.nz/sites/default/files/2021-05/Its-early-days-for-the-new-digital-technologies-curriculum-content.pdf

Falkner, K., Sentance, S., Vivian, R., Barksdale, S., Busuttil, L., Cole, E., . . . Quille, K. (2019). An international study piloting the measuring teacher enacted computing curriculum (metrecc) instrument. *ITiCSE-WGR '19 (Working Group Reports on Innovation and Technology in Computer Science Education)* (pp. 111–142). ACM: NY.

Fleming, Ú., & McInerney, C. (2019). *JCCiA - final report v1.* Limerick: Lero.

Fleming, Ú., & McInerney, C. (2019). *JCCiA - interim report.* Limerick: Lero. Retrieved September 31, 2021, from https://lero.ie/sites/default/files/2019_TR_04_Junior%20Cycle%20Coding%20in%20Action%E2%80%93%20a%20CPD%20initiative%20to%20support%20the%20introduction%20of%20the%20Junior%20Cycle%20short%20course%20Coding.pdf

Gal-Ezer, J., Beeri, C., Harel, D., & Yehudai, A. (1995). A high school program in computer science. *Computer, 28*(10), 73-80.

Gill, T. (2017). *Uptake of gce a level subjects 2017 statistics report series no. 121.* Cambridge: Cambridge Assessment. Retrieved August 24, 2021, from https://www.cambridgeassessment.org.uk/Images/518880-uptake-of-gce-a-level-subjects-2017.pdf

ICT Ireland. (2009). *Smart schools = smart economy: Report of ICT in schools joint advisory group to the minister for education and science.* Ireland: Department of Education. Retrieved September 13, 2021, from https://assets.gov.ie/24670/be87ca90e27e4c898f0029cfded3fca5.pdf

Jones, S. P., Bell, T., Cutts, Q., Iyer, S., Schulte, C., Vahrenhold, J., & Han, B. (2011). Computing at school. *International comparisons, 7*, 2013.

Keane, N., & McInerney, C. (2017). *Report on the provision of courses in computer science in upper second level education internationally.* Ireland: Lero and NCCA. Retrieved November 20, 2022, from https://ncca.ie/en/resources/computer_science_report_sc/

McGarr, O. (2008). The development of ICT across the curriculum in Irish schools: A historical perspective. *British Journal of Educational Technology, 40*(6), 1094 - 1108.

McGarr, O., & Johnston, K. (2021). Exploring the evolution of educational technology policy in Ireland: From catching-up to pedagogical maturity. *Educational Policy, 35*(6), 841-865.

McGarr, O., McInerney, C., Exton, C., & Power, J. (2019). *Leaving certificate computer science teachers' cpd programme - interim report.* Limerick: Lero: SFI-funded project (Discover programme). Retrieved August 31, 2020, from https://www.lero.ie/sites/default/files/Leaving%20Certificate%20Computer%20Science%20CPD%20Interim%20Report%20October%202019.pdf

McGarr, O., McInerney, C., Exton, C., & Power, J. (2020). *Exploring teachers' professional development to support the roll-out of Computer Science in Irish second-level schools - Final report.* Limerick: Lero: SFI-funded project (Discover programme). Retrieved February 12, 2021, from https://lero.ie/sites/default/files/LCCS%20PD%20Final%20Report%20August%202020.pdf

McKenna, P., Brady, M., Bates, P., Brick, J., & Drury, C. (1993). *New information technology in the irish school system.* Luxembourg: Office for Official Publications (EC).

Moynihan, M. D. (1986, January 1). Computer education : Ireland : a case study. Loughborough University, Loughborough University, UK. Retrieved August 31, 2020, from https://hdl.handle.net/2134/10837

NCCA. (2011). *Towards a framework for junior cycle.* Ireland: NCCA. Retrieved August 20, 2020, from https://ncca.ie/media/2466/towards_aframework_juniorcycle.pdf

NCCA. (2015). *Framework for junior cycle.* Dublin: Department of Education and Skills. Retrieved August 20, 2021, from https://ncca.ie/media/3249/framework-for-junior-cycle-2015-en.pdf

NCCA. (2016, June 1). *Short course coding specification for junior cycle.* Retrieved October 31, 2022, from DES: https://www.curriculumonline.ie/getmedia/cc254b82-1114-496e-bc4a-11f5b14a557f/NCCA-JC-Short-Course-Coding.pdf

NCCA. (2019, April 1). *Leaving certificate computer science.* Retrieved from NCCA: https://www.curriculumonline.ie/getmedia/a4feb183-69fe-4144-9add-56a13a5aa3f8/CS-Coursework-Assessment-Guidelines-201904_en.pdf

NCCA. (2019, May 1). *Primary curriculum review and redevelopment information for schools.* Retrieved September 14, 2021, from NCCA: https://ncca.ie/en/resources/primary-curriculum-review-and-redevelopment-information-for-schools

NCCA. (2019). *Primary developments: final report on the coding in primary schools initiative.* Ireland: NCCA. Retrieved from https://ncca.ie/media/4155/primary-coding_final-report-on-the-coding-in-primary-schools-initiative.pdf

NCCA. (2021, September 13). *Digital media literacy*. Retrieved from NCCA: https://curriculumonline.ie/Junior-cycle/Short-Courses/Digital-Media-Literacy/

NCCA. (2021, September 13). *Framework for junior cycle*. Retrieved from NCCA: https://ncca.ie/en/junior-cycle/framework-for-junior-cycle/

NCCA. (2021, August 31). *Primary curriculum*. Retrieved from NCCA: https://curriculumonline.ie/Primary/

NCCA. (2021, August 30). *Transition year*. Retrieved from NCCA: https://ncca.ie/en/senior-cycle/programmes-and-key-skills/transition-year/

Ofqual. (2019, August 1). *Selected a level subjects 2019.* Retrieved August 20, 2020, from Ofqual: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/825429/A-Level-infographic_current___3_.pdf

Oldham, E. (2015). Setting the context: developments in the Republic of Ireland prior to schools IT 2000. In E. Oldham, D. Butler, K. Marshall, & L. Margaret (Eds.), *Shaping the Future: How Technology Can Lead to Educational Transformation* (pp. 19 – 45). Dublin: The Liffey Press.

Scottish Qualifications Authority. (2021, April 29). *Annual statistical report: advanced higher: Computing science.* Retrieved from sqa: https://www.sqa.org.uk/sqa/94723.html

Scottish Qualifications Authority. (2021, April 29). *Annual statistical report: n5: computing science.* Retrieved from sqa: https://www.sqa.org.uk/sqa/94723.html

State Examinations Commission. (2021, August 31). *State examinations statistics*. Retrieved from State examinations commission: https://www.examinations.ie/?l=en&mc=st&sc=r19

The Royal Society. (2017). *After the reboot: computing education in uk schools.* London: The Royal Society, Computing Education. Retrieved August 15, 2020, from https://royalsociety.org/-/media/policy/projects/computing-education/computing-education-report.pdf

Zur Bargury, I., Muller, O., Haberman, B., Zohar, D., Cohen, A., Levy, D., & Hotoveli, R. (2012, October). Implementing a new computer science curriculum for middle school in Israel. *2012 Frontiers in Education Conference Proceedings* (pp. 1-6). IEEE.

A. Appendix

A.1. Table of Irish Educational Terminology

The following table gives an overview of the key terminology used in this paper. The paper is written in the Irish context and as such the authors have used Irish terminology to refer to the school levels and exams. This is may not be a familiar jurisdiction for all readers so this table should help readers in most other jurisdictions.

Table 5. Table of Terminology - Part 1

Terminology Table		
Term	Description	Definition
K-12	Kindergarten to 12th Grade	All school levels
Primary School	Ages approx. 4 to 12 years	Eight years from Junior Infants up to 6th class
Secondary School	Ages approx. 12 to 18 years	Split into Junior Cycle and Senior Cycle
Junior Cycle	Lower Second Level (US), GCSE levels (UK)	Ages 12 years to 15 years
Senior Cycle	Upper Second level (US), A levels (UK)	Ages 15 years to 18 years
LC	Leaving Certificate	State Exam before University
JC	Junior Certificate	State Exam after Junior Cycle (now abolished in favour of Junior Cycle
CESI	Computer Education Society of Ireland (later Computers in Education Society of Ireland)	The main Teacher Professional Network for CS in Ireland
DES	Department of Education	Government Body for Education in Ireland
TES	Teacher Education Services	Promotes the quality of teaching and learning through quality teacher training programmes
LERO	Science Foundation Ireland Research Centre for Software	Proving insights and reports on the implementation of the national CS curricula
ASTI	Association of Secondary Teachers, Ireland	One of the post-primary teachers' unions in Ireland
PDST	Professional Development Service for Teachers	Provides Teacher Continuous Professional Development (CPD) for teachers

Table 6. Table of Terminology - Part 2

Terminology Table		
Term	Description	Definition
NCCA	National Council for Curriculum and Assessment	Provides research informed curriculum and assessment
DEIS	Delivering Equality of Opportunity in Schools	Schools eligible for extra state supports
NFQ	NationalQualifications Framework	The Irish National Framework of Qualifications (NFQ) is a 10-level system used to describe qualifications in the Irish education and training system
CS	Computer Science	The term used to describe the Computer Science subject in the Irish Educational system
GCSE	General Certificate of Secondary Education	The General Certificate of Secondary Education is an academic qualification in a particular subject, taken in England, Wales, and Northern Ireland.
EU	European Union	The European Union (EU) is a unique economic and political union between 27 European countries.
SEC	State Exams Commission	The State Examinations Commission is responsible for the development, assessment, accreditation and certification of the second-level examinations of the Irish state.
Short Courses	Short Educational Courses at Junior Cycle	Students can acquire a level 3 qualification on the NQF