Capacity for, Access to, and Participation in

Computer Science Education in Ireland

Ollscoil na Gaillimhe
University of Galway

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Research supported by Google

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Executive Summary

According to the European Commission's Digital Education Action Plan 2021-2027, to enhance digital skills and competences for the digital era, opportunities to learn basic digital skills must be provided from an early age. These include computing education, along with comprehensive knowledge and understanding of data-intensive technologies, such as Artificial Intelligence (AI). The recently published "Harnessing Digital: The Digital Ireland Framework'' states that the digital transformation of the Irish economy involves "strengthening the centrality of education, research and innovation in the Irish economy" (Department of the Taoiseach, 2022, p.11).

Computer Science (CS) is the study of computer technology, including how coding, programming and computational thinking can be used to solve problems, and how computing technology impacts the world around us. Throughout the world, CS curricula are being introduced in primary and post-primary education systems, offering young people the opportunity to move away from being passive users of computers to becoming designers and to developing a thorough understanding of *how* technology works. Coupled with this is the knowledge, ways of thinking, problem-solving and creativity involved in the diverse field of CS – skills that are invaluable for individuals in the 21st century, and that can bring the benefits of innovation and digital transformation to national and global economies alike.

The Irish education system has embraced CS in recent years through pilot projects to integrate computational thinking into the primary curriculum, by introducing CS as a stand-alone subject at post-primary, and by developing initial teacher education and continuous professional development/in-service teacher programmes. It is therefore timely to assess the ecosystem in terms of capacity for, participation in, and access to CS in order to preserve the success and growth of this relatively new discipline, and to ensure it remains rooted in an active and equitable approach to participation by *all* young people across Ireland.

This study, led by the School of Education at the University of Galway and supported by Google, evaluates the provision of CS in schools in Ireland through a lens of diversity and inclusion. This report unbundles the national landscape and positions CS at the forefront of the wave of policy, accreditation and transformative change already underway in the Government of Ireland's digital agenda. The findings have implications for the integration of CS into the curriculum and into teacher education nationally, along with future developments in education and digital policy.

Key Findings

Capacity for Computer Science

» Our findings show that the **Capacity for** CS education in Ireland is rooted in the implementation and sustained growth of the new Leaving Certificate subject. Currently, CS at Senior Cycle is limited by the low numbers of post-primary schools offering Coding as a Junior Cycle short course and by the significant shortage of teachers qualified to teach the subject to Leaving Certificate level. As of August 2022, there were 34 accredited CS teachers registered with the Teaching Council.

» The capacity of the Irish education system to facilitate CS education is highly contested with constraints being placed on school timetables, due to, for example, mandated hours for Wellbeing. Coupled with this is a low level of awareness and a pervading misunderstanding about what the discipline is (and what it is not – there is often a confusion with it being the same as digital literacy) among key stakeholders across the ecosystem.

» Although elements of the discipline of CS have been successfully piloted in recent years, it is not yet a formal part of the primary curriculum, meaning that very few students have the opportunity to be exposed to the basic concepts, practices and skills of CS from an early age. The new Primary Curriculum Framework (NCCA, 2023) offers a promising opportunity for the introduction of CS to all primary school students in Ireland, under the new key competencies of the framework, including 'Being a Digital Learner'. Professional development in CS education should no longer be viewed as an elective for primary teachers but rather be embedded within all initial teacher education programmes.

Access To Computer Science:

» The findings relating to **Access to** CS reveal a bias towards other subjects, such as Physical Education (PE) and Politics and Society, being easier to implement. In 2021, of the 215,127 students registered at Junior Cycle level, 14,007 students studied Coding. In comparison, 43,725 students studied Social, Personal and Health Education (SPHE), 63,529 PE and 215,127 Civic, Social and Political Education (CSPE) short courses, subjects seen as relating to Wellbeing.

» Of the 1,684 students who studied CS for Leaving Certificate in 2022, there was a male-female ratio of 78:22 (State Examination Commission, 2022), revealing a significant gender gap.

» The curriculum, perceptions and understanding of digital literacy, teacher capacity, and a shortage of facilities are the key barriers to providing access to CS in schools. Additional challenges include the lack of teacher expertise in the current staff (against the backdrop of a national challenge of teacher shortage), low teacher confidence, and negative student perceptions of the subject, or lack of understanding.

Participation In Computer Science

» Our Case Study of schools in Galway City and County, serve as a snapshot of **Participation in** CS education in Ireland. Results show that students who chose to study CS are positive about the subject and their experience of learning it, in particular the practical, hands-on nature of the course. Having an interest in CS and/or Coding was a motivating factor in deciding to pursue the subject, along with the prospect of jobs and future career plans. Additionally, the findings suggest that parental education attainment level has an impact on students' decision to study CS at Leaving Certificate.

Recommendations

1 Consolidated Understanding

We need to develop a shared understanding of CS and strengthen its acceptance as a foundational competence for all, enabling young people to become active participants in a digital economy and society. We need to help school decision-makers to recognise and understand the importance of CS for all students, building systemic knowledge to support good decision-making, and helping them find ways to balance competing academic expectations. Additionally, we need to actively engage parents and students by informing them of the importance of CS education to future success and help them become partners and advocates in making the needed systemic improvements.

2 Support for Policy

Much has been accomplished in Ireland to date with this relatively new academic discipline in schools, but far more needs to be done to ensure that CS education is available and accessible to all students. Broad engagement is needed with key stakeholders across the education system to highlight and optimise the benefits of CS as a key digital competency for all.

3 Systemic Rollout

We need a holistic approach to the introduction of computing competencies in formal education and to create a learning pathway from preschool, through primary and into post-primary school. We need to scale CS education throughout the education system to ensure that all students may participate in this learning regardless of gender, race, school location and socioeconomic status.

4 Comprehensive Integration

To ensure this learning pathway across the formal education system, CS, along with digital and computational competencies, must be truly embedded within all initial teacher education programmes and through continued investment in in-service programmes for teachers. Ensuring that new teachers exit from teacher preparation programmes prepared to teach appropriate CS content at their respective levels will build greater capacity across the entire education system.

Abbreviations

CESI	Computers in Education Society of Ireland
CS	Computer Science
CSO	Central Statistics Office
CSPE	Civic, Social and Political Education
CT	Computational Thinking
DEIS	Delivering Equality of Opportunity in Schools
ICT	Information and Communications Technology
IT	Information Technology
JC	Junior Cycle
JCT	Junior Cycle for Teachers
LCCS	Leaving Certificate Computer Science
NCCA	National Council for Curriculum and Assessment
PDST	Professional Development Service for Teachers
PE	Physical Education
SEC	State Examinations Commission
SPHE	Social, Personal and Health Education
STEM	Science, Technology, Engineering and Mathematics
TY	Transition Year

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1. Introduction

Due to the ubiquity of computing in our daily lives, there is an educational imperative to support creative and quality education in Computer Science (CS) for the world of today, and for the future. In recent years, CS education has experienced unprecedented growth globally, in terms of new programmes, technologies and curricula to support learners to engage in CS learning initiatives, both in school and community-based.

At a macroeconomic level, research suggests that in countries where employees have technology skills, there is higher economic growth through increases in productivity (Maryska, Doucek, & Kunstova, 2012; Jorgenson & Vu, 2016), illustrated in Figure 1 and Figure 2. At the microeconomic level, CS skills benefit the individual (Salehi et al., 2020). Increasingly, the era of digital education requires that everyone has a fundamental grasp of how computing works (Selwyn, 2015; 2019).

CS is a scientific discipline that encompasses computers and algorithmic processes including their principles, their hardware and software design, and their impact on society. Two of the most important aspects of the discipline are the use of computational thinking (CT) and the development of algorithms. CT is a broad problem-solving technique that allows students to use fundamental concepts of computing (such as decomposition, pattern recognition, and abstraction) and the power of computing technology to solve problems across multiple disciplines. Algorithms are an ordered set of step-by-step instructions that computers require to carry out any activity. The process of writing these instructions is commonly referred to as "programming" or "coding".

CS in national curricula (or subjects relating to the discipline) offers students the opportunity to move away from being passive users of computing to becoming designers of computer systems and developing a comprehensive understanding of how technology works. The ways of thinking, problem-solving and creativity in the discipline of CS, as described above, have become invaluable parts of life and are important beyond ensuring that we have enough skilled workers (Alano, 2016).

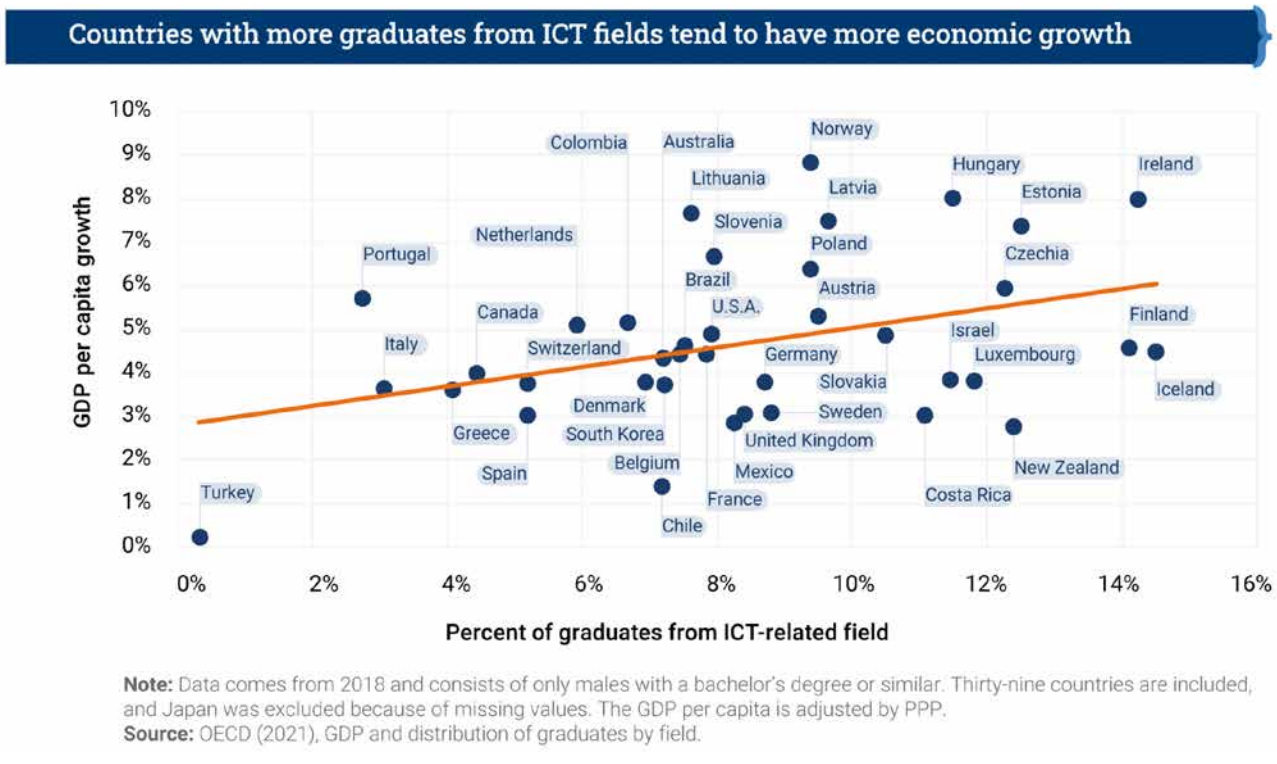


Figure 1. Countries with more graduates from ICT fields tend to have more economic growth (Vegas, Hansen, and Fowler 2021)

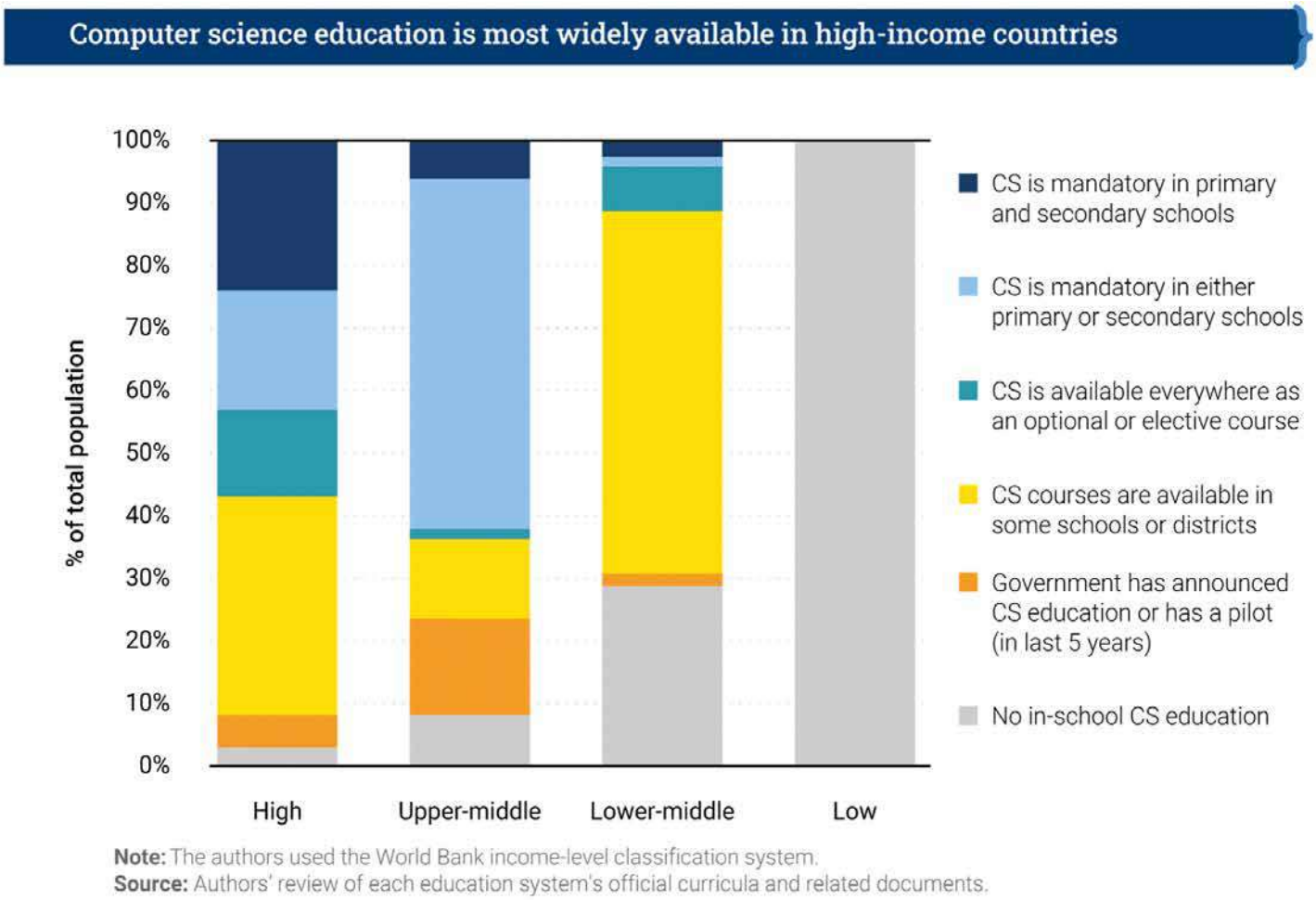


Figure 2. Computer science education is most widely available in high-income countries (Vegas, Hansen, and Fowler 2021)

The CS education pathway in Ireland

CS is a relatively new subject in schools in Ireland. Its introduction to the post-primary curriculum in 2018 (at Leaving Certificate, ages 16-18) was a landmark in Irish education and continues to shape the trajectory of digital education policy (Department of Education 2016, 2019; National Council for Curriculum and Assessment 2017). Since 2016, Coding has been available at Junior Cycle as a short course.

While there is currently no provision for CS at primary level, there is potential for all primary school students to learn key elements of the discipline (such as CT and coding) under the key competencies and subject areas of the new Primary Curriculum Framework (NCCA, 2023).

Figure 3 summarises the current status of CS availability in schools in Ireland.

The CS education pathway in Ireland

Primary School								Post-Primary School					
Junior Infants	Senior Infants	1st Class	2nd Class	3rd Class	4th Class	5th Class	6th Class	1st Year	2nd Year	3rd Year	Transition Year (optional)	5th Year	6th Year
Age: 5								**Age: 12**					**Age: 18**

Coding in Primary Schools

Pilot initiative, 2017-2019: 40 schools.
Support materials and best practice activities are ***available*** to schools interested in introducing coding and computational thinking, but ***optional*** (requires confident, trained teacher)

The new ***Primary Curriculum Framework*** (NCCA 2023) includes 'Being a Digital Learner' as one of seven key competencies for children's learning.

Coding Short Course

Approx 100 hours, ***optional*** course (requires confident, trained teacher).
Link between Primary and Leaving Cert CS: aims to *"build on any coding skills that primary students might have acquired while offering insight into possible future studies in computer science and software engineering."*
Curriculum doc

Computer Science

New ***optional*** subject since 2020 (pilot 2018-20), part of Leaving Certificate. Content includes computing, algorithmic processes, problem-solving with programming and CT, understanding the role of technology in society.
Curriculum info

Figure 3. Coding and Computer Science landscape in Ireland

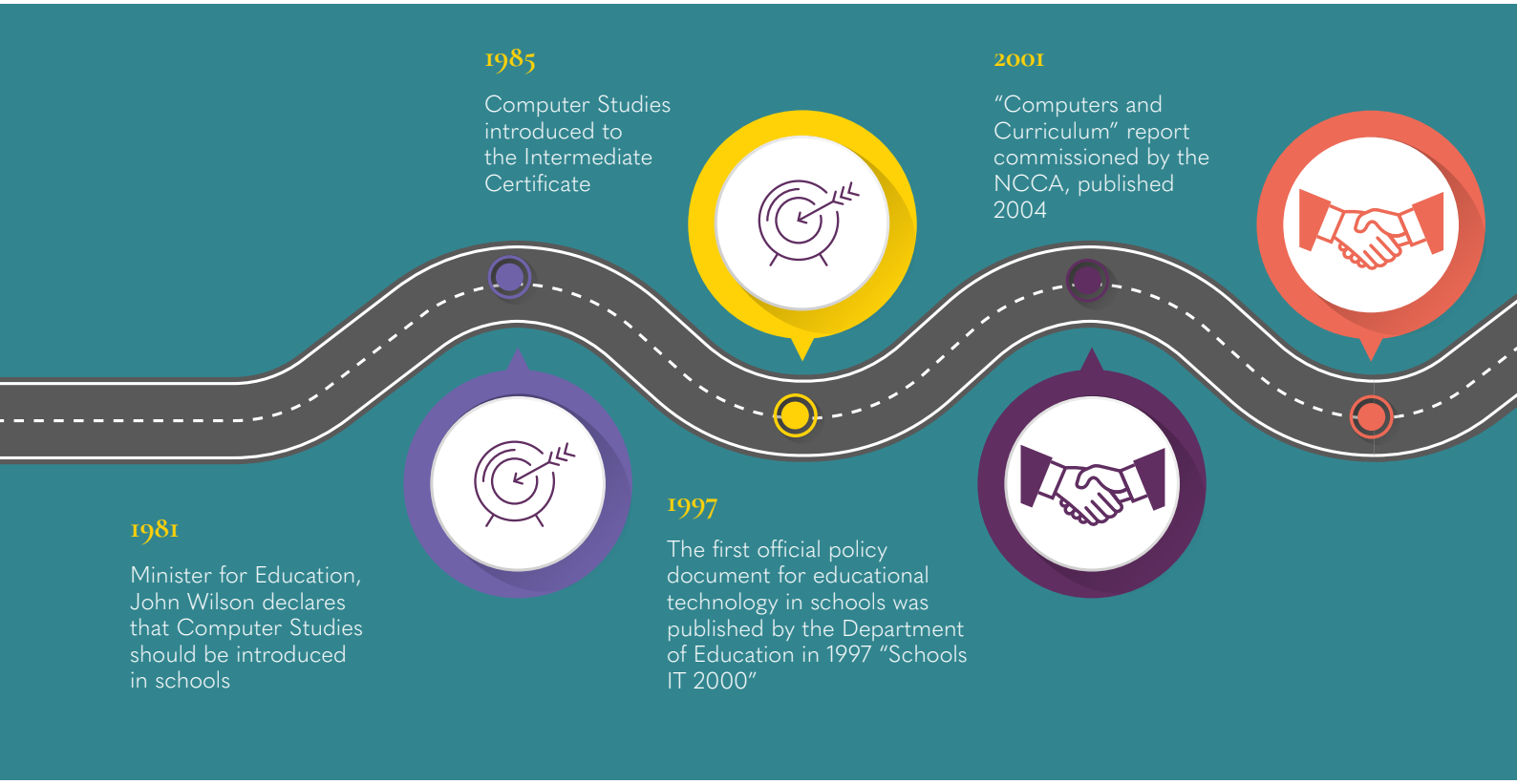
Project Rationale

The introduction of CS competencies at a young age can be viewed as investing in national digital transformation, benefiting society and the national economy. CS education has been linked with higher rates of college enrolment and improved problem-solving abilities (Brown & Brown, 2020; Salehi et al., 2020) and as we progress through the 21st century, CS education "promises to significantly enhance student preparedness for the future of work and active citizenship" (European Commission, 2022).

Nevertheless ethnic minorities, females, and those from lower socioeconomic areas have not been afforded the same opportunities in CS education (Sax et al., 2016). It has been demonstrated globally, and in the US in particular, that the diversity gap in CS is not due to talent differences amongst various demographic groups (Sullivan & Bers, 2012; Cussó-Calabuig et al., 2017), but rather due to a discrepancy and imbalance of access to CS content (Google and Gallup 2016; Code.org & CSTA, 2018; Du & Wimmer, 2019), cultural perceptions, and the lack of female and minority representation in the media (Ayebi-Arthur, 2011; Downes & Looker, 2011; Du & Wimmer, 2019). Additionally, supporting teachers to develop the necessary skills and confidence levels remains one of the most significant challenges to broadening access to CS (Vegas & Fowler 2020).

In Ireland, "data on STEM subject enrolments indicate that the take up of the physical sciences and technology subjects is lower amongst girls, and the availability of these subjects is also more limited in all-female schools" (Goos et al., 2020). Despite the 20-year trajectory of growth in CS in the formal education system here (Figure 4), we need to move towards scaling and improving the offering and capacity within the system, to ensure equitable access for *all* students.

An evaluation of the current position is paramount to developing future requirements and needs, ensuring appropriate capacity for and access to CS throughout formal education.



Current research of the Irish context regarding the intersectionality of the topics to address diversity, equity and awareness of CS is limited. It is evident that students from marginalized groups are less likely to have access to CS courses, and when such disparities are unaddressed, innovations and contributions from diverse creators are missed. Advancing policy to prioritise equity and diversity of CS education is important. Understanding the levels of access to CS in the Irish education system, the diversity of student participation and systemic factors influencing student uptake of the subject is necessary and the foundation of this research.

This project was led by the School of Education at the University of Galway and supported by Google. It set out to evaluate current CS learning opportunities in the primary and post-primary sector in Ireland through a lens of diversity and inclusion, teacher education and professional development. For this project, diversity was defined in terms of gender, race, socioeconomic status and ethnicity, and the intersection of diverse groups (Alozie et al., 2021).

The project objectives were to:

1. Evaluate and understand three critical areas in the context of the education system in Ireland: Capacity for, Access to, and Participation in CS.

2. Provide a snapshot of the current landscape relating to CS education in Ireland and make future recommendations on how to increase equitable integration of CS across the formal education system.

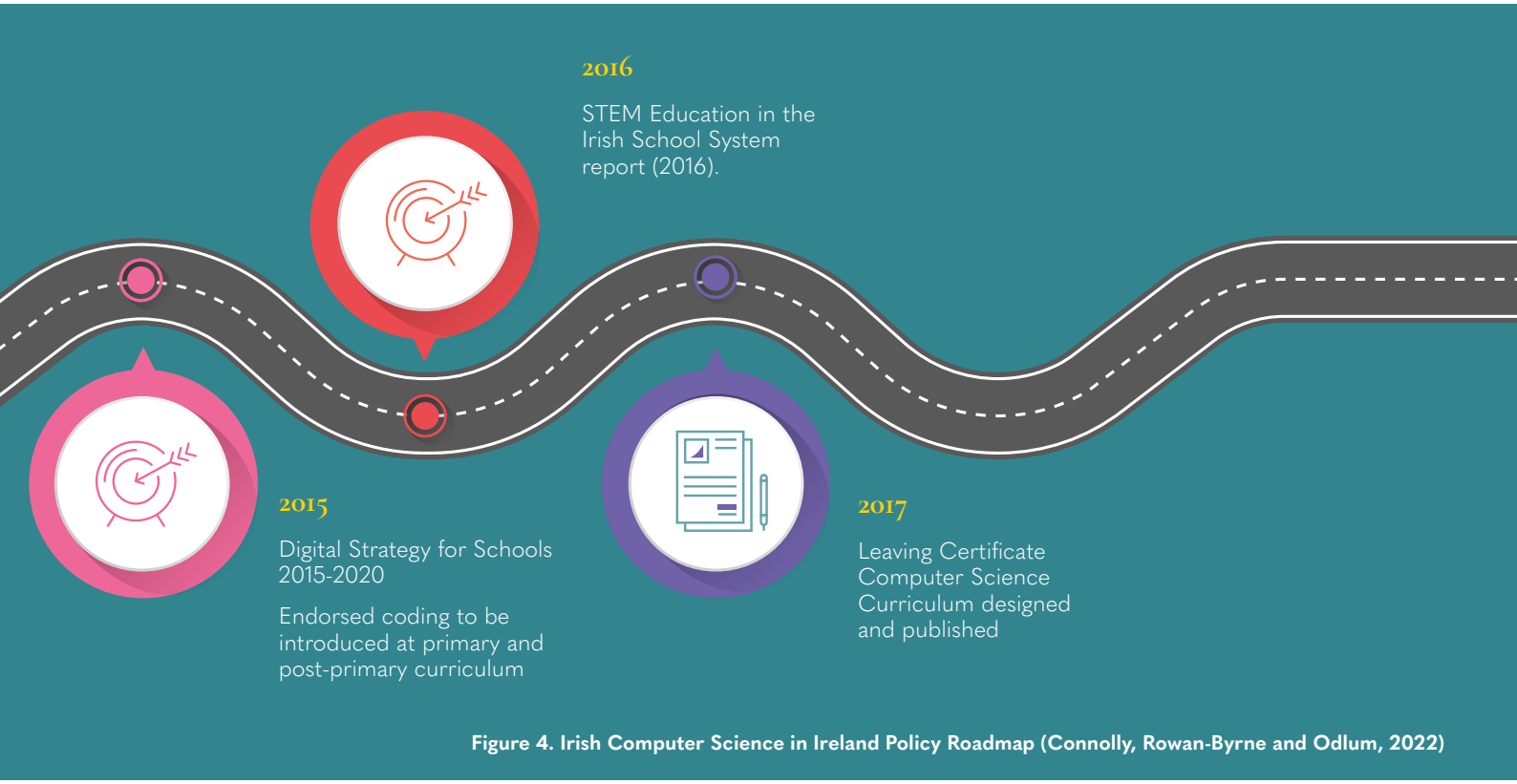


Figure 4. Irish Computer Science in Ireland Policy Roadmap (Connolly, Rowan-Byrne and Odlum, 2022)

2.
Research Methodology

This research is grounded in the CAPE model (Fletcher & Warner, 2021). The study focuses on three components of the CAPE model, namely Capacity for, Access to, and Participation in CS education in Ireland, Figure 5.

1. **Capacity for** is concerned with whether or not there are enough resources to support and maintain high-quality CS instruction, and evaluating the availability of resources in the education system to provide and maintain high-quality CS learning experiences at school. These resources include teachers, funding and policies that make implementing CS instruction within the curriculum (primary, post-primary) possible and inclusive.

   A desktop review of the current CS offering was conducted along with focus group interviews with experts in the field. Markers of Capacity for included the number of teachers certified to teach the subject in Ireland, the availability of CS teacher education programmes and the number of schools formally teaching Computer Science and Coding.

2. **Access to** focuses on whether or not students have the opportunity to learn CS. This can be operationalised as students attending a school that offers CS courses/subjects and an evaluation of the teacher education landscape in order to understand the opportunities available to teachers (pre-service and in-service).

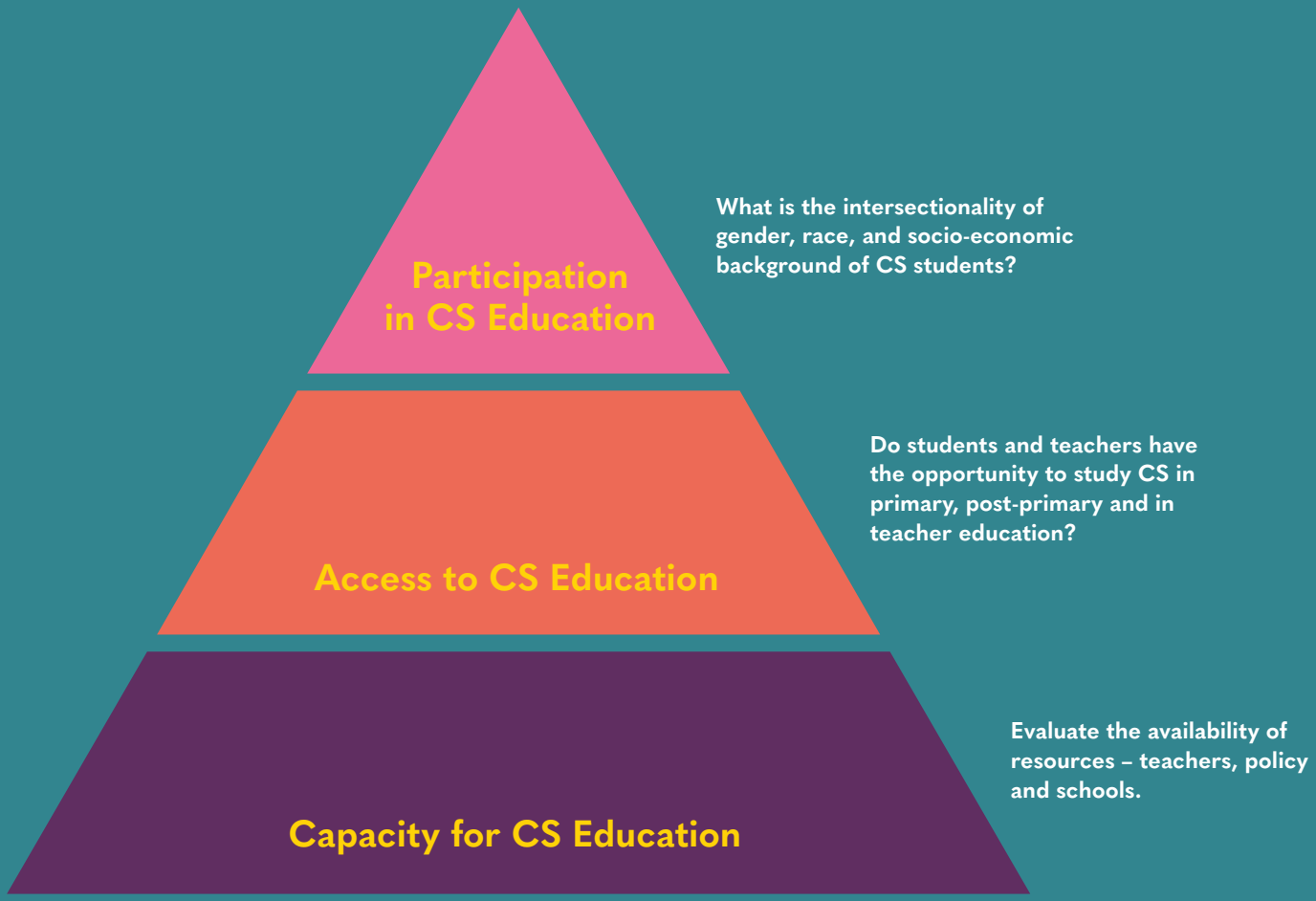
   Focus groups were conducted with teachers and school leaders from different school types (primary and post-primary) to ascertain interests, potential and challenges of CS education.

3. **Participation in** is the extent that Irish students are actively engaged in formal CS learning opportunities when offered by their school. It also concerns the diversity of CS education provision in Ireland, through the lens of gender, race and socioeconomics, as well as the intersectionality of diverse groups and challenges.

   A case study catchment area was chosen to review where questionnaires were administrated. Markers included the numbers in the school committing to or withdrawing from CS; and the scope of diversity of the CS student.

Table 1 summarises the participants involved in each phase, the research instrument used and the data collected, with details of each component of the Research Design explained in Appendix C.

Figure 5. CAPE model, adapted from Fletcher & Warner, (2021)



Participants	Phase	Level	Instruments	Data	Number of Participants
P Students	Participation in	P	Desktop Research (Previous Reports)	Capture Landscape	n/a
PP Students	Participationin	PP	Questionnaire Focus Group	Student profile, of those that choose to study CS Comments from students regarding their CS Experience	27 from 3 schools
P Leaders	Capacity for	P	Focus Groups Desktop Research (Previous Reports)	Are teachers ready/prepared to teach Computational Thinking (CT) in new primary Maths Course? Does the school have the appropriate equipment?	4
PP Leaders	Access to	PP	Focus Groups	School profiles that offer CS courses	4
P Teachers	Capacity for	P	Focus Groups	Are they ready to teach CT in primary? Do they know what CT is?	4
PP Teachers	Access to	PP	Focus Groups	School-level factors which determine CS/JC Coding offering or not, recommendations	3
Stakeholder Experts	Capacity for, Access to	P and PP	Focus Groups	Factors affecting access and capacity for CS	4

P= Primary, PP = Post-Primary

Table 1 summarises the participants involved in each phase, the research instrument

3.
Findings

3.1 Capacity for

Capacity for is concerned with whether or not there are enough resources to support and maintain high-quality CS instruction (Fletcher & Warner, 2021). Resources include teachers, funding and policies that make implementing CS instruction within the curriculum (primary, post-primary) possible and inclusive.

This phase of the research involved a desktop review of the current CS offering within the Irish education system by examining the proportion of current to planned or possible programmes. Indicators included the number of teachers that are certified to teach CS in Ireland, the number of schools that are formally teaching CS and Coding at post-primary, policy documents and available funding, professional development teachers have pursued and the number of registered CS teachers.

In Numbers (2021/2022)

391,698

Post-primary population

14,007

Students studied JC short course in Coding

117

JC Coding available in 117 schools

1,604

Students who completed the LCCS exam

114

LCCS available in 114 schools

Coding

59.4%

LCCS higher level

72.2%

Coding

40.6%

LCCS higher level

27.8%

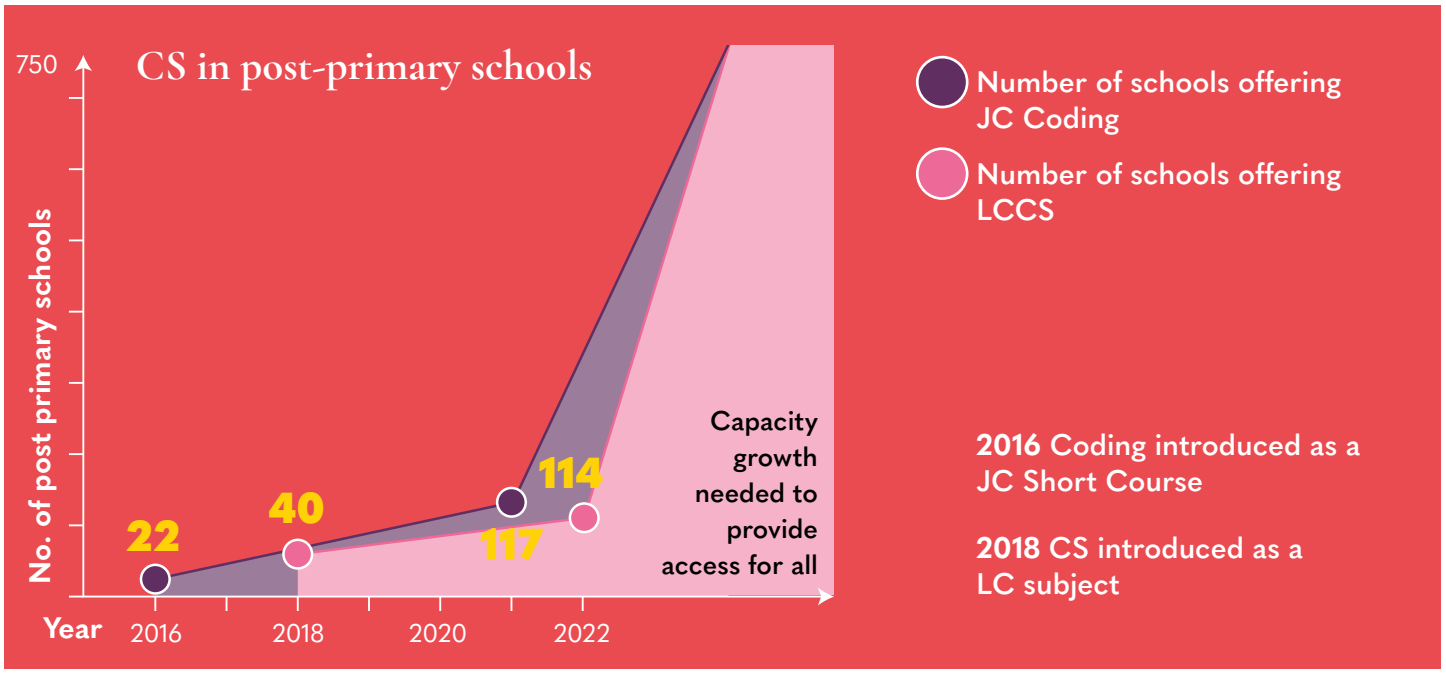
3.1.1 Current Status of CS Education Landscape

LCCS is a relatively new subject, first piloted in 2018 with 40 schools (Phase 1), leading to 739 students taking this subject for the Leaving Certification examination in 2020 (www.examinations.ie). 52 schools participated in Phase 2 (2019), with a further 48 schools participating in Phase 3 (2020). Since 2018, the PDST has engaged with a total of 140 schools, offering a robust programme of professional learning opportunities to teachers and school leaders to support the introduction of this new subject (PDST email, 2022). In 2021, 706 students sat the LCCS examination (www.examinations.ie). In comparison, in 2021, PE (also introduced on a phased basis in 2018) and Politics and Society (first introduced in 2016) had student numbers of 1,600 and 2,222 respectively.

Coding was introduced in 2016 with an initial cohort of 22 schools, with 10 of these schools registered as officially offering Coding for Junior Cycle (Department of Education, 2018). This increased to 40 schools in 2017, 108 in 2020, and 117 schools in 2021 (CSO email, 2021, 2022; Department of Education, 2018, 2019).

Teachers do not have to be registered as a CS teacher with the Teaching Council in Ireland to teach JC Coding. However, 125 schools (excluding duplicate enrolments) have engaged with supportive training available from 2016 to 2022 with the Junior Cycle for Teachers (JCT), a professional development support service for teachers. Unfortunately, this supportive training has been discontinued.

Coupled with this challenge, is a change to the Junior Cycle curriculum mandated from September 2021, which states that 400 hours of the timetable be dedicated to Wellbeing (Department of Education, 2021) for all incoming first years. Wellbeing is a composite subject that has three pillars: Physical Education (PE) 135 hours, Social, Personal and Health Education (SPHE) 100 hours, and Civic, Social and Political Education (CSPE) (100 hours). Schools must also include 65 hours to a Wellbeing programme designed specifically for their students. Although introduced as new short courses, PE and CSPE had already been part of the Irish Curriculum: CSPE was a Junior Certificate subject offered in Ireland from 1997 to 2019, while PE was long established as a non-examination subject. Hence, schools already had trained and qualified teachers in-situ. By comparison, Coding was a new discipline for the majority of schools, with new content and required a new pedagogical approach.



An interview and a focus group with CS education experts was conducted to explore in depth and validate the findings from the desktop research regarding **Capacity for** CS in the Irish education system. Analysis of the key points raised by the participants reveal key findings relating to a lack of capacity for CS; for example, there is no scope in the timetable due to competing subjects and specific training for the JC Coding short course has been discontinued.

The lack of CS teachers was raised as an important issue to address in increasing the capacity of CS instruction in Ireland. *"If they want computer science to be taught in schools, well surely you need people that can teach it"* **(Participant1)**.

The high stakes associated with the LCCS examination and assessment process also affects capacity and participation, which **Participant8** outlined: *"You can have some schools offering it to all of their first-year classes... and then they would maybe split into the digital media and short course in Coding. Whereas when it gets to the Computer Science at Leaving Cert, it's a totally different ballgame. Because you, you know, you're looking at points, and it's much more competitive."*

Nevertheless the *"existence of the Junior Cycle Coding course cannot be underestimated in increasing capacity within schools, supporting teachers but also for students taking Leaving Certificate Computer Science"* **(Participant7)**.

The teaching and pedagogical approach to teaching JC Coding and CS was raised as a positive. *"It's less kind of this rote learning stuff. So, you know, I think there's still capacity out there. But we're just a little bit constrained, but certainly there's still an appetite for it."* **(Participant5)**.

The capacity in the school teaching staff to offer both the short course in Coding and LCCS was highlighted as a challenge *"There are a lot of schools that now want to expand the knowledge within the teacher cohort, within the staff. So they may have it in the school, but they're trying to expand it now across the staff members and in the school itself"* **(Participant9)**.

Regarding the misconception of device and equipment provision, one participant explained: *"So all you need is some sort of device, a decent internet and an outlet, and you're ready to go, you know, so, I mean, the overhead is much lower than what it used to be...Most of the coding teachers that I've met have a good sense of what they need, they may be constrained by their just physical setups, and the schools."* **(Participant9)**.

3.1.2 Teacher Supply (Post-primary)

Teachers do not need formal recognition from the Teaching Council to teach the short course in Coding. However, the majority of those teaching Coding have previously engaged in a rigorous and comprehensive professional development programme with the JCT, involving teachers from 125 schools (Lero email, 2022). Training for Phase 2 of Coding (2019-2021) consisted of three full days, and four 1.5 hour online workshops (Lero email, 2022). This curricular-focused supportive training from the JCT was discontinued in May 2022 (JCT, 2022).

An elective programme has now taken its place under the Arts in Junior Cycle umbrella. Three 1.5 hour elective creative coding workshops in Python, Scratch and HTML were offered in 2022 (Lero, 2022). This amendment in policy has significant ramifications for the necessity of computing education to be embedded in our post-primary education curriculum.

In order to be a Teaching Council accredited teacher of CS, one must have 60 ECTS credits of CS at Level 8 qualification. The ECTS must be in specific areas: Software Engineering and Project Management, Programming, Computer Systems, and the teacher must have studied two of the following modules: Web Development, App Development, Robotics, Databases, AI, Modelling, Embedded Systems or Animation (Teaching Council 2023). Teachers must also have a recognised teacher education qualification.

In 2022, there were 34 accredited LCCS teachers registered with the Teaching Council of Ireland (Teaching Council email, August 2022). As a comparison, PE, piloted in 2018 as an examinable subject, had 3,146 registered teachers. The subject of Politics & Society is also relatively new, piloted in 2016 with 41 schools. This subject had 102 teachers registered with the Teaching Council in August 2022. See Table 2.

There are currently over 140 teachers involved with the LCCS programme. Therefore, the vast majority teaching CS are doing so without Teaching Council accreditation for this subject.

Table 2: Teacher Numbers

Accredited Teacher Numbers 2022			
	PE	Politics & Society	**Computer Science**
January	3,146	55	**16**
August	3,234	102	**34**

Currently there are four Universities providing Teaching Council accreditation for Computer Science at post-primary (Table 3).

Educational Institution	Course Title	Year programme commenced
University of Galway	Bachelor of Education (Computer Science and Mathematical Studies)	2019
University of Limerick	Bachelor of Science with Mathematics and Computer Science	2020
Maynooth University	Masters of Science in Mathematics Education	CS added as an additional subject/pathway in the MSc in 2022
University College Dublin	MSc in Mathematics and Science Education	CS added as an additional subject/pathway in 2021

Table 3: University, teacher education providers with accredited CS programmes

3.1.3 Summary

CS is not currently a formal part of the Irish primary curriculum. Despite "demands to include new aspects of learning in the curriculum such as Coding and Computational Thinking" (NCCA, 2020, p. 2), CS is not a recognised curriculum area or subject in the new Primary Curriculum Framework (NCCA 2023). However, there are opportunities for schools to introduce elements of CS under the new key competencies of the framework, including 'Being a Digital Learner'.

The main barriers relating to the Capacity for and for the growth in the numbers of students learning CS at school is CS not being offered to students, as well as instances where there are no teachers with a suitable skillset in the staff cohort.

Our CS expert stakeholders, in a focus group, highlighted the following four elements of concern regarding capacity and teacher expertise:

1. **Teacher confidence with a need to upskill teachers and Department of Education inspectorate**

Teacher confidence in undertaking and learning a new subject, leading its rollout within a school community and then teaching the new subject at Senior Cycle examination level is to be commended. Commitment to the subject by teachers is pivotal to the longevity of the CS within our education system. Supporting our CS teachers, along with school leadership teams encouraging the uptake of the subject amongst parents and students needs to be championed.

2. **A sustained model of support in order to integrate CT/coding within other subjects in the curriculum**

As stated in the Digital Strategy for Schools to 2027 (Department of Education, 2022): "It is important that the curriculum, from primary to Senior Cycle, offers multiple opportunities for the development of digital skills and digital literacy" (p. 39). A sustained and supportive programme for continuous teacher professional development will be required for such implementation of digital skills. It will be necessary to integrate CT and coding and other aspects of the discipline of CS throughout the continuum and provide professional development to all teachers in primary and post-primary levels.

3. **Provision of concrete examples of how to teach CS.**

As a new subject, teachers naturally rely on a bank of resources and artefacts for classroom use. Sharing existing lesson plans, schemes of work and facilitating a CS community of practice is a requirement to ensure teacher agency development and empowerment to lead the development of the subject at both primary and post-primary level. The CS teacher association, CSEI, have operationalised a CS community of practice for teachers, and the PDST have a website, www.compsci.ie to support teachers. Continued promotion of and investment in these Department of Education supported resources to prospective CS teachers and school leaders is essential.

4. **Communication and awareness of the subject are vitally important.**

There still remains a disconnect on the understanding and knowledge regarding the scope and awareness of CS. It is necessary to communicate to parents, school leadership, and all educational stakeholders of the importance of the skill for future development. In addition, there is a requirement that all stakeholders responsible for assessment, inspection and leadership within our education ecosystem understand or have an awareness of the discipline of CS, and all that it encompasses, so that it is not confused with digital skills or basic digital literacy.

3.2 Access to

Access to, focuses on whether or not students have the opportunity to learn CS. This can be operationalised as students attending a school that offers CS courses, offering an evaluation of the CS landscape for primary and post-primary.

The research question was: What factors affect whether a school will offer Leaving Cert Computer Science or Junior Cycle Coding to their students? Teachers and leaders from different school types (primary and post-primary) were selected to ascertain interests, potential, and participation in CS Education; both their formal and non-formal influences were determined.

3.2.1 Access to the Short Course in Coding

In 2021, of the 215,123 students registered at Junior Cycle, 14,007 (6.5%) took the short course in Coding. (Table 4). While it is encouraging to see that 40% of the students who studied Coding were female (Table 5), this trend is not maintained at Leaving Certificate level. Looking to third level for comparison, currently 20% of students studying ICT are female, a statistic that has not changed in the last three years (HEA, 2022, p. 4).

	1st Year	2nd Year	3rd Year
Coding 2021	5.9%	6.6%	7.1%
Coding 2020	5.2%	6.4%	6%

Table 4. The number of school students enrolled in each year of JC Coding (CSO email, 2022)

			Schools
Coding 2021	8,285	5,722	117
Coding 2020	7,183	4,903	108

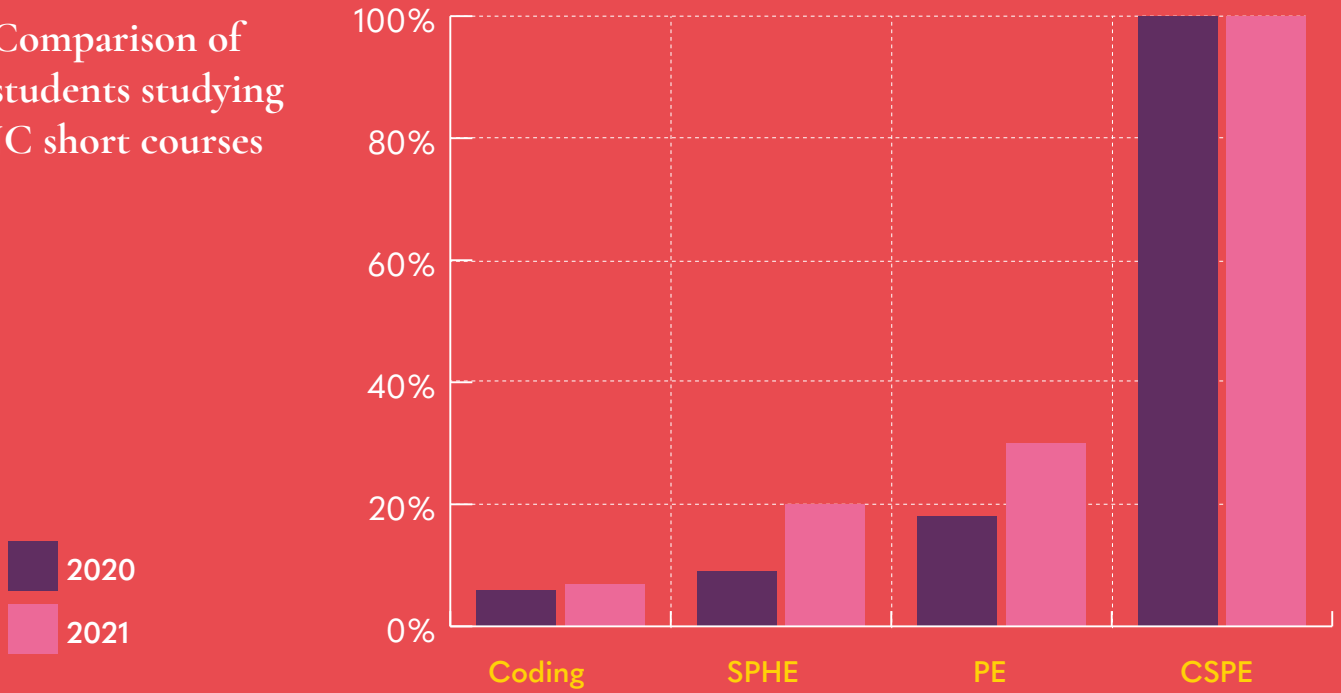
Table 5. Student gender information and schools numbers related to the Coding short course (CSO email, 2022)

For Junior Cycle certification a student typically takes nine subjects (with English, Mathematics, Irish, and History compulsory) and two short courses. Table 6 shows the wide range of short courses available at JC and the numbers of students enrolled in 2020 and 2021. Data from the CSO 2021 reveal that many schools are now doing short courses in Wellbeing subjects. Interviews with school principals and teachers confirmed the view that if students are mandated to do Wellbeing subjects, many schools believe they should do them as a short course and get an award from the state.

Subject	Academic Year 2020	Academic Year 2021
Artistic Performance	2,819	2,734
Chinese Language and Culture	n/a	287
Civic Social & Political Education	30,499	161,887
Coding	12,086	14,007
CSI: Exploring Forensic Science	469	394
CSPE (Civic, Social, Political Education)	175,569	53,240
Digital Media Literacy	8,829	11,250
Personal Project: Caring for Animals	275	459
Philosophy	239	211
Philosophy (NCCA & COGG)	2,117	2,353
Physical Education JC short course	37,288	63,529
SPHE (Social, Personal, Health Education)	19,462	43,725

Table 6. Short Courses in Junior Cycle schools and Student Enrolment (CSO email)

Comparison of students studying JC short courses



3.2.2 Access to Leaving Certificate Computer Science

CS is a relatively new subject that was introduced on a phased basis into the Leaving Certificate curriculum in 2018. Of the 728 post-primary schools in Ireland (Government of Ireland, 2022), 114 schools provided this subject in 2022 (CSO email, 2022). This equates to only 15.6% of all post-primary schools offering LCCS, directly affecting students' access.

In 2021, there were 128,549 students registered for the post-primary Senior Cycle. Of this number, 3,005 were registered for the LCCS subject (CSO email, 2022). This equates to 2.3% of senior cycle students studying CS.

In 2022, 382 students who studied LCCS were female and 1,302 were male, a male-female ratio of 78:22 (State Examination Commission, 2022). In 2021, the male-female ratio was 74:26 (State Examinations Commission, 2021). These data point to an emerging significant gender gap.

With reference to the 2022 LCCS students, 382 are female and 1,302 are male, resulting in a male-female ratio of 78:22 (State Examination Commission, 2022). This shows that the male-female ratio for LCCS students is declining, with a 2021 ratio of 74:26 (State Examinations Commission, 2021).

The introduction of the subject was supported by a comprehensive continuing professional development programme delivered by the Professional Development Service for Teachers (PDST). The PDST have, so far, engaged with 140 schools to help teach this subject, with 114 of these schools currently offering the subject.

Student Numbers			
	PE	Politics & Society	**Computer Science**
2021	2.6%	3.6%	**1.1%**
2022	8.5%	4.2%	**2.8%**

Table 7. Student LC Exam Numbers for PE, Politics and Society, and CS 2021 and 2022 (State Examination Commission, 2022; State Examinations Commission, 2021)

3.2.3 Provision of Computer Science in post-primary schools

Participants were asked why their school offered CS or why their schools would be interested in providing it, discussing the factors and barriers they perceived in offering the subject to young people.

Our findings show that on-the-ground understanding of CS varies greatly, with terms IT, computer studies, CS and Coding being used interchangeably by school leaders and teachers. The lack of clear, inspiring language about what CS is (and, more importantly, what it *isn't*) can make it difficult for students, teachers and parents to understand why it is an essential skill and an important subject to consider. Our research points to a need for greater awareness of the scope of CS as a discipline and the differences in terms and terminology for all stakeholders in the ecosystem, who ultimately influence young people and the system.

Schools which provide CS used vivid words when explaining their rationale for providing the subject, such as: "modern", "21st century learning", "forefront", "very strong in the STEM-based area", "natural progression", and "progressive school".

In their interviews, school principals and teachers referred to the following four topics as challenges when introducing formal CS courses: (1) the Irish curriculum, (2) perceptions, awareness and understanding of digital literacy, (3) teacher capacity, and (4) facilities. Each is discussed in turn in the sections that follow.

The Irish Curriculum

The biggest blocking factor for Coding and stuff was Wellbeing. Because now, in September its mandatory. That was a short course in PE, SPHE, and CSPE. **(Participant1)**

I wasn't in a position to offer because there was no scope on the timetable. **(Participant4)**

In Ireland, at Junior Cycle a school can offer students ten examinable subjects with no short courses, nine examinable subjects with two short courses, or eight examinable subjects with four short courses. With reference to Coding, one of the most significant issues to access is seen as 'Wellbeing'. **Participant2** succinctly states its effect on the timetable: *"It's effectively one full day in the week [that] has been given up to Wellbeing"*. For this reason, principals feel that the Wellbeing subjects should become students' short courses, as *"they're doing the hours anyway, would it not be as well to get some recognition for it?"* **(Participant2)**.

In interviews, principals outlined the difficulties the mandatory 400 hours of Wellbeing has caused to the timetable and their facility to offer Coding. Analysis showed that many strategies have been employed by Principals to accommodate 400 hours on the timetable, from reducing examinable subjects to reducing the hours associated with a subject. One principal outlined how she is considering changing from 40 minutes to one-hour classes. Another stated:

Our students were doing 10 examinable Junior Cycle subjects... so this year, we've reduced it from 10 examinable subjects to nine...because of having to incorporate 400 hours of wellbeing. **(Participant2)**.

Coupled with the Wellbeing requirement, schools also outlined that having subjects mandated by their management bodies, such as Religion and 'Ethical Education', can put further pressure on their timetable. A school that is currently offering Coding highlighted that to keep this option and to facilitate the Wellbeing requirements, they will need to reduce to eight examinable subjects from nine. *"We are going to have no choice but to go to eight examinable [subjects]"* **(Participant4)**. Principals outlined that reducing the availability of examinable subjects has consequences, as it directly affects a specific teacher and the availability of that subject at Senior Cycle.

Participant3 noted the difficulties of a smaller school and introducing a new subject, that it still has the *"same pool of students"* with *"more people dragging on it"*. They also outlined how, being a diocesan school, they need to offer religion as a compulsory subject at Junior Cycle level. As a result, they are to reduce examinable subjects to offer Coding. *"As I said, while you'd love to introduce it, you can't. You're limited in 45 hours per week ... so you're limited in the space in which you have"*. However, whilst they can't introduce Coding, Participant3's school are looking to introduce CS to the timetable 2023. The participants from smaller schools discussed the realities of introducing a new subject (ie LCCS) into their school, such as smaller class sizes and the need to ask for curricular concessions from the Department of Education to run this subject.

Participant1 explained that to find the time for Wellbeing on the timetable they had to remove Religion as an examinable subject, reducing its slot on the timetable from three times a week to one. He also stated that his school wouldn't currently be introducing CS at Senior Cycle. Whilst some students had approached him to introduce this subject, he believed Leaving Certificate PE was a better option for his school to introduce. He had a qualified teacher on staff, students had no previous access to CS topics, and with the Leaving Certificate examination expected to be reformed further in the coming years, he was reluctant to introduce another new subject.

Perceptions, awareness and understanding of Digital Literacy

Students' access to a subject may be impeded by their perception and knowledge of the subject.

Where the formal CS course (LCCS) is taught, there generally exists an informal computing/IT class. As an example, in one school, IT classes are taught from first year to sixth year to the students who do not take choir and orchestra. It is also available in Transition Year, where students will engage with Lego Education to develop Computational Thinking. However, in that school, TY is not compulsory. In another school all first years do one hour a week of engineering science, where Coding is a part of that subject.

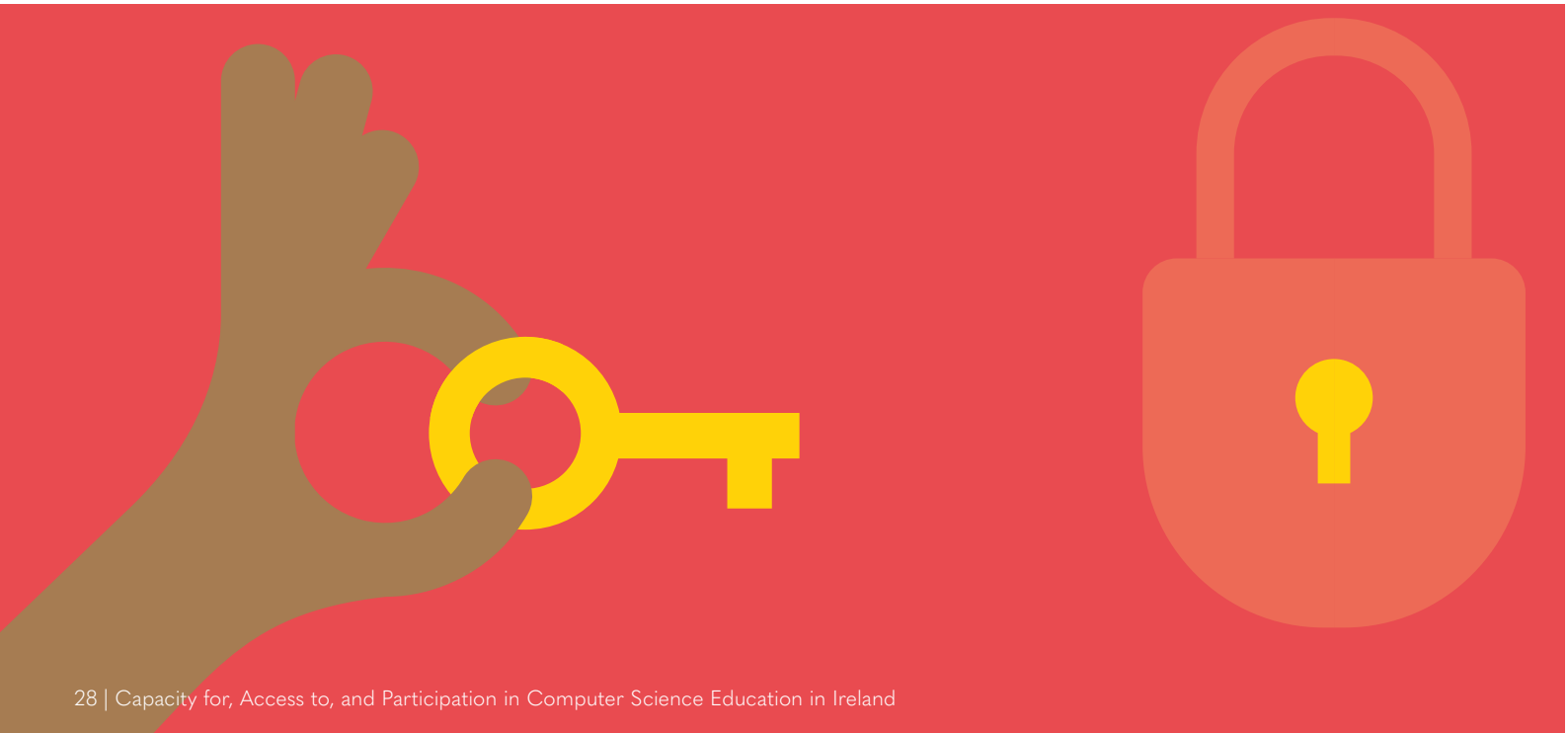
Teachers expressed concern in introducing Coding to the timetable when there was a need for students to increase their digital literacy skills first.

"We should be looking at things like the child's right to learn computer science, or digital, at least be digitally aware that that needs to be brought to the fore ... Because I do think, I do think it should be mandated." **(Participant1)**.

Due to the mandated hours for Wellbeing, school timetables lack flexibility and have very little scope to introduce new subjects. However, seven of the eight teachers/Principals interviewed highlighted their perception of teenagers' lack of digital literacy skills and how finding time to teach these skills was a priority, more so than learning to code or other aspects of the discipline of CS. Both teachers and principals outlined the need to develop students' fundamental digital literacy skills, especially when it's needed now for the completion of Classroom Based Assessments for Junior Cycle; the lack of informal CS courses due to timetable constraints; and TY being an optional year in all schools.

"When some students come into the class, they're touching the screen, expecting to swipe, and they don't know how to switch on a computer. So they do have to become familiar with the hardware and with the general use of the computer as well." **(Participant5)**

"You know, simple things like that, or to save a file, or to retrieve one or to present a PowerPoint or whatever is not, you'll be amazed how limited students are." **(Participant1)**



Teacher Capacity

For the schools offering CS, having a qualified teacher was the main reason for providing it. *"I'm not being smart, but it was the fact that I was here"* **(Participant5)**. Of the four schools that are currently offering CS, one was a new school that purposely hired a teacher with CS experience from the beginning, one teacher was hired specifically for the role, one teacher was currently on staff but had completed CS as part of their degree, and the last teacher, whilst "out of field", is the IT Coordinator in the school who had an interest in this subject. Participants highlighted that teachers are actually very few and far between.

"To get an CS teacher that's actually qualified is very hard to get and so we have an CS teacher at the minute, hours dependent he may or may not be here next September." **(Participant4)**

"I don't have a qualified teacher in the area of computer science. And I've looked up the teaching Council registration, and it's very clear, you need to have a computer science qualification." **(Participant2)**

Participants outlined the realities of introducing a new subject, especially in an established school where school leaders have to provide subjects based on the expertise of their current staff cohort, especially those who are permanent members of staff. Participants also expressed that to offer either Coding or LCCS, they need an existing staff member to upskill or a teaching job/vacancy to occur within the school.

The current CS teachers highlighted the necessity of having more than one qualified LCCS teacher in the school to cater for student demand (Participant 4 needed to run two Coding classes simultaneously) and for teachers going on leave, such as parental leave or maternity leave.

Facilities

Teachers and principals reported that facilities, such as access to devices, are an impediment to introducing CS. All principals acknowledged that their schools had access to computer rooms and/or laptops with a charging trolley. However, the three principals whose schools used physical books and encouraged paper based homework and writing expressed concern regarding access to the appropriate devices at home. Participant2 explained that in preparation for home-schooling due to Covid 19, they surveyed students and the majority only had access to a phone; those with a laptop in the house shared it with siblings or parents. Participant1, whose school is a DEIS school, acknowledged that access to devices would be a concern. Participant7 stated that a requirement to do LCCS in their school was having a suitable device at home. Participants 5 and 6 confirmed that they had at least one if not two students (over their current fifth/sixth-year cohort) who did not have access to a device at home and who were studying LCCS. However, they did try to loan laptops to these students.

The CS teachers confirmed that their school had access to laptops, but stated that the ideal situation is to have some devices allocated only for the use of CS students, as the demand on devices is high due to Junior Cycle Classroom Based Assessments. They also stated the importance of having a dedicated CS room for the LCCS students, to store projects etc. Teachers also stated that the lack of funding available for LCCS was a barrier. Whilst funding of €3000 was available for Phase 1 schools, since 2019 no direct funding has been available for schools introducing this subject.

3.2.4 Summary

In summary, our research found that the main barrier to Access to CS is the perception that other new subjects, such as PE and Politics and Society, are easier to implement. Other findings relating to Access to CS include the lack of teacher expertise in the current staff (against the backdrop of a national teacher shortage in many other subject areas), combined with low levels of teacher confidence to upskill in CS; students' lack of digital literacy and their misperceptions of the subject; as well as a need for adequate computing resources and facilities in schools.

Regarding the JC Short Course in Coding, feedback reiterates the restriction in timetabling because of the mandatory 400 hours that must be allocated to Wellbeing, as well as how "schools have three mandatory Short Courses – CSPE, SPHE and PE and may include a maximum of four other short courses for each year in their Junior Cycle programme" (Department of Education, 2021, p.1) , which restricts many schools from offering Coding.

3.3 Participation in

Participation in is the extent that Irish students are actively engaged in formal CS learning opportunities when offered by the school. It also concerns the diversity of participation in CS education across the ecosystem, considering gender, race and socioeconomic factors, as well as the intersectionality of diverse groups and challenges.

Galway, City and County, was selected as a sample Case Study for the purposes of this research. There are 47 post-primary schools in County Galway, ten with DEIS status. Of this, 4 post-primary schools (8.5%) are boys only, 6 (12.7%) girls only and 37 (78.7%) mixed gender. 42.5% of the schools are located in urban areas, with 57.5% in rural areas. Examining the profile of County Galway's 47 post-primary schools further, it can be noted that ten (21%) are located in the Gaeltacht Region, eleven schools (23%) teach all subjects through Irish and there are no fee paying schools.

Data from Lero, the Science Foundation Ireland Research Centre for Software, (email, 2022) show that five schools in County Galway participated in JCT Coding training, with only two of the five schools currently offer Coding.

With reference to LCCS, six schools will offer this subject from September 2022. The breakdown of schools offering CS by location shows that 70% are based in the city and 30% in rural areas (as defined by CSO).

Case Study

A profile of Galway's 47 post-primary schools

- **58%** of schools are located in a rural area
- **11** schools teach all subjects through Irish (23%)
- **9** DEIS (19%)
- **10** located in the Gaeltacht Region (21%)
- **37** schools are mixed gender, 6 single-sex (female) and 4 single-sex (male)

A profile of Galway's 8 Coding/ LCCS post-primary schools

- **37.5%** of CS/Coding schools are located in a rural area
- **1** school teaches all subjects through Irish (Coding) (12.5%)
- **1** DEIS (Coding) (12.5%)
- **1** located in the Gaeltacht Region (Coding) (12.5%)
- **5** schools are mixed gender, 2 single-sex (female) and 1 single-sex (male)

3.1.1 Students

A questionnaire was issued to LCCS students to ascertain their socioeconomic status, ethnicity, computer usage, and familiarity with technology. The design of the closed questions (the Student Questionnaire and ICT Familiarity Questionnaire) was informed by the Programme for International Student Assessment (PISA) (Organisation for Economic Co-operation and Development, 2017). The design of the closed questions (the Student Questionnaire and ICT Familiarity Questionnaire) was informed by the Programme for International Student Assessment (Organisation for Economic Co-operation and Development, 2014, 2017). Student answers to closed questions and "simple" open questions were exported from digital forms into a spreadsheet before being loaded into a data analysis software package. This data was then cleaned with simple cross-tabulations (Cohen, Mannion and Marrison, 2022; Baron & Siepmann, 2000). The research team coded the answers to simple open questions, such as country of birth, into categories, which were then numericalized. Descriptive statistics, frequency, and percentage were then run on the collected data to depict both central tendency, i.e., students' most common response to the items, and percentages.

The answers to the 'complex' open questions, i.e. concerned with students' previous experience with computing and technology, and future career plans, were analysed using content analysis with the procedure documented as per Lamprou and Repenning (2018). Responses are grouped according to several categories created from students' own answers.

Twenty seven students from three schools answered the questionnaire. The three schools offer LCCS. Two schools were in an urban setting, the other was in a rural area with a high urban influence. Details of the schools which participated are:

» School 1 is an all-boys school. The students had just finished TY and will commence fifth-year LCCS in 2022. Twenty seven students were taking LCCS and three students (10% of this class) answered the questionnaire.

» School 2 is an all-girls school. Five students from this school answered the questions. This equates to 45% of LCCS students in the school (including both fifth-year and sixth-year students).

» School 3 is a mixed-gender school. Nineteen students completed the questionnaire, 42% of the LCCS population at the school.

The majority of students identified as male gender (19 males and eight females.) This correlates with the national gender breakdown of students studying LCCS (Examinations, 2021).

Most students were born in Ireland to Irish parents, with three (11.5%) of the students being born outside the country. Similarly, most students' parents were born in Ireland, with only four students having at least one parent born outside of Ireland. English was the most common language spoken at home by students (92.6%), with two students reporting alternatives, i.e. Irish and Italian.

3.3.2 Socioeconomic Status

The socioeconomic status was measured using three indices: parental educational attainment, parental occupational status and a measure of "household possessions" (Avvisati, 2020)." The socioeconomic status questions employed in this study were based on these questions. Most students who responded to this item reported that their mothers had attended further education, with 54% attending university and 19% attending a further college. Just under 27% of their mothers had stopped their formal education at post-primary education. Students reported similar educational attainment in respect to their fathers, i.e. 54% of fathers had attended third-level education institutions. However, a higher number, just over 42%, stopped their formal education at second level. To put these numbers in context, the CSO (2022) reports that Galway City has the second highest percentage of persons (55.2%) with a third-level qualification (and had ceased education). In 2019 the CSO reports that "higher levels of education are associated with higher levels of income."

3.3.3 Engagement with Computer Science activities

Questions relating to engagement with CS included: participation in various CS activities, motivation for studying CS, career expectations, and their intention to study CS at third level.

Students were asked to state how often they engage in a variety of CS-related activities. The nine activities are shown below.

	Watch TV	Books	Websites Topics	YouTube	News Gaming	News Non Gaming	Magazines	Club	Website Organisation
Never or hardly ever	77.8% 21	59.3% 16	37% 10	29.6% 8	51.9% 14	51.9% 14	92.6% 25	88.9% 24	59.3% 16
Sometimes	22.2% 6	40.7% 11	40.7% 11	29.6% 8	14.8% 4	40.7% 11	3.7% 1	11.1% 3	29.6% 8
Regularly		18.5% 5		22.2% 6	29.6% 8	3.7% 1	3.7% 1		7.4% 2
Very Often		3.7% 1		18.5% 5	3.7% 1	3.7% 1			3.7% 1
#	27	27	27	27	27	27	27	27	27

Table 8. Engagement with Computer Science Activities

Table 8 highlights that, based on the "Regularly" or "Very Often" categories, the majority of students reported not regularly engaging in CS activities. A relatively small percentage of students (ranging from 3.7% to 11.1%) reported engaging in three of the listed CS activities: "Follow news of Computer Science, or Computer Science organisations (non-gaming) via forums, blogs or Microblogging", "Read Computer Science magazines or articles in newspapers" and "Visit websites of Computer Science organisations". No student reported that they regularly engaged in three activities: "Watch TV programmes about Computer Science", "Visit websites about Computer Science topics" and "Attend a Computer Science club". However, whilst no students reported that they "Visited websites about Computer Science topics", 40.7% indicated that they watch YouTube videos about Computer Science topics. This was the most common activity engaged in "very often" or "regularly" by students, followed by "Follow news of Computer Science, or Computer Science organisations (gaming) via forums, blogs or microblogging" and "Borrow or buy books on Computer Science topics". In this survey, more students (22.2%) indicated that they would borrow/buy a book on Computer Science topics (very often or regularly) than visit a website about Computer Science topics.

Twenty-six students responded to the question: "Did you do Coding or Computer Science at primary school? If Yes, please give details." Eleven students (42%) confirmed that they had done Coding at primary school. Of these students, nine provided more detail; seven stated how the language studied was Scratch, and two stated how the Coding was conducted in the school but after hours. In relation to the afterschool clubs, one was a Coder Dojo club set up in the school, the other was "Short program on microbit Coding in an after school club".

Students were asked to indicate their level of agreement (strongly disagree, disagree, agree, strongly agree) with four statements intended to capture their perceptions of how beneficial CS learning is to their future study and career plans.

- Making an effort in my Computer Science subject is worth it because this will help me in the work I want to do later on
- What I learn in my Computer Science subject is important for me because I need this for what I want to do later on
- Studying my Computer Science subject is worthwhile for me because what I learn will improve my career prospects.
- Many things I learn in my Computer Science subject will help me to get a job

The majority of students agreed with all the above statements, indicating that they perceive CS to be beneficial to their future educational and career plans. These answers were comparable to students' responses to the open question: *"Why did you choose to study Leaving Certificate Computer Science?"*, with 66% of students specified in their responses that jobs and future career plans influenced their subject choice of LCCS (Table 11). Notably, 48% indicated that an interest in CS and a desire to learn more also influenced their decision.

3.3.4 Why did you choose to study Leaving Certificate Computer Science?

The students in the focus group were asked the question *"Why did you choose to study Leaving Certificate Computer Science?"* to explore their answers in-depth. The majority of the students stated how having an interest in this subject was their primary motivating factor in its selection. Student4 specified that this interest is a necessity for doing the subject.

"So I feel like you do need to be interested in computers to actually do the subject." **(Student4)**

Another student selected CS due to timetabling reasons.

"I don't really have many other options, is the only one on that would suit with my timetable." **(Student2)**

The participating students also indicated that their friends' subject choices had no bearing on their choice to study CS. They further outlined that they had previous experience with CS, as it is 'informally' studied in the school in both first and transition year, Table 9.

Content	Description	Example	Mentions
Interest	Answers mention students' interest and enjoyment of CS. It includes answers related to learning topics in this subject.	"I enjoy learning about the subject and its different aspects" "I didn't have access to computers when I was younger. Circumstances changed, and now I do, and this has opened up a whole new world and language for me that I desperately want to learn." "I wanted to learn how to program"	13 (48%)
Third Level	Answers mention LCCS in relation to third-level courses	"It helped because I want to do a course on I.t I have experience with them" "I want to do sound engineering which computer science plays a role in"	3 (11.1%)
Career	Answers mention future jobs and careers.	"I like computer science and there's good money in a computer related career" "Want to work in Software engineering industry" "Wanted to get an idea of what a career in computer science would be like"	18 (66.6%)
Other	Answer relate to various issues: timetable, money, parents	"It was my only choice to suit my timetable with other subjects I preferred" "Money money money monaasaaaaaay" "Most jobs need computer science now and my parents both work in the area"	4 (14.8%)

Table 9. Results from the analysis of the open-ended question: 'Why did you choose to study Leaving Certificate Computer Science? Please give details.' (N=27)

Are you happy with your choice?

Students were also asked a further open question concerning their satisfaction with studying CS. Only the answers from students who completed a year studying LCCS were analysed. This resulted in 24 individual responses. Of these, 21 indicated they were happy with their choice, and 19 offered an explanation. These 19 responses are coded and summarised in Table 10 with 68% of students' answers highlighting how students find the subject interesting or enjoyable.

Content	Description	Example	Mentions
Interest/ enjoyable	Answers related to liking and finding the content interesting or enjoyable	"Yes, I'm learning a lot of things about the computer that I didn't know before doing this subject" "Yes as I am interested in it" "yes, I like the subject" "yes its very interesting and cool" "Yes, its very interesting so far and I enjoy it quite a lot"	14
Fun Class	Answers related to the CS class being enjoyable. Students specifically mentioned CS class	"yes i enjoyed the classes" "yes I'm happy i chose it because its a relaxing class .."	2
Jobs/ Skills	Answers relate to CS jobs or skills learned	"Yes, because I need it for my future career." "I think it's a valuable skill to have and I'm really glad I did it" "Yes as I find it helpful and fun at the same time"	4
Other	Answers relate to various answers, such as happy with choice but found it difficult or the subject too easy.	"Yes but it was difficult being the first year doing it (with covid)" "yes , very easy to grasp"	2

Table 10. Positive Results from the analysis of the open-ended question: 'Are you happy with your choice to study Computer Science? Please give details.' (N=19)

Three students were unhappy with their choice; two students explained why. Their answers both relate to the content, albeit in different aspects. One student perceived the course to be too theoretical, the other too difficult.

The students who participated in the focus group had just completed the LCCS examination. It was evident that the high-stakes nature of the examination was forefront in their mind. Their answers revolved around the examination, in particular the emphasis on rote-learning, the newness of the subject, and the resulting lack of past exam papers.

"I suppose the only thing was like the exam, we didn't know exactly what will come up with, there hasn't been that many patterns is a little bit stressful learning, like not knowing what to know." **(Student4)**

Two students referred to the difficulty of the content for example:

"I suppose I just couldn't really understand a lot of it, I found it kind of hard to like actually understand most of it." **(Student2)**

The majority of students agreed that the applied learning tasks were the most enjoyable aspect of the course. Only one of the four students intended to study CS at third level; the other three had very different plans: literature, art college and phlebotomy. No student regretted studying the subject, and all recognised that the skills they learned are relevant for future job opportunities.

"I think that there's a lot of like job opportunities, like when you put down like on your CV that you'd like have experience with doing like computer science and that kind of thing." **(Student3)**

Student 4 highlighted how she earned a sense of identity and enjoyed now being known for her computing skills. *"But also, it's just kind of nice to be known for something, like to be someone that can help with computer science stuff, like the IT person in the house or whatever, like, it's nice to be that person"* **(Student4)**.

However, all students indicated that their perceptions of the LCCS differed from reality. Two students had envisaged that LCCS would contain more content on hardware. Similarly, others stated that they were surprised at the amount of theory. *"I suppose maybe I thought it'd be a lot more on computers and less theory, but there was actually like a good amount of theory then what I thought than there would be in the end"* **(Student2)**.

Career Expectations

40.7% of the respondents indicated they intended to study CS at third level. A further 22% were undecided, with 33% responding negatively to the question. An analysis of student answers, affirmative and non, is provided below in Table 11 and Table 12.

Content	Description	Example	Frequency
Yes: Money	Answers refer to the monetary aspect of CS	"Yes, I'll be taking it due to my enjoyment and the broadness of the field. (Also due to is lucrativity)" "yes , good money"	2
Yes: Enjoyment	Answers refer to students' enjoyment of the subject	"Yes because it is very interesting and seems fun unlike many other courses"	2
Yes: The future and the broadness of the subject	Answers related to the job prospects and students wanting to work in the field	"Want to work in software engineering" "yes. alot of jobs" "Yes - computers are rewriting the future, and I want to be a part of that story." "yes as it has a variety of job opportunities"	7

Table 11. Results from the analysis of the open-ended question (affirmative): "Do you intend to continue studying Computer Science at third level? Please give details as to why or why not."

Content	Description	Example	Frequency
No: other Interests	Students mention their intent to study other areas. These are classified as: 1 STEM 3 NON STEM 1 Both 3 Not Stated	"i do not intend to but my preferred course covers aspects of it" "no I do not, because I am going to study a baking course" "No, I want to study biomedical science"	9
No		"No As I am Not good enough"	1
Unsure	Students relate how they are unsure of their future plans.	"I'm not 100% sure what i want to do at third level but I'm leaning into something computer science based" "I'm not sure if I would like to or not"	7

Table 12. Results from the analysis of the open-ended question (non-affirmative): "Do you intend to continue studying Computer Science at third level? Please give details as to why or why not."

4.
Recommendations

Computers are so ubiquitous in today's world that being an educated citizen requires a solid understanding of computing technology, how computers can serve or harm, and how we can best employ them to serve both individuals and society. This research highlights a range of emergent issues and challenges for the effective integration of CS skills and practices within formal education in Ireland across the primary and post-primary sector. In acknowledging and tackling the tightly intertwined issues of gender balance, equity and inclusion, there is a necessity for all students attending primary and post-primary school to have equal opportunity to develop basic CS understanding and skills, including CT and coding.

Much has been accomplished in Ireland to date but far more needs to be done to ensure that access to CS education in schools is available and accessible to all students. To date, only 15.6% of Irish schools offer LCCS. Student numbers are noticeably low when compared to other relatively new subjects such as PE and Politics in Society. And girls continue to be significantly under represented in existing classes. In our analysis, and in proposing recommendations, this research suggests how Ireland can continue and expand its efforts to scale and improve CS education in schools in the years ahead..

Recommendations for the future development of CS in the Irish education system are presented in Figure 8. These are:

Figure 8. Project recommendations

1 Consolidated Understanding

There is a clear need for developing a consolidated and shared understanding of CS and its relationship with 21st century education. A recommendation from our findings is to strengthen the acceptance of CS as a foundational competence for all, enabling children and young people to become active participants in a digital economy. Exploiting the potential of CS in fostering problem-solving abilities across various disciplines and strengthening the synergies amongst stakeholders to boost quality computing education will be key. Without doubt, there is a communication and awareness challenge in that all stakeholders – the research community, policy makers, educational authorities and decision makers, school leaders, teachers, teacher unions, families, educational organisations, and enterprises – prioritise and are fully aware of the necessity to champion the development of, access to and participation in CS education. The research conducted by the Computational Thinking Educational Policy Initiatives (CTEPI), Hsu et al., (2019) notes a general trend to push for broader access and enhanced learner interest occurring when CT is part of mandatory study. "CT is a foundational skill that all students should have to be digitally competent and active participants in a world where computing is pervasive and from a desire to motivate interest in CS and STEM, especially among girls and underrepresented minorities" (Hsu et al., 2019, p. 268).

2 Support for Policy

The second recommendation is regarding Support for Policy, which includes raising awareness about the purpose and benefit of developing CS skills and competencies in the curriculum. A clear finding from our research is that educational stakeholders – school leaders, parents, teachers, career guidance, curriculum developers, department inspectors – need communications and an awareness surrounding the benefits of student CS skills. There is a specific need to prioritise measures to address gender balance, equity, and the inclusion of quality computing education across the continuum. Monitoring the impact of teaching computing concepts to students will provide insight and influence future policy development, most especially when inspectors have CS competencies.

3 Systemic Rollout

There is a clear necessity for Systemic Rollout adopting a holistic approach to the introduction of computing competencies in formal education in an equitable manner. It is well known that a knowledgeable, competent, and well-prepared teacher is vital to student learning (Chetty, Friedman and Rockoff 2014; Rivkin et al., 2005) and this is also true for CS education. Nonetheless, Ireland has only 34 CS teachers on the Teaching Council register. This shortage of qualified teachers is a barrier to providing all students with equitable access to CS education, like that similarly experienced in other jurisdictions. Cateté et al., (2020) stress that initial teacher education and teacher professional development need to prepare student teachers to teach CS to cohorts with diverse ethnicities, socioeconomic backgrounds, and genders. In sustaining a systemic rollout and a holistic approach to computing competencies within our education system, the provision of professional development for the upskilling of teachers' pedagogical content knowledge in computing and CT competencies is crucial. From our research to date, there is a necessity to prioritise the assessment of CT as a foundational competency in our educational system. CS and CT professional development for teachers and stakeholders, with support measures, is recommended. The Department of Education and relevant stakeholders need to commit sustained investment and provision of high-quality professional development for teachers involving medium and long-term training interventions, enacting the curriculum, and encouraging teacher and learning agency in CS (Scanlon and Connolly, 2021).

4 Comprehensive Integration

The final recommendation is comprehensive integration of CS across all levels in our formal education system. We need to articulate and implement a strategy for the integration of CS through the continuum from primary school through to Senior Cycle. As our research demonstrates, there is no current provision for computing or computational skills development at all in primary level, with time-constrained provision evident at Junior Cycle level. The Department of Education and curriculum bodies need to make space in the curriculum to include foundational computing concepts in order to develop CS skills, providing clear and concise guidelines to teachers on the amount of time to devote to teaching basic CS contents, as well as resources to develop high-quality instructional material, ensuring that understanding, comprehension, and practice align.

Concluding remarks

All young people need to be educated in CS competencies, ensuring they are able to apply and integrate this important 21st century skillset elearning across a variety of subjects and disciplines, regardless of their area of interest and future career goals. In every country where huge strides have been made in providing quality CS education to all students, these gains were framed by visionaries and then embedded deeply into the national education system through changes to educational policy and the financial support to implement those policies. The findings of our research point to a need to continue the progress already made with introducing CS into the Irish education system and to build on the momentum of the dedicated and engaged CS community of educators, school leaders, parents and policy-makers. Equity and diversity are overarching values that must be specifically addressed in policy development to avoid perpetuating disparities. As Ireland's our education ecosystem progresses the use of technologies underpinning our digital economy, we must also ensure we direct the same educational ecosystem towards the achievement of an equitable, fairer, safer, and more just society.

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Appendices

Appendix A: Submission to Department of Education, January 2022

Research Briefing presented to Deptartment of Education LCCS Framework Group

January 2022 | Cornelia Connolly, Colette Kirwan (NUI Galway), Claire Conneely (Google)

Research Title: A Review of the Capacity for and Access to Computer Science Education in Ireland

Led by NUI Galway, with the support of Google Ireland, this research project aims to evaluate current Computer Science (CS) learning opportunities in the Irish primary and post-primary curriculum, through the lens of diversity and inclusion, teacher education and professional development. We also aim to identify the opportunities and key factors for growth and development of CS, as a relatively new school subject in Ireland. Taking the CAPE pyramid (Fletcher & Warner, 2021) as an example model to ground this project, the research will focus on the first three areas in the context of the Irish curriculum: Capacity for, Access to, and Participation in CS education.

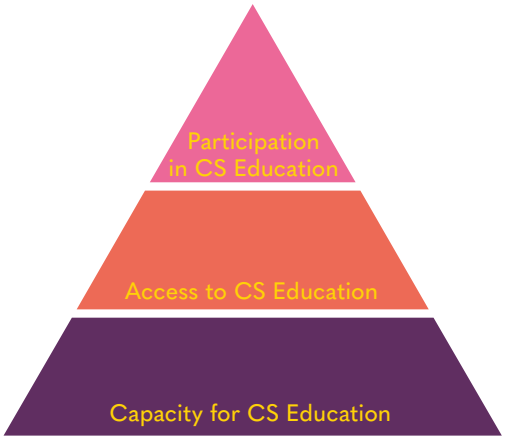

Figure 5. CAPE model, adapted from Fletcher & Warner (2021)

1. Capacity for: We will evaluate the availability of resources in the education system in Ireland to provide and maintain high-quality CS learning experiences at school. These resources may include teachers, students and policies that make implementing CS instruction within the curriculum (primary, post-primary) possible and inclusive.

2. Access to: Access can be operationalized as attending a school that offers CS courses – therefore evaluation of our CS landscape in regard to primary, post-primary and teacher education (pre-service and in-service).

3. Participation in: Regarded as enrolling in CS courses when offered by the school. There is a necessity to scope the diversity in Irish CS education, considering gender, race and socio-economic, as well as the intersection of diverse groups and challenges

The focus of this research will be the publication of a report / policy document detailing the current landscape relating to CS education in Ireland and future recommendations on the equitable integration of Computational Thinking/Coding/CS education across the Irish curriculum. Interim reports will be published through the duration of the project, along with a final report and accompanying infographic(s) to be disseminated to key stakeholders in the education sector, policy makers etc. The research will be led by NUI Galway, with the support of Google Ireland.

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Appendix B: Focus Group Questions

Expert Stakeholders (Post-Primary) Questions

1. Could you explain your role in relation to Computer Science Education in Ireland?
2. What limits are placed on the service you provide?
3. What helps a school succeed with Computer Science?
4. Have any schools dropped out of the programme or no longer offering CS education—if so, why?
5. What challenges/barriers have you come across regarding schools and Computer Science education?
6. What advice would you give to schools thinking of teaching Computer Science?
7. Are there extra resources that your organisations need to increase Capacity for Computer Science education?

Expert Stakeholders (Primary) Focus Group Questions

1. Could you explain your role in relation to Computer Science Education in Ireland?
2. What limits are placed on the service you provide?
3. What challenges/barriers have you come across regarding schools and Computer Science education at the primary level?
4. What factors do you believe will affect schools when delivering the new computational thinking component of the primary maths curriculum?
5. What advice would you give to schools when delivering computational thinking?
6. Are there extra resources that your organisations need to increase Capacity for Computer Science education at the primary level?

School Leaders (Post-Primary) Focus Group Questions

1. What factors affected your decision to offer/or not CS programmes? What barriers did you have to overcome?
2. Where would CS be placed on the timetable? Is it in bands-- and students choose one subject from the offered bands etc? What subjects are offered with it?
3. How is the subject Computer Science perceived in the school?
4. If there is a demand for this subject in the school—how are they offered to students?
5. What advice would you give to schools running formal CS programmes?
6. Are there resources that your school need to run this Computer Science, that you are currently missing?

School Leaders (Primary) Focus Group Questions

1. Would you mind giving me an overview of your school, regarding type, number of teachers, students, subjects offered, location, etc?
2. Does your school currently offer any Coding or CS teaching?
3. Are you aware of computational thinking being integrated into the primary maths curriculum?
4. Are you confident that your school can meet these new requirements?
5. Does your school have digital devices available?
6. Would the teachers in your school be confident teaching computational thinking?

Post-Primary Teachers Focus Group Questions

1. What factors affected your school's decision to offer/or not CS programmes? What barriers did you have to overcome?
2. Formal CS courses are new to the Irish curriculum. What made you choose to teach this subject?
3. How would the subject Computer Science be perceived in your school?
4. What type of student chooses CS in your school?
5. In your opinion, how do the students perceive the Computer Science subject?
6. Would your students all have a device such as a laptop/a computer at home?
7. What advice would you give to teachers wanting to teach CS?

Primary Teachers Focus Group Questions

1. Do you currently teach any Coding or CS teaching at primary level?
2. Do you know what computational thinking is?
3. Are you aware of computational thinking being integrated into the primary maths curriculum?
4. Do you know what pedagogies to use to teach this subject?
5. Would you be confident teaching computational thinking?
6. What resources do you think should be in place to help teachers with computational thinking?

Post Primary Students Focus Group Questions

The purpose of the focus group for students is to explore in detail (if necessary) answers related to the open ended questions from the questionnaire.

1. Why did you choose to study Leaving Certificate Computer Science?
2. Why did you choose to study Coding?
3. How do you enjoy the programme of study?
4. Did you friends also choose to study CS, why or why not?
5. Do you intend to continue studying Computer Science at third level. Please give details as to why or why not.
6. Do you believe the course has benefit outside of the subject domain of Computer Science?
7. Would you recommend this subject to other students?

Appendix C: Research Design and Data Collection

A case study approach was adopted as it facilitated "the detailed inquiry of a unit of analysis as a bounded system, over time within its context" (Harrison et al., 2017). The data collection was conducted during January-April 2022, in three phases.

1. Phase 1: Capacity for

Phase 1 involved a review of the current CS offering within the Irish education system. Examples include LCCS, LCA, JC Coding, and primary. Markers included the number of teachers that are certified to teach CS in Ireland; the number of schools that are formally teaching CS and Coding at second-level; policy documents and available funding; training teachers have pursued and registered CS teachers. Therefore, both desktop and qualitative research was conducted. The desktop research was directed at teacher numbers and pre-service teacher education. The research question to be asked was: Does Ireland have the capacity to maintain and support CS education at the post-primary level? Four CS education 'Stakeholder Experts' contributed to the qualitative research from the University sector, professional teacher services, curriculum development and outreach training. Their interviews explored, in depth, the findings from the desktop research.

2. Phase 2: Access to

Phase 2 explored the research question:
What factors affect whether a school will offer Leaving Cert Computer Science or Junior Cycle Coding to their students? Teachers and leaders from different school types (primary and post-primary) were selected to participate in interviews and focus groups in order to ascertain interests, potential, and participation in CS Education; both their formal and non-formal influences were determined.

3. Phase 3: Participation in

Phase 3 of the research was a case study of schools in Galway. It sought to understand the extent to which students were engaged in CS education. Markers included the numbers in school committing to CS, or withdrawing from CS – why? – and the scope of diversity of the CS student.

4. Research Participants

Table C1 summarises the participants involved in each phase, the research instrument used and the data collected during each phase.

Participants	Phase	Level	Instruments	Data	Number of Participants
P Students	Participate in	P	Desktop Research (Previous Reports)	Capture Landscape	n/a
PP Students	Participate in	PP	Questionnaire Focus Group	Student profile, of those that choose to study CS Comments from students regarding their CS Experience	27 from 3 schools
P Leaders	Capacity for	P	Focus Groups Desktop Research (Previous Reports)	Are teachers ready/prepared to teach Computational Thinking (CT) in new primary Maths Course? Does the school have the appropriate equipment?	4
PP Leaders	Access to	PP	Focus Groups	School profiles that offer CS courses	4
P Teachers	Capacity for	P	Focus Groups	Are they ready to teach CT in primary? Do they know what CT is?	4
PP Teachers	Access to	PP	Focus Groups	School-level factors which determine CS/JC Coding offering or not, recommendations	3
Stakeholder Experts	Capacity for, Access to	P and PP	Focus Groups	Factors affecting access and capacity for CS	4

P= Primary, PP = Post-Primary

Table C.1: Research participants in each phase

To operationalise 'Access to' and 'Participation in' an in-depth exploration, a case study approach was used to establish the barriers or factors that influence a school's decision to offer CS at post-primary level. This was operationalised as focusing on Irish schools located in County Galway. Galway was chosen as its city is the fourth biggest in Ireland; 20% of its population lives in the Gaeltacht (Irish-speaking area), and it has a good balance of rural and urban schools (Údarás na Gaeltachta, 2022). Qualitative interviews were conducted to explore factors and barriers affecting 'Access to' formal CS courses at post-primary. Four post-primary principals, three post-primary CS teachers and four CS education experts contributed to these findings. Using the NVivo software, Braun and Clarke's (2006) six-step thematic analysis framework was followed in analysing the qualitative data collected from semi-structured interviews. This data both complements and validates the findings from the desktop research.

Participants	Phase	No. Participants	Instruments	Location	School/Participant Description
PP Leaders	Access to	4 participants 3 Female 1 Male	1 Focus Group 2 Interviews	2 Urban 2 Rural	1 Coding school 1 school working with PDST (phase 3), will offer CS to TY in 2022 and LCCS will be implemented in 2023 2 schools not offering CS and explained why
PP Teachers	Access to	3 participants 2 Female 1 Male	Interview	2 Urban 1 Rural	All schools offering CS from September 2022
Stakeholder Experts	Capacity for, Access to	4 participants 1 Female 3 Male	Focus Group Interview		2 Focus groups and 1 interview 1 PDST 2 LCCS expert 1 Coding expert

Table C.2: Summary of participants used to gather Access To qualitative data