Exploring teachers' professional development to support the roll-out of Computer Science in Irish second-level schools

Final Report - August 2020

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LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS LIST

ALT	Applied Learning Task
CAP	Curriculum & Assessment Policy Unit
CBE	Computer Based Exam
CS	Computer Science
DEIS	Delivering Equality of Opportunity in Schools
DES	Department of Education and Skills
ICT	Information and Communications Technology
LCCS	Leaving Certificate Computer Science
Lero	Science Foundation Ireland Research Centre for Software
MOOC	Massive Open Online Course
NCCA	National Council for Curriculum and Assessment
NW	National workshop
PCK	Pedagogical content knowledge
PD	Professional Development
PDST	Professional Development Service for Teachers
SFI	Science Foundation Ireland
STEM	Science, Technology, Engineering and Mathematics
TES	Teacher Education Section

1 EXECUTIVE SUMMARY

In 2017, the Department of Education and Skills (DES) initiated the development of a Computer Science (CS) Leaving Certificate subject. The first phase of its introduction involved a selected group of 40 schools. As part of this first phase, teachers from these schools embarked on a professional development (PD) programme which commenced in the spring of 2018 prior to the subject's launch in schools the following September.

The PD programme was provided by the Professional Development Service for Teachers (PDST) and aimed to support the teachers throughout the period of implementation of the new subject. The PDST's programme for the participating teachers consisted of several components including national workshops, skills development workshops, regional cluster meetings, webinars, MOOC recommendations and online resources (including an online portal for engagement and resource sharing).

A Science Foundation Ireland (SFI) funded research project (under the Discover programme) was established to (i) track the development of the teachers' progress during the first two years of the subject roll-out, (ii) explore the development of the teachers' pedagogical knowledge and (iii) to examine the role of the PD infrastructure in contributing to the development of their knowledge and skills.

The research adopted a mixed-method approach conducted in two stages. Stage 1 involved the analysis of the teachers' use of the online platform (Slack) and an analysis of the data from a questionnaire distributed to all teachers towards the end of the first year of the PD programme.

Stage 2 of the research involved visits to a representative sample of ten participating schools, which took place between October and December 2019. Each site visit included interviews with the Leaving Certificate Computer Science (LCCS) teacher(s), the principal and the guidance counsellor. The school visits also provided opportunities to observe the 6th year (18 years of age approx., final year of study) LCCS classes and have informal discussions with some of the 6th year students.

The research found that participating schools were geographically dispersed throughout both rural and urban settings and reflected the broad range of school types and sizes in Ireland. Of the 29 schools that responded to the questionnaire in the first stage of the study, less than a third of the schools reported offering the Junior Cycle short course in Coding (31%) and the Junior Cycle short course in Digital Media (21%) - four of the schools offered both courses. The questionnaire also found the participating teachers were generally experienced, with over half having more than 10 years teaching experience and only 17% having less than 5 years of teaching experience. 38% of the teachers were female and almost all teachers had previous experience teaching ICT or providing ICT support in their schools.

The general shift towards project-based, student-centred learning was commented on as one of the biggest characteristics of the new subject which brought challenges for some teachers and students. The greatest challenge for teachers related to the teaching of the specific subject and attempting to gauge the appropriate pacing of the subject and the depth of treatment required for particular topics. Catering for the range in students' previous experiences and interests of their classes was also reported as a challenge. Despite these challenges, when talking about their practice in the interviews, the teachers' comments showed evidence that they were reflecting on their practice and had made many changes to how they approached their teaching of the subject based on their experience of the first year of implementation.

Students enjoyed the applied nature of the subject and the real-life application of the tasks provided, but the novel pedagogical approach, requiring more self-regulated learning skills, was a challenge for some students to adjust to. Many of the students reported acquiring other skills beyond CS knowledge. They identified how they were able to apply the problem-solving skills, acquired in the subject, in other settings. Echoing similar comments by teachers, concerns about their performance in the Leaving Certificate examination was also mentioned.

The level of female participation in the subject was low and this was recognised by many of the teachers, principals and guidance counsellors. There was an acknowledgement within the schools that female participation needed to be increased and that a wider range of students should be encouraged to undertake the subject (particularly beyond those wishing to pursue careers in CS). Despite this recognition, some comments by the teachers and school leaders suggests the presence of an implicit bias. Some teachers' comments showed an unconscious leaning towards traditional perceptions of the subject that associated it as a 'difficult' subject suited to particular students with an 'aptitude' for it. These perceptions were not evident in the students' comments.

Teachers reported that the schools had adequate levels of computer resources to deliver the subject, but some raised concerns about the level of technical support provided and the need to have a more suitable space to facilitate project work and group-work. Teachers also raised concerns about some students' level of access to suitable ICT resources for home study.

In relation to the PD provided, the face-to-face workshops were the most valued, but differences emerged about what they should focus on - reflecting the heterogeneous nature of the group. The Slack platform provided a helpful repository of resources and advice for the teachers and the regional cluster meetings were viewed as helpful but did not appear to be a critical part of the PD framework. The other elements of the PD, including the MOOCs and webinars, did not feature prominently and while seen as helpful did not appear to be central to the teachers' experience of the PD programme. Additional supports from third-level and industry advocates in the area of CS in schools were also seen as helpful and the PDST team were highly praised.

In discussing the issues that have emerged from the research, the study outlines a series of recommendations. Amongst them, they include: ways of supporting the integration of the subject in schools and particularly the pedagogical approaches underpinning the subject, supporting student engagement, addressing negative and restrictive perceptions of the subject and further enhancing the professional development provided to teachers.

The study concludes that the launch of a new Leaving Certificate subject was very successful. The dedication and interest of the participating teachers and the comprehensive professional development framework put in place and delivered by the PDST has been pivotal to its success. That being said, as the implementation moves into the second phase and incorporates more schools, it will be important to ensure that the promotion of the subject remains a priority. In particular, further work needs to be done to encourage greater female participation and greater participation amongst students that would not have traditionally considered the subject. This promotion, both within schools and the wider society, needs to be prioritised in the short-term to ensure that traditional views of the subject do not become entrenched in the educational system, similar to how other STEM subjects are perceived by students.

2 INTRODUCTION

In 2017, the Department of Education and Skills (DES) initiated the development of a Computer Science (CS) Leaving Certificate subject. This launch followed a period of consultation with key stakeholders and the completion of a scoping exercise exploring the provision of CS in upper second-level education in other countries[1]. To design the subject, and following the partnership approach to curriculum development, the National Council for Curriculum and Assessment (NCCA) convened a development group consisting of representatives from the various educational stakeholders as well as business and industry representatives. (See Appendix 1 for the development group details and Appendix 2 for the specification details). As a result of the work of the development group, the new subject was launched in September 2018.

The first phase of its introduction involved a selected group of 40 schools. In addition to considering the teachers' previous skills and knowledge in the area of CS, schools were also selected based on other criteria to ensure that they were geographically dispersed across the country and represented the range of post-primary schools in Ireland including rural and urban, single-sex and mixed, DEIS (school located in a socio-economically disadvantaged area), large, medium and small schools as well as the different types of post-primary schools (Community, Comprehensive, Secondary, Vocational). (See Appendix 3, 4 and 5 for the school selection criteria, a list of the Phase 1 schools and their geographical spread.) As part of the Phase 1 roll-out of the subject, teachers from the schools embarked on a professional development (PD) programme which commenced in the spring of 2018 prior to roll-out in the schools the following September.

The PD programme was provided by the Professional Development Service for Teachers (PDST) and aimed to support the teachers throughout the period of implementation of the new subject. A Leaving Certificate Computer Science (LCCS) Steering Group was also established by the DES to oversee its roll-out.

In 2017, a group of researchers at the University of Limerick, in Lero (The Science Foundation Ireland (SFI) Research Centre for Software) and the School of Education, were awarded SFI (Discover programme) funding to track the development of the teachers' progress during the first two years of the subject roll-out, specifically to explore the development of the teachers' Pedagogical Content Knowledge (PCK) and to examine the role of the PD infrastructure in contributing to the development of their knowledge and skills.

As part of this research project, a sub-group of the Steering Group was formed to assist in, and have oversight of, this research study. The sub-group comprised of representatives from DES (TES, CAP, Inspectorate), Lero, and the PDST. This group held regular meetings throughout the course of the project which informed the on-going design of the research methodology. While an interim report[2] was published after the first year of the study, encompassing an analysis of the online collaboration platform (Slack) used as part of the delivery of the PD and the analysis of the responses to a teacher questionnaire distributed

[1] https://ncca.ie/media/2605/computer_science_report_sc.pdf

[2] https://www.lero.ie/sites/default/files/Leaving%20Certificate%20Computer%20Science%20CPD%20Interim%20Report%20October%202019.pdf

to all participating teachers towards the end of the first year, this final report includes the data from the second stage of the research. This second stage included site visits to a representative sample of 10 schools (25%) in which interviews with teachers, principals and guidance counsellors were undertaken. In addition, during these site visits the researcher had the opportunity to meet with students, observe a lesson and see samples of student work.

This report is presented in four sections. The first section outlines the PD framework used in the roll-out of the subject and the second outlines the methodology employed by the study. Following this, the findings of the study are presented before discussing the implications of the findings and offering a series of recommendations.

3 OVERVIEW OF THE PD FRAMEWORK

The PDST's programme for the participating teachers consisted of a number of components as shown in Figure 1 below. To ensure a manageable group size for the delivery of the components, teachers were divided into two cohorts for some of the activities. Underpinned by a strong social constructivist philosophy with a goal of establishing communities of learners, the PD framework provided opportunities for teachers to interact and collaborate in both formal and informal ways. National workshops and fundamental skills development workshops provided opportunities for teachers to interact face-to-face at key times during the year. In addition, informal engagement was also encouraged and facilitated through the Slack platform. Regional cluster meetings were established to encourage teachers to collaborate at a local level and share experiences and practice. The participants also had access to webinars, online MOOC courses and additional resources on CompSci[3] website on the Scoilnet platform. A leadership workshop was held for school principals and an industry day was available to all teachers.

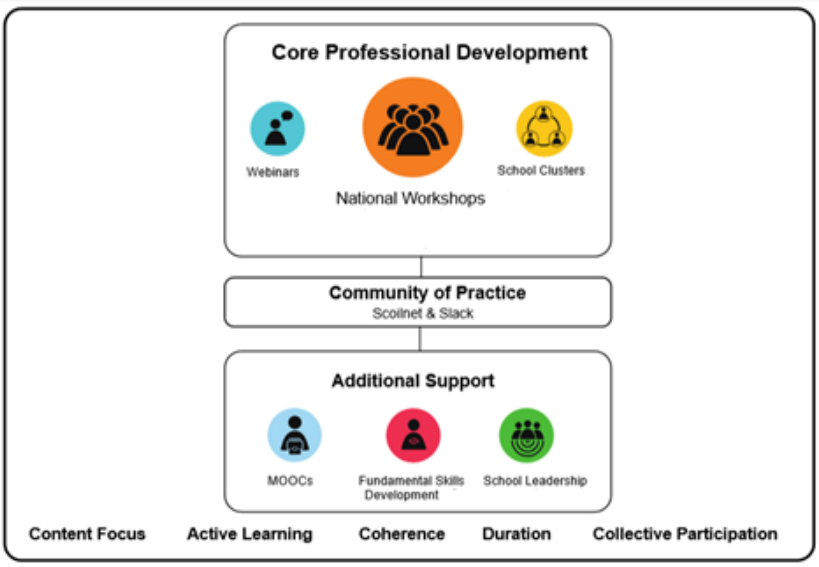

Figure 1 - PDST's PD Framework[4]

In brief, the key elements of the PD framework examined in this study included:

- **National workshops:** These were two-day residential workshops, which addressed pedagogy and curricular content (see Appendix 6 for content details). Three national workshops took place each year and the teachers were divided into two cohorts for all except the first and last workshops. The final workshop was moved online due to Covid19 restrictions.

- **Fundamental Skills Development:** Three residential workshops to address programming skills were included in the PD programme. The first camp (three days) introduced teachers to Python fundamentals and the second workshop (one day) covered more advanced Python concepts. The final skills workshop introduced the teachers to HTML, CSS and JavaScript. Teachers were

[3] https://www.compsci.ie/
[4] https://www.scoilnet.ie/uploads/resources/26525/26261.pdf

involved in many hands-on exercises during the camps and were provided with detailed manuals as support material[5].

- **Webinars:** Three webinars were included in the PD programme. The first, titled *'Perspectives of Teaching Programming for Leaving Certificate Computer Science'*, was presented by Dr Sue Sentence, the second titled *'LCCS from Inception to Implementation'* involved a panel of representatives from the LCCS Development Group and the third titled *'Insights into the promotion of inclusion in Computer Science education'* was presented by Dr Colleen Lewis of Harvey Mudd College. The webinars were approximately two hours in duration and took place in the evening.

- **MOOC Recommendations:** Optional online MOOCs were offered to the teachers during the first year of the PD programme, details of which are outlined in Appendix 7.

- **Regional Cluster Meetings:** Six regional clusters were set up for teachers to share their thoughts and build up a community of practice. Details of schools by cluster are available in Appendix 8. Four rounds of regional cluster meetings took place during the PD programme.

- **Slack Platform:** In addition to all the face-to-face opportunities mentioned above, Slack was used to assist with the development of a community of practice. It was a closed online communications platform for the participating teachers to seek help, answer requests and share resources and it was facilitated by the PDST.

An overview of when these PD activities took place is outlined in Figure 2 below and additional details are available in Appendix 9.

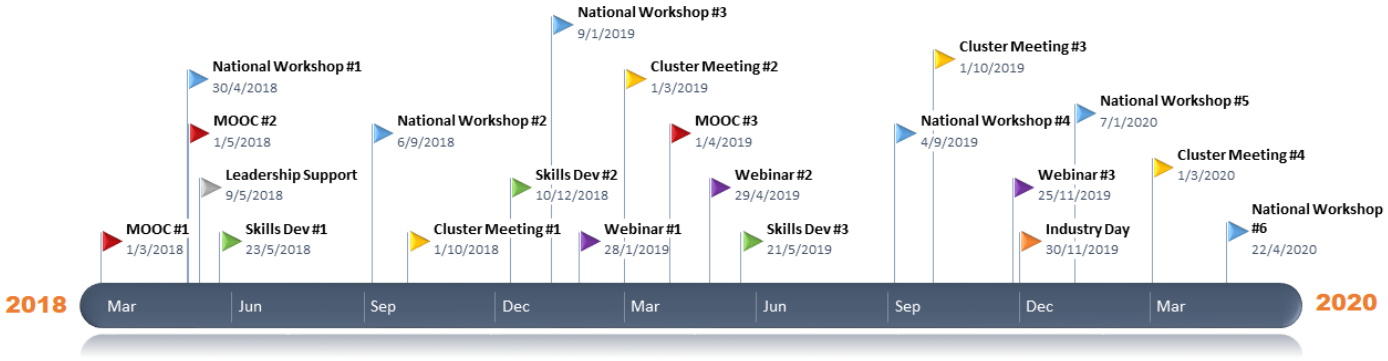

Figure 2 - Timeline of PD activities

This research team attended a number of events to meet the teachers, to communicate plans, to obtain consent for research purposes and to gain a general insight into the nature of the events provided.

[5] https://www.compsci.ie/cpd/

4 METHODOLOGY

The research adopted a mixed-method approach conducted in two stages as outlined in Figure 3 below.

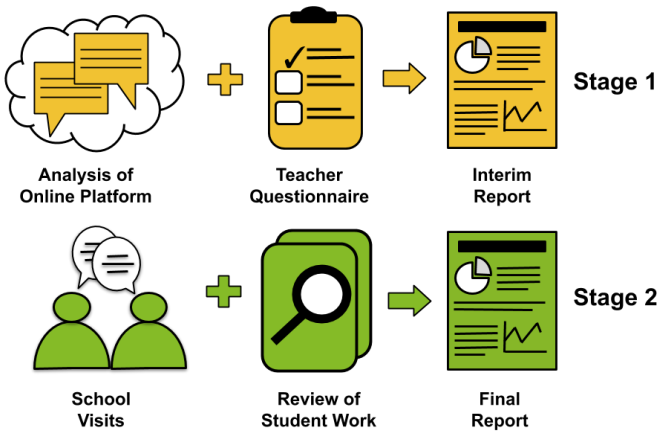

Figure 3 - Multistage approach to this study

4.1 STAGE 1

This first stage reported on in the interim report, involved the analysis on the teachers' use of the Slack platform and an analysis of the data from a questionnaire distributed to all teachers towards the end of the first year of the PD programme.

In relation to the use of the Slack platform, 43 Slack users (40 of the Phase 1 teachers and three PDST staff members) consented to their data being exported from the platform to undergo analysis. Python scripts were used to extract this data set which consisted of 2038 posts across seven Slack channels (discussion fora).

A mixed-method questionnaire informed by the Slack data analysis and aiming to obtain the teachers' experiences of the roll-out of the new subject, was developed and distributed at the May 2019 national workshops. Responses were received from 29 of the teachers representing a 65% response rate.

4.2 STAGE 2

The second stage of the research involved visits to a representative sample of ten participating schools, which took place between October and December 2019. Being representative of the range of schools involved in the Phase 1 roll-out, they consisted of different sized schools, DEIS schools, urban and rural schools, single-sex and mixed schools and different school types.

Each site visit included interviews with the LCCS teacher(s), the principal and the guidance counsellor to explore how the subject was implemented at a school level and how the teachers had progressed in their professional development. The school visits also provided opportunities to observe the 6th year LCCS classes and have informal discussions with some of the 6th year students. Twelve LCCS teachers, ten

principals and nine guidance counsellors were interviewed. Two of the ten schools had two LCCS teachers. A graphical representation of this selection process is provided in Figure 4 below.

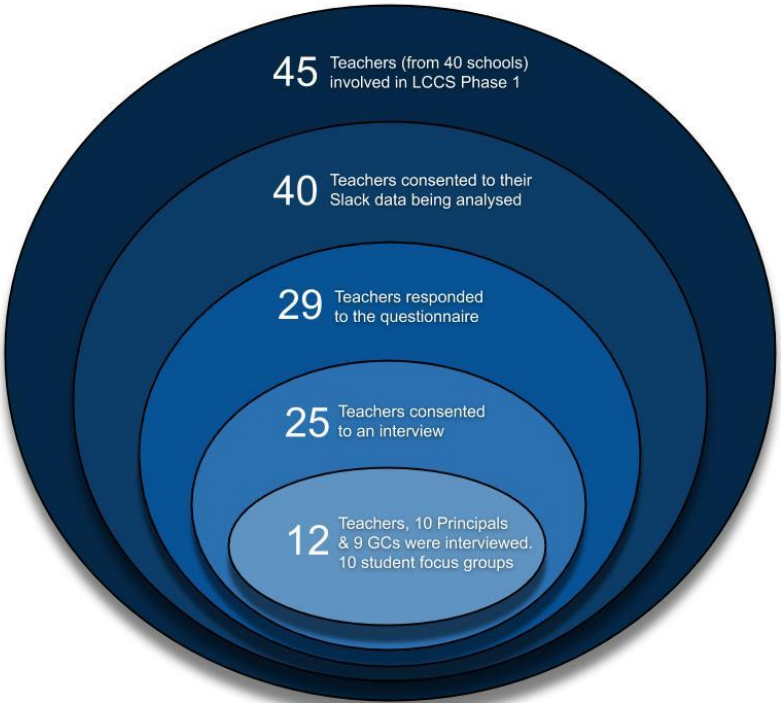

Figure 4 - Tiered sampling strategy used in the study

The study was granted approval by the University of Limerick's Faculty of Science and Engineering's research ethics board. In compliance with this ethical approval, all potential participants were provided with information on the study and details of how the collected data would comply with the confidentiality and anonymity guarantees as laid out in the ethical approval application. Each participant was then asked to complete a consent form to indicate their willingness to participate in the study and had the freedom to withdraw from the study at any time without the need to provide a reason.

Analysis of the research data varied depending on the type of data collected. For the teachers' user records of the Slack platform, a statistical analysis of the data was undertaken to establish their patterns of use. For the teacher questionnaire issued in May 2019, a statistical analysis of the closed questions and a thematic analysis of the open-ended questions was undertaken. For the school-based element of the study, all teacher, principal, guidance counsellor and student interviews were recorded. Being central to the study, all the teacher interviews were transcribed and underwent a thematic analysis by the research team. This analysis involved a reading of the transcripts by the members of the research team followed by several rounds of discussions where the main themes were discussed and agreed. A similar thematic analysis of the audio recordings of the principal, guidance counsellor, and student interviews were also undertaken to identify the main issues emerging. Sample completed student work was examined in each site with the teacher. These conversations about the student work were also recorded and analysed.

5 RESEARCH FINDINGS

5.1 GENERAL OVERVIEW OF THE PARTICIPATING TEACHERS AND SCHOOLS

5.1.1 Schools

In selecting the 40 Phase 1 schools, and as previously mentioned, care was taken to ensure that the schools were geographically dispersed throughout both rural and urban settings and reflected the broad range of school types and sizes. One of the key goals of the teacher questionnaire, issued in May 2019, was to gain further information on these participating schools and the participating teachers.

Results of the teacher questionnaire, in which a 65% response rate was obtained, reflected this diversity of schools showing both mixed and single-sex schools, urban and rural school as well as schools of different sizes and types (Community, Comprehensive, Secondary and Vocational). (see Figure 5).

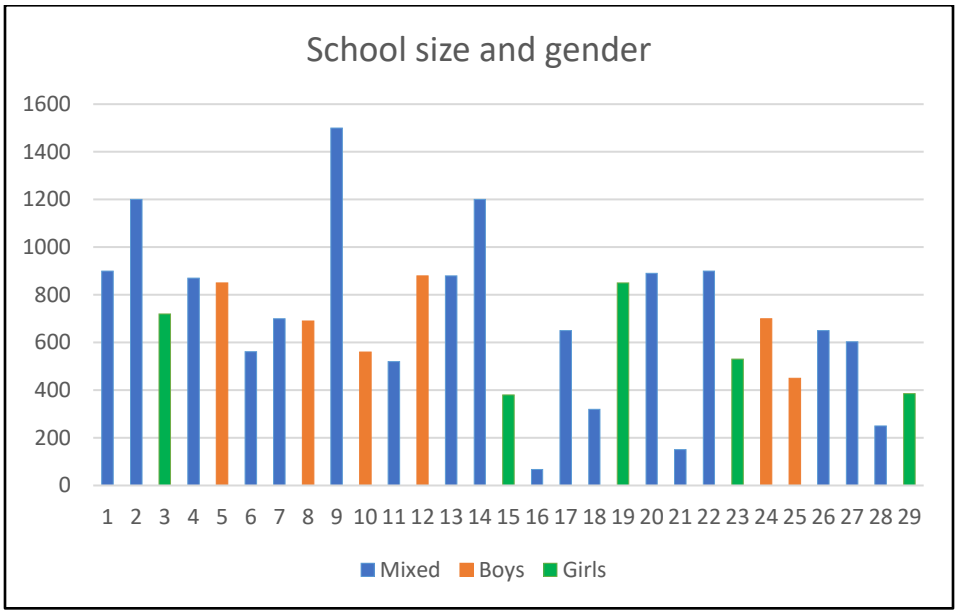

Figure 5 - Schools by size and gender (teacher questionnaire May 2019)

The questionnaire also sought information in relation to whether the schools were already providing Junior Cycle short courses in this area which may reflect an established tradition and interest of coding and CS provision in the school. Less than a third of schools reported offering the Junior Cycle short course in Coding[6] (31%) and the short course in Digital Media[7] (21%) - four of the schools offered both courses (see Figure 6).

[6] https://www.curriculumonline.ie/Junior-cycle/Short-Courses/Coding/
[7] https://www.curriculumonline.ie/Junior-cycle/Short-Courses/Digital-Media-Literacy/

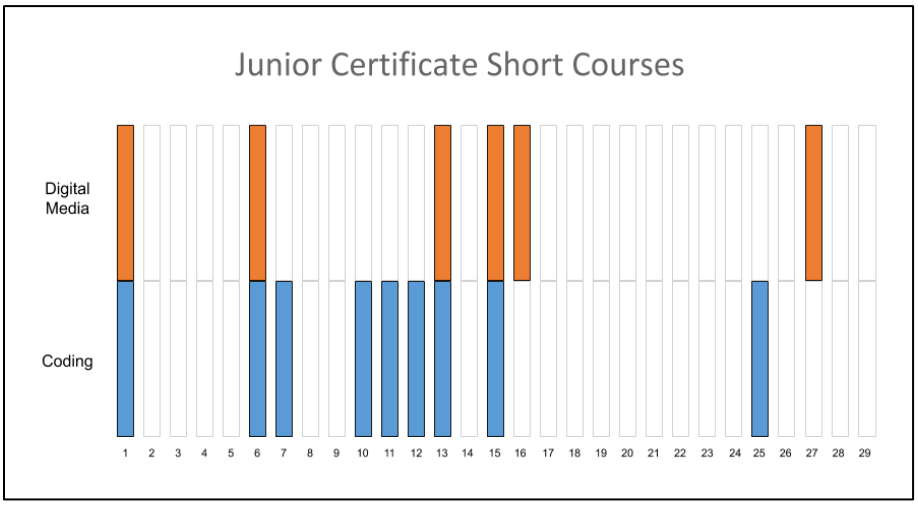

Figure 6 - Schools offering JC Coding / Digital Media (teacher questionnaire May 2019)

For further information on school demographics including gender, type, size and DEIS status see Appendix 10.

5.1.2 Teachers

The second part of the teachers' questionnaire sought information on the teachers' background. This section of the questionnaire examined the teachers' previous experience, their number of years teaching and the number of years teaching in their current school. Responses to this question indicate that 52% of teachers had more than ten years teaching experience and that only 17% had less than five years teaching experience, suggesting an overall experienced group of teachers (see Figure 7) and of this group, 38% were female.

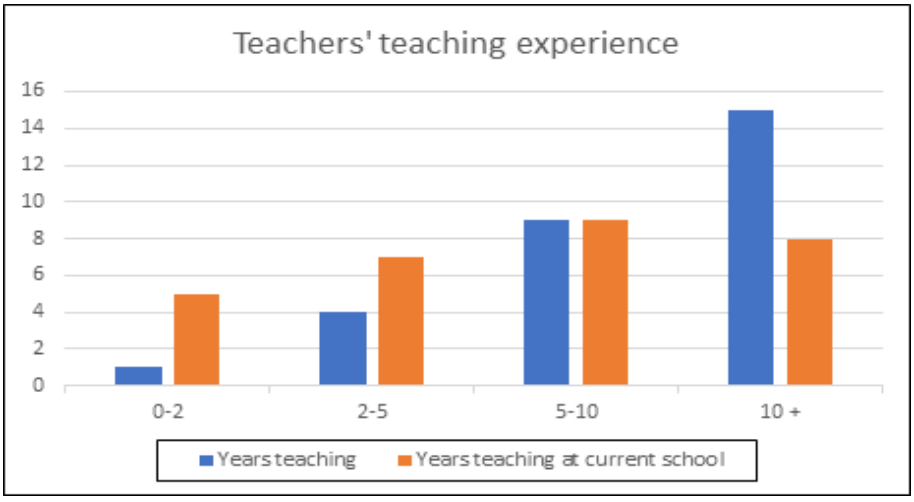

Figure 7 - Teachers' teaching experience (teacher questionnaire May 2019)

The questionnaire also sought information on their teachers' previous experience of teaching ICT in school and their general level of experience with technology, as reflected by their contribution to the school's

technical support provision or their previous experience in the IT industry. The breakdown of these three aspects are provided in Figure 8 below and it highlights that, as expected, this group of teachers were generally quite experienced in teaching ICT in their schools and contributing to the provision of technical support. Further still, 41% had experience in the IT industry.

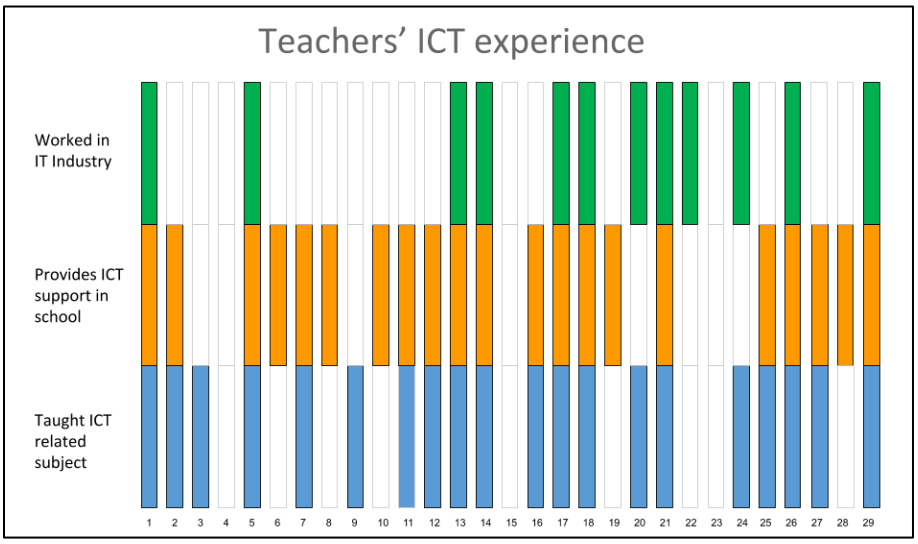

Figure 8 - Teachers' ICT experience (teacher questionnaire May 2019)

5.1.3 Students

The questionnaire also provided an opportunity to gain further information on the student cohort. It was reported by the teachers that CS was available as an option to all students and 79% of the teachers reported teaching one class group in their school (21% of teachers taught two groups). In terms of the gender of students undertaking the subject, while 38% of the teachers teaching the subject was female, only 22% of the overall population of the CS students in the 29 schools that participated in the first stage of the study were female (as reported by the participating teachers). In the mixed schools of this cohort, only 16% of the participating students were female. Indeed, in some cases, class groups had only one or two females in a class of over 20 students. Figure 9 below shows the gender breakdown by school and the yellow dots are used to highlight mixed schools.

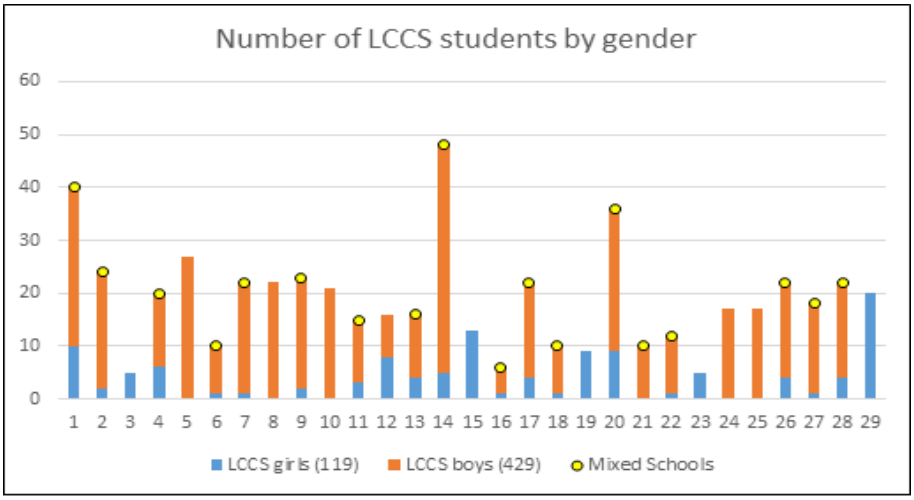

Figure 9 - Students by school and gender (teacher questionnaire May 2019)

5.1.4 Timetable

In relation to the timetabling of the subject in the school, the questionnaire sought the number of single and double class periods used in its delivery. The responses indicated that schools offered a range of classes from single 40-minute lessons to double 80-minute lessons. Nine of the schools offered single 55-60 minute class periods. In schools with 40-minute class periods (20 out of the 29 schools), the majority of timetabled classes tended to be single class periods with only one double class period offered. This reliance on single 40-minute class periods raises questions about the extent to which the project-based learning, fundamental to the delivery of the subject, is effectively facilitated in such timeslots.

5.2 TEACHERS' EXPERIENCES OF CS SUBJECT ROLL-OUT

5.2.1 General pedagogical challenges

During the interviews, the teachers spoke about many pedagogical challenges that they faced when teaching the new subject. While many were specifically related to unique pedagogical issues associated with teaching of CS, there were also numerous comments made referring to the overall educational philosophy of the programme that encouraged more student-led, problem-based approaches to learning;

> *So, with Computer Science, it is about getting them to do the work a lot of the time and getting them to kind of, you know, learn from it rather than me telling them. (Teacher A)*

> *… it's challenging because it's a different way of teaching compared to other subjects that we teach, because it's a more project-based, applied-learning tasks, you know, it's not really quite a didactic type teaching … your students need to sort of discover some of these concepts themselves through projects. (Teacher I)*

For some teachers, that had experience of teaching in this more constructivist way, the adoption of this approach was a continuation of their existing approach to teaching. Whereas for others, this shift from a more teacher-centred tradition to a more student-centred approach was a significant change. For example, one teacher (Teacher K) commented on the 'creativity' of the subject and claimed that, '*once*

you've given them enough scaffolding on it', the students could achieve their goals. The teacher's attitude towards this more student-led approach was influenced by existing pedagogical practice as the teacher claimed to be, '*big on the constructivist approach',* suggesting a familiarity with this pedagogy before taking on the new subject.

For other teachers, the more project-orientated, group-based work was more of an adjustment. In describing this change in practice, the new subject was frequently compared to the teachers' existing subject specialisms. In the following two interview excerpts, two teachers describe this difference by comparing the new pedagogical approach with existing subjects' pedagogies;

> *It's a kind of a strange setup for a teacher, especially in maths. [normally in maths] I'd be … very involved in their work, whereas in the ALTs I felt I was standing back more, which can be a bit uncomfortable as well, but … it's amazing what they'll learn themselves ... So that was an eye-opener, I suppose as well that, you know, they'll, they can learn stuff themselves. They don't need you all the time. (Teacher D)*

> *… there's a lot more kind of freedom or flexibility, in that, like some of the other subjects are a bit more rigid. Like physics ... everything's good to go, whereas some of the Computer Science is more creative, it's more interdisciplinary, it's more whatever the students want to go with. … There's definitely more discussion. It lends itself to more group-work and more teamwork and more investigation and finding different ways that things can work. (Teacher H)*

As the excerpts above highlight, the more project-based learning that adopted a group-based approach was a marked difference from their traditional pedagogical practices and for some, this was a challenge.

On a similar note, there was also evidence from the teachers' comments that this change in the overall pedagogical approach was also a challenge for the students. The adjustment to more project-based learning, that called for a more independent initiative from students, was one challenge for the students, as one teacher noted;

> *It's mostly project-based work that they're doing and very little of sort of the teacher standing up saying, 'learn off this and learn off that', … that's very different for us as a teacher, and I think it's also been certainly a challenge for the students as well because sometimes they feel they're not making progress. (Teacher I)*

The ability to work in teams was also mentioned as a challenge for some students by the teachers, perhaps reflecting the novelty of this approach for many of the students. During lesson observations, it was noted that the teachers were employing student-centred pedagogies in the delivery of the subject.

5.2.2 Subject-specific challenges

As well as adjusting to the overall pedagogical philosophy of the programme, the teachers also reported a number of other pedagogical challenges that were more specific to the teaching of the subject content. While the earlier challenges of adjustment could be seen as general pedagogical challenges, that could be faced by any teacher shifting to a more student-centred, project-based approach, other challenges related to the unique pedagogical content knowledge (PCK) (Schulman, 1987) of the subject. Being challenges that related to their unique PCK, they exposed the sometimes-limited subject knowledge of the teachers and this was exacerbated by their other teaching commitments, as one noted;

> *When you're working 22 hours, it's very, very hard to get the time to go and do this all yourself and then to try and bring it back and implement it in the classroom. That's what I'm finding very, very tough. (Teacher D)*

The double challenge of acquiring the subject content as well as developing suitable resources was explained by one teacher who argued;

> [*it takes] a huge amount of personal time. … you've two things going on where I as a teacher have to upskill, but then I also have to spend a lot of time gathering resources and getting classes ready for students because we don't have them [resources]. (Teacher A)*

As expected from a group of teachers taking on a new subject, the teachers reported on specific subject-related challenges of implementing the subject.

As the interviews were conducted in the late Autumn term of the second year of the programme, the teachers had completed a significant amount of the course, but at that point, concerns were raised about the amount of course content within the subject that they were expected to complete;

> *And I think they will have to change it. I think they will because it seems to be the feedback I'd say from everyone. … it seems to be nearly like first year Computer Science students in college standard, as opposed to something that you can actually reasonably do inside in a class. (Teacher D)*

> *I'm definitely under pressure to cover all those learning outcomes and embed the skills that they need to achieve the learning outcomes. And at the end of the day, there is an exam. I know that they might not want to think about this, the department and that you're not teaching to an exam, but students are ... (Teacher A)*

These concerns may indicate that the course is ambitious in terms of its expectations of teachers and students, but it could also be a result of the teachers' lack of familiarity with the subject. For example, a significant number of comments by the teachers related to issues associated with the pacing of the subject, where they expressed uncertainty in relation to the breadth and depth that was required in addressing key areas of the course. Some expressed concerns that they had not addressed issues in sufficient depth, whereas others believed they had devoted too much time to particular topics and learning tasks;

> *We've gotten fabulous resources with the ... you know PowerPoints, computational thinking and you know Python and different things that we have, like some brilliant work that the NCCA have done, but like there's still huge areas that are way too broad and you don't know what level to go into (Teacher B)*

> *I think that at the very least, even a teacher book even if students don't have books, but something to give us guidelines on well here, there's the learning outcomes and you know you need to go this far into that learning outcome or that far. We don't fully and that's definitely something across the teachers, we discuss it all the time that we don't fully understand how much we need to be teaching in certain areas. (Teacher A)*

These comments echoed the concerns expressed in the teacher questionnaire collated in May of that year; For example, at that time, the teachers mentioned challenges teaching new concepts as well as 'finding the right level to pitch it at'. One teacher, for example, wrote;

> *It is a challenge to know how deep to go into each LO [learning outcome] in order to cover it in sufficient details for their assessment. (Teacher questionnaire)*

These concerns about whether they had devoted sufficient attention to areas, and whether they were moving through the course at a sufficient pace, was exacerbated by societal pressures associated with the Leaving Certificate examination;

> *That would be my concern, I wouldn't want them not to achieve due to something that I might have overlooked or not covered in enough detail for them or even that I didn't prepare them enough for it ... while it's great they love the programming and they go off and do things, at the end of the day, they do have to go off and sit an exam. So, I suppose when I see the sample paper and see we're concerned about the depth of the knowledge that they need to display in their written work. (Teacher B)*

This powerful influence of the state examinations was also mentioned by principals, with one noting that;

> *… teachers just by our nature we're going to be judged, as far as we're concerned, on the exam and you'd have built up an experience that you knew exactly what your exam was like and what you needed… what you needed to do to get there, whereas [my CS teacher] would be feeling like maybe a little bit in the dark and wants to see where it's going to and I'm delighted that the mock [exam] is coming up. (Principal B)*

The interviews also captured how the teachers were developing their PCK through practice. While acknowledging the value of the professional development provided, much of their pedagogical knowledge appears to have been developed through their practice, which aligns with research on the development of teachers' PCK (Schulman, 1987). For example, in talking about their practice, the teachers described how they catered for the mixed abilities in their class groups and how they approached the teaching of key concepts. In the following interview excerpt, for example, the teacher describes how they used feedback from student tests to modify their pedagogy;

> *So obviously test results are your main indicator. … so, like they would have done poorly in those test results, even though I thought I'd covered them to death, … I found out afterwards [it] was the difficulty [of the questions], they didn't know which answers they should be giving for different questions. So, then I had to spend more time going back over that and teaching that element to them … with the more practical elements. You can see they're not really grasping this, I need to spend a bit more time on it and do another activity. I need to come up with another activity for them to give you another side of it and another bit of time to embed it. (Teacher A)*

Establishing norms of practice was also an issue that emerged in the interviews and echoed previous comments from the teacher questionnaires. The setting and completion of homework arose as a significant challenge;

> *So, that's the biggest challenge, I think, it's the students not putting the effort outside of the classroom into their coding skills. And I always say it's like an instrument, they need to be practicing and practicing and practicing and they're not really practicing. (Teacher I)*

In general, the teachers reported a lack of engagement with homework tasks during the initial implementation of the subject and they appeared to have implemented different approaches to encourage homework. While one school had reported 'giving up' on setting homework, other schools,

having gained experience, reported some success in getting students to work independently at home. That being said, there were concerns expressed about whether the level of independent work set for the students would be sufficient for the students to be successful in the subject. This again reflects the ongoing development of the teachers' pedagogical knowledge and how best to approach the teaching of the subject.

Another challenge, related to the specific teaching of the subject content, was the students' prior experience and knowledge of coding. As the teacher questionnaire highlighted, while some schools offered the Junior Cycle short course in coding, this was not established long enough to have an impact on the first cohort of students. Some teachers reported having to deal with a significant variation in pupils' skills and knowledge and in dealing with student misconceptions of what the programme entailed. Teachers also reported surprise in learning that some students lacked basic digital literacy skills and therefore had to spend time teaching these skills to get them on a par with other students;

> *There's a huge knowledge gap for them when they get into Senior Cycle. So we've been struggling with that, trying to address that gap, you know, and these students need to work extra hard to try and catch up on that, you know, so that's the challenge there. (Teacher I)*

An associated challenge related to catering for the diverse experiences and skills of a class and the overlap with the Junior Cycle short course in coding and students' lack of engagement with the content they had previously covered.

As this section highlights, the general shift towards more project-based, student-centred learning was a challenge, but the greatest challenges related to the teaching of the specific subject and attempting to gauge the appropriate pacing of the subject and the depth of treatment required for particular topics. Catering for the range in students' previous experiences and interests of their classes was also reported as a challenge. The pedagogical challenges first reported in the teacher questionnaire in May 2019 were reiterated in these teacher interviews again. These challenges largely reflect the challenges experienced by out-of-field teachers when taking on a new subject (Du Plessis, 2016) and therefore one could see these as expected challenges rather than specific to the subject of CS or this curriculum initiative.

5.2.3 Reflecting and learning from completed student work

As part of each school visit, completed student work was also observed. Teachers were asked to provide a spectrum of student work samples for this exercise. It was initially envisaged that this analysis of student work would provide an opportunity to assess the extent of progress made at a school level and gain an understanding of the level of student learning. However, it proved difficult to compare the student work in each school as in many instances different ALTs were provided by the teachers based on what work had been completed. Despite this limitation, this task proved to be a very worthwhile exercise as the student work was examined with the teacher and this provided an opportunity for the teachers to talk about their practice, and in particular, what they had learned from undertaking the ALTs. Therefore, these recorded interactions with the teachers captured unique insights into their pedagogical practice that was not obtained through the more formal one-to-one interviews. As the teachers were focused on talking about the student work, it provided them with an opportunity to reflect on their past practice and talk about what they had learned from the experience as they were now teaching a new cohort of students that had recently entered 5th year.

Despite the challenges outlined in the previous section, many of the teachers' comments showed evidence that they had reflected on their teaching from year one and had made adjustments/changes to their approaches. These changes ranged from minor changes such as the order that ALTs were tackled or the use of particular software to more substantial changes in their pedagogy (including how they helped students develop ideas for projects, how project work was planned and how they supported student independent learning). These comments, therefore, reflect the professional insights they had acquired through the teaching of the subject and highlight they continually developed their teaching expertise as they progressed through each ALT. Examples of reflective thinking/learning from practice were evident in many areas as the following examples highlight:

> Introducing the project brief - *And this time I spent a little bit longer speaking to them about what I wanted to see. I mean, I think last year I talked a lot of wishy washy now on reflection. ... they need to know exactly what I wanted*. *(Teacher D)*
>
> Following the project brief - *And then I suppose the most important thing they learn that comes in are design loops [the cyclical process of design] and going through and making sure that we're meeting the brief ... (Teacher B)*
>
> Generating ideas - ... *what we tried to do is start off with a design statement, what they're trying to do. We always get them to research, to write down the ideas that they had before they started the project, because when they start the project, they might have loads of ideas that they want to do, so we want to get them to formally write them down and maybe describe what they were thinking of doing, some advantages and some disadvantages (Teacher I)*
>
> Group-work - *… but looking at it from my point of view, a lot of the time, as soon as you start to put them together, it generates into a gossip fest and to actually keep them focused is a big problem. So as a large group with my students it wouldn't work (Teacher G)*
>
> Scaffolding - *And what I found is that having those tutorials [sample code] are useful because if we just started out saying, okay guys, off you go, they'd be like, wouldn't be able to do it, you know, so having this scaffolding (Teacher I)*
>
> Student Reflection - *I found I needed to do that [regular reflections with students] because I just found the planning wasn't at the level that I would have hoped they would have been at, even though we spent a lot of time on the design process and how important it was ... maybe some of them were coasting and maybe not thinking about their contribution. They're looking at the project as a whole and they're not thinking, how am I contributing or what skills have I developed (Teacher B)*
>
> Group Assessment - *Well, actually, I had to change that [joint group assessment] [be]cause there was people not coming in and I decided to assess them on the part that they were working on. And [be]cause if they were say to write up the project and one guy did all the coding and did a really good job. Why should he be punished because the report isn't done? So, I found on the second ALT that I needed to do something about that, and I did yeah. (Teacher C)*

Common to all the above statements is teachers speaking about their experiences of teaching the subject and the insights they have gained from this which has led to a change in their practice. This highlights the importance of classroom practice in the development of teachers' professional knowledge. While the

professional development programme has guided them and scaffolded the development of their understanding of CS pedagogy, it was the classroom experience that was central in advancing their pedagogical competence in the subject.

5.3 STUDENT EXPERIENCES OF CS SUBJECT ROLL-OUT

5.3.1 Student experiences of studying CS

Each school visit included a group interview with students, providing an opportunity to gain the students' perspectives of the subject. These group interviews were normally conducted in a classroom setting without the presence of the teacher and normally contained approximately seven to eight students per group. The students reported very positive views of the subject with many indicating that they looked forward to their CS classes, as one student commented, '*I don't really view it as a subject. It's more just like an hour in the day when you actually enjoy a class*'. In relation to the content of the subject, there was no specific area of the course that stood out as being the most enjoyable. Instead, students highlighted different areas of the course as their most enjoyable topics ranging from areas as diverse as coding in Python to web design to micro:bits. There were however many comments made that indicated that the most enjoyable aspect of the subject was the way it was taught. Students commented on the active nature of the subject, the interactive components and the emphasis on creativity as the following student quotes highlight;

> *… we don't just sit there and look at books and write all day … we get to write code and like make it work ... (Student Focus Group 4)*
>
> *It's just different. Everything else, you have your books and you all look at the board and just write for an hour for the most part, but this one, like you're doing your own work … (Student Focus Group 5)*
>
> *… a lot in class is more of a debate format, so we will talk openly about how we feel about things and I feel lots of teachers should adapt that to their method of teaching in CS because it helps it so much to go into your head ... you're having real conversations. You remember things that your friends say more than you'll remember like what the teacher says sometimes ... Everyone has their own perception of technology ... so I think it's really important that you can share that in a group and base your own opinions off of that. (Student Focus Group 4)*
>
> *It feels more relaxed than other subjects. It's more like laid back. We do a lot of work ... but it's way easier than writing constantly ... so it feels more chilled out than other subjects such as Maths … the teacher doesn't tell you what to do, it's more you find out yourself and you can choose what you want to do as well like in the ALT projects and stuff ... It's more about your own creativity ... you can choose what to do and that's better than other subjects. (Student Focus Group 3)*

The Applied Learning Tasks (ALTs) appeared to have contributed to the authenticity of the learning experience. For example, in the student quote below, the metacognitive value of the ALT task in helping the student to assess the extent of their own learning is evident. So too is the motivational aspect of working with real data;

> *I feel like the ALTs are really good because they kind of highlight where you are in CS because it's hard to realise how much you've learnt up until then. Until you've done the ALT, and you're like 'Oh! I can actually do that' and get a proper result for your coding and your CS work … like the one [the ALT task] where you have the data from online and you need to take it and put it on a graph, it makes you feel you actually can have an impact on like the outside world because you can kind of track the data and portray it on a graph. (Student Focus Group 4)*

In reporting their experiences of the subject, the students also recognised the wider skills they had developed as a result of studying the subject, these included teamwork and collaboration skills developed through engaging with groupwork. However, the most commonly reported benefits of the subject related to problem-solving and self-directed learning. The selection of student quotes below highlight how the students have an awareness of these developing skills and, as the second quote highlights, that they have applied these acquired skills in other subjects;

> *… Problem-solving is another skill, like it's not really in most other subjects because most others just require rote learning, learning off stuff from PowerPoint, so I think this is a really engaging subject because, like especially with the projects and stuff, you actually have to really think about what you're doing (Student Focus Group 8)*

> *It [the subject] made me get a bit better at maths, I think. I'm in ordinary level, but I'm not on the lower end of it anymore. Because we have to problem solve in Computer Science, it made me learn how to apply that in Maths and different things along those lines. (Student Focus Group 5)*

> *The way that you learn is completely different because I feel every other subject you're already stuck in a routine of, if you're stuck, you ask your teacher. Whereas in CS, we have a process. If you're stuck, the first thing you do is ask your friend, and then if you still can't get it, you look it up online and then, if you don't know the answer, then you go to your teacher and ask them. So, they're kind of the last resort, which I feel is very relevant to the workplace. So, it's preparing you for that … (Student Focus Group 4)*

The students' acquisition of these broader skills and competencies beyond the subject of CS was also commented by the teachers who recognised these 'softer' skills that were developed, as one teacher, speaking about their students' developing confidence to undertake a presentation, noted;

> *At the time [the start of the course], getting them to do a presentation would not have been particularly positive. They're at the stage now where they're much more comfortable as a group together so by Christmas I will be able to get them to do short presentations on their work. (Teacher G)*

The challenges of taking on the subject reported by students were varied but they commonly noted difficulties in starting to learn how to code. In saying that, while this journey was challenging for some, they acknowledged that their skills had improved and that they enjoyed when they had solved a problem they had worked on;

> *It can be annoying sometimes because you can't move on sometimes if you have an error. That's the only real complaint I'd have about it (interviewer: But when you resolve it?) … It feels amazing (Student Focus Group 5)*

> *It's frustrating if you don't get something, like oh my god, I get the mads there some days! ... But then, once you get it, it's like a relief, a light bulb moment. (Student Focus Group 6)*

In a similar vein, speaking about the Applied Learning Tasks (ALTs), a student offered a similar view about the challenging but enjoyable aspect of the task;

> *They [the ALTs] are challenging but they're enjoyable. Like it does challenge you a bit, but like it's nice when you get them, like you get the satisfaction of getting it right and you get to see like how you do it … everyone will have a different way of doing it, so it's really nice to see like how everyone thinks differently about them. (Student Focus Group 4)*

The comments above suggest that the students were beginning to learn how to deal with the cognitive challenge and recognising their emotional reaction to this challenge, which is an important skill in self-regulated learning (Zimmerman, 1989, 2000). These comments also indicate that this more independent and problem-based approach to learning was new to students and not commonly employed in other subjects. For that reason, some of the comments about the challenges of the subject could be seen more as a reflection of the dominant examination-focused approach of other subjects, rather than a criticism of the new subject. For example, in the student quotes below, the absence of defined and accepted course content, as set out in a textbook which could be recited in an exam, was seen as a challenge;

> *The biology course will have set definitions that everyone has to learn. Same with physics and the other sciences and most of the other subjects in general. But since you don't have that in CS you have to rely on finding that through the internet and you will find contradictory sources at times and that can be a struggle when you are trying to think of a set answer for a question in the exam. (Student Focus Group 9)*

> *In other subjects we have books and we learn what's in the book ... but here we can learn from experience … for theory part we would rather have a book. (Student Focus Group 4)*

The pressure of the Leaving Certificate examination was also evident in a number of student responses where a lack of certainty of what would be addressed in the exam was mentioned. It is understandable, that with the introduction of a new subject, such concerns would emerge, however, during the time of the data collection in the schools, the trial exam issued to schools in October 2019 did appear to allay some of the fears, as the following quote highlights;

> *I was worried about that until we got the mock exam because I thought it was fair enough, it was a fair exam … there was nothing asked that was like, that wouldn't be part of, like everything that was asked was stuff that we'd come across that you wouldn't really have to learn-off. It's stuff that you just learn from doing the projects and doing all the other tasks and stuff that [our teacher] has set us … (Student Focus Group 9)*

Therefore, it could be argued that the novelty of the subject was both a 'blessing and a curse'. On one hand, the novel pedagogical approach underpinning the philosophy of the subject was seen as fresh, engaging and motivating by the students, but on the other hand, this novel approach, being quite different to what the students had experienced before, highlighted how the students had been somewhat 'conditioned' for rote learning by their engagement with other subjects. These challenges therefore reflect a tension between the pedagogical approach of the new subject and the existing subjects rather than a criticism of the new subject per se.

5.3.2 How the students viewed CS as a subject

Students have their own perception of what CS is and the interviews provided an opportunity to capture these views. For some students, their perceptions of CS are relatively informed as they have had some background in programming through hobbies and extra-curricular projects. For other students, their knowledge of what CS entails is more closely associated to the broader area of ICT, or perhaps the playing of games, as one teacher noted;

> *I mean, their perception, the first thing I ask them is their perception, what they think Computer Science is. And it's always games. It's always the main thing. It's the games. (Teacher K)*

This misconception by some students was also echoed by guidance counsellors who noted that some associated with ICT;

> *… but yeah I do think that they need to kind of be as informed as they can before taking this up because it's so new and they just kind of, as I said, some people just hear computers and go oh sure I spend all evening on the computer, it'll be grand and they're not aware of what's involved. (Guidance Counsellor 4)*

> *So when they then sat in the class and realised it was a lot of, now I'm not, you know, hugely familiar with the content of it, um, that it was a lot of problem-solving and you know, not an advanced kind of class of coding. They, they didn't like it. (Guidance Counsellor 5)*

During the analysis of the interviews with students, several themes related to the perception of CS as a Leaving Certificate subject emerged. In a similar manner to the other interviewees, student observations related to how the subject was perceived and associated with other subjects. Some saw it as another science subject, 'no matter what course you doing, now everyone is asking for a science so you might as well pick the most creative one' (*Student Focus Group 5*), whereas others believed that, unlike other science subjects, it afforded greater opportunities for creativity;

> *It's refreshing because all the other science subjects they're not really, you don't have a chance to show your creativity (Student Focus Group 5)*

The area of gender balance for the new CS subject was also an issue that students discussed in their interview sessions. While one female student undertaking the subject reported no issues with the material, she added that, '*People are always asking me oh what's it like being the only girl and it's not any different, we're all doing the same work*' (*Student Focus Group 5*). However, she did provide an interesting window into a wider problem of the perception of CS as a boys' subject;

> *Two years ago when I was picking the subject, they were like, oh Computer Science, it seems like a boy's subject when I was asking like my Mam and just people in the school about it, so that was my perception of it (Student Focus Group 5)*

On a more hopeful note, there were some indications of change taking hold with an understanding of the problems of the past, as this male student observed;

> *Back in the day, like in a different era, people would say this wouldn't really be for girls like, but I suppose it kinda is, but girls still look on it as not a girly subject ... girls would be more into Home Ec[onomics] or Music or Art or something like that ... but still like, I would recommend it to girls. (Student Focus Group 6)*

These broader societal expectations of the subject were reflected in the teachers', principals' and guidance counsellors' interviews, as the following section highlights.

5.4 PERCEPTIONS OF THE SUBJECT

5.4.1 Subject classification

As each school included interviews with teachers, principals and guidance counsellors, the study also explored their perceptions of the subject. Across these interviews, there were differences in terms of how the subject was perceived and associated with other subjects. For instance, CS was sometimes associated with Mathematics or Applied Mathematics and Physics;

> *So, I have one student who would struggle with regular math's anyway and sees this as a Mathsie subject and is struggling quite a bit (Teacher G)*

> *… so like at the moment I'm seeing sort of a range of students who are applying for it, like the ones who are, you know, the traditional sort of maths, physics, applied maths, and then just people who are interested in, in computing and hardware and software generally, like, you know, so a range I think yeah. (Guidance Counsellor 9)*

On the other hand, others associated it with the practical subjects such as Engineering and Construction Studies;

> *It's similar to woodwork, you can't show up in the last day of woodwork having learnt off a bunch of stuff and build a table….basically like a combination of, I would say woodwork and maths stuck together on a computer. (Teacher E)*

> *… I suppose we have the engineering, we have construction, you have tech graphics, which goes into CAD. So, we have students interested in technology subjects and this was seen as kind of an added layer. (Guidance Counsellor 1)*

Further still, another teacher seemed to consider that it was more closely associated with languages;

> *… the principal came around, he was asking about it, they're trying to bring it in and he was asking me and he was saying that here's the thing, you know, it's like a language, so it's attractive to people who are good at language. I kind of disagree. Um, the students I see ... (interviewer: Was he saying as in French and Spanish languages?) … Yeah, yeah cos people do say it is a language and you need to be kind of, so coding is a language and the creativity part of it. Um, I kind of disagree, the students I see good at it are the students who are good at maths. (Teacher L)*

How the subject is perceived is an important issue, as it can influence how it is marketed at a school level to potential students and parents and how it is located in the timetable, determining what subjects it competes against. This can have implications for female participation and participation amongst the wider student cohort. The data suggest that, at present, what the subject is associated with (and as a result its status) is in flux. Given the diverse ways in which it is perceived, it may take some time and perhaps a new generation of teachers to see how the subject is positioned within the hierarchy of Leaving Certificate subjects and what it is associated with. This may ultimately determine the success of the subject in terms of the numbers of students attracted to studying it. While the principals and guidance counsellors generally emphasised the universal value of the subject during their interviews, at times their

comments suggested an implicit bias for its vocational value for CS careers, for example, one principal, in providing a reason why not all students would be interested in the subject, noted that, '*You're not going to get all the kids. Like all the kids aren't going to be computer scientists*' *(Principal E).*

5.4.2 Difficulty and Appropriateness

A subject's level of perceived difficulty plays a significant part of how it is perceived in general. Subjects considered more difficult often carry greater status, but this perception of difficulty can also limit the take up of the subject (McGarr & Lynch, 2017). The difficulty and appropriateness of CS was an issue raised by many, with some considering CS best suited to "academic students";

> *… the students are going to take it up, like coding you'd think in general is going to take quite the academic students. (Teacher L)*
>
> *Going forward, yes, I do think it's not for every student I would be concerned about some of the ones who are actually taking it up who will struggle. Do you know that sort of way? (Guidance Counsellor 2)*
>
> *I'm finding it difficult for the students. Some students to me, don't have the aptitude at all now maybe that's me and my attitude, that I should be believing everybody can do this. But I, I just like come across students and there's no sense of logic. (Teacher J)*
>
> *All teachers believe that there should be an ability in this direction [to be] mandatory to get into a class. Of course, all principals are saying we don't hold that theory for any other subjects, so we can't be that black and white (Principal H)*
>
> *When you do out your option list, we say to people, if you're picking physics, you need to be good at Math's, what we put down for Computer Science is problem-solving (Teacher A)*

Others saw it as a broader and more accessible subject;

> *No. No. I think we're trying to make it Computer Science for all. (Teacher A)*

5.4.3 Gender Balance

The area of gender balance for the new CS subject is of a great interest to many, because as a new subject it does not carry the gender-stereotype baggage associated with existing Leaving Certificate. subject areas. Yet despite the opportunities afforded by this new subject in terms of addressing gender disparities from the onset, the data of student enrollment outlined earlier indicates that a significant gender imbalance has emerged already. For example, questionnaire data (see Figure 9 - LCCS Students by school and gender) revealed that in mixed schools, female student representation was only 16%, indeed, in some cases, class groups had only one or two females in a class of over 20 students. Teachers, principals and guidance counsellors showed an awareness of this under-representation in the one-to-one interviews as the following excerpts indicate;

> *You're talking about maybe 10% representation for women and I would have preferred to see that go much higher. I suspect looking at the year groups below year five at the moment … it's unlikely to improve much (Teacher G)*
>
> *A lot of our girls, maybe don't see it as a career option at all, do you know, they're going to go for the traditional, you know, options and yeah. And it's the same for, you know, for engineering (Guidance Counsellor 5)*

> *We have similar issues with girls coming through from primary school in the area PE and then in any of the other technical subjects as well. So, they would perceive things like engineering as not being for girls and they would perceive, we say construction as not being for girls. (Teacher G)*

On a more positive note, there were also some anecdotal suggestions about how the representation of females in Leaving Certificate CS might be improved with the inclusion of earlier opportunities in Junior Certificate;

> *Girls - if you don't get them in Junior Cycle, you definitely won't get them taking it for Leaving Cert. (Teacher F)*

> *Although I'm just looking at that small coding class in 3rd year and there are a good few girls in it there … So, if you get them early enough, you're lucky. And now that we have it all the way up which is brilliant you can definitely see it. (Guidance Counsellor 2)*

5.5 TECHNOLOGY RESOURCES AND INFRASTRUCTURE

5.5.1 Technical Support

Several themes emerged in relation to technological resources. One issue that came up consistently related to the growing use of technology for a wide range of subjects in secondary schools, without a dedicated and appropriately trained technical support staff. The CS teachers often took on the role of general ICT support;

> *… in reality I'm Mr IT in the building, so I get called on a lot. (Teacher E)*

> *We could do with IT people who are hired full time. I mean, myself and [other teacher] do the IT in school, so, you know, we're off fixing your computer if it's broken. Do you know that kind of thing, it's just … there's a lot of IT stuff that really could use … a lab assistant effectively. (Teacher F)*

These teacher experiences were also reflected in the principals' comments with one principal admitting that, '*It's not like an ETB, you don't have a tech support… we're completely dependent on the goodwill of the [LCCS teacher] to be here night and day doing stuff' (Principal E).*

In other instances, the ICT support had been either outsourced or centralised, which also introduced a number of coordination and access issues;

> *We used to be able to change passwords ourselves myself and the IT administrator in school. We can't do that anymore we have to contact the ETB to do it so we have to get a ticket and even like they wiped all my software last year, all the hours and days of work installing and wiped and I only got that fixed last week… I now have admin access so I can install programs which is great (Teacher B)*

> *We were using Idle for the start of last year and I ran into an awful lot of problems in school because I wasn't the IT admin. (Teacher D)*

5.5.2 Lab space and classroom availability

While the provision of technical support was a challenge in some schools, their level of technological infrastructure did not emerge as an issue in the teacher interviews. In this regard, the schools appeared to have appropriate levels of technological hardware and recent policy initiatives related to the digital strategy for schools appears to have helped in achieving this;

> *The digital strategy has allowed now for a whole fit out of new computers in the school and extra IT trolleys and stuff in the school and now the ETB have come behind and given us the [MS Office] 365 so that's going to change the way we teach every subject. (Teacher A)*

Physical issues relating to classroom size and storage of projects and related hardware were more apparent than problems relating to the suitability of the computers that these labs contained;

> *… getting the lab time, having enough space, like those types of things. The more kind of physical, you know, we could do with bigger rooms (Teacher F)*
>
> *The problem in the schools is yeah, my lab time is a massive issue with us. (Teacher D)*
>
> *Well the lab physically is quite restricted. (Teacher C)*
>
> *… equipment is a big one… it is very bitty. And by bitty I mean like there's lots of moving parts… even keeping the lab clean is just a challenge… especially if you've got like 15 projects on the go, where do you store those projects? (Teacher F)*

The provision of a dedicated lab for the subject brought several benefits such as being able to do preparatory planning or having a dedicated space for on-going student projects, as this teacher describes;

> *Like I am lucky that I have gotten the room. The problem I'd have is that say I would have time ... free time in the timetable where I meant to be able to be in the room to work on projects or do things and then you'd have another class come in…. being a bit more authoritative and kinda saying well no this is my room (Teacher B)*

5.5.3 Access to technology in the home

Another theme that emerged related to the lack of infrastructure and technical setup that the students had access to at home. For example, some students had access to PCs and Wifi connectivity but others only had access to iPads, tablets or phones, which are less than adequate when students are assigned programming tasks to complete. The following comments below from the teachers demonstrate the variation in the students' access to appropriate technical resources at home and the teachers' commitments to educational equality;

> *I just don't want the situation where I feel like I'm alienating a student because they don't have a laptop or a computer at home. So, um, yeah, I've found that kind of tricky, because I know there's, there's one or two in both classes and is it fair to set homework that they can't do? (Teacher C)*
>
> *… for the Leaving Certs, … I think we almost had tears ourselves from just trying to get them to homework at home and coding and you get kind of, well the big thing is obviously some of them don't have a computer at home that they can sit and work at. Some of them only have iPads or phones. So again, the equipment, the technology is a problem there. (Teacher F)*
>
> *Not all my students have broadband at home ... or Wifi. That is an issue. Not all my students have a device at home… city kids who can go to a library even if they don't have these things at home they can access it more freely than a student [in a rural area] can (Teacher B)*
>
> *Some of them have iPads at least, but others don't. So, they've nothing at home. They've no iPad, no computer. They've got their mobile phone, you know, but you can't exactly do the coding on that, you know, so they're doing nothing at home. They've no textbooks to study from you know,*

> *you can't expect a parent to say sit down there and open that book or anything like to them because there's nothing to open. (Teacher J)*

> *… homework is an issue and one of the reasons why homework is an issue for me in this school is that, one of the first things I ask the students is, does anyone have a computer at home. And a few years ago, I would have got a better response, with laptops and all this kind of stuff. There was a big push you know parents would say, well, if they're going to study properly, you know, maybe they should have a computer and they'd put a lot of money towards getting it. What you'll find now is ... they'll have a tablet at home or else they are just using their phones. (Teacher G)*

As well as the access to suitable digital resources at home to complete homework, the shift from traditional paper-based exercises to online, collaborative group projects appeared to be a challenge for many students as they did not associate computer use as 'real' work. The opposition to this change was apparent in the teachers' comments where some indicated that students were inclined to successfully complete pen and pencil assignments, but there is less success with students completing online assignments. Teachers are overcoming this struggle by focusing on theory for homework assignments;

> *… every time I give them a written assignment, pen and pencil, they all come in with a done. If it's on a computer, which should be easier, they don't do it because they don't remember it. They don't consider it real homework. Do you know what kind of way? Or they go on to the computer and then they get distracted on YouTube and then they go to bed and they realize they never did it. … it's a very new thing doing video lessons and they have not like clicked into the routine of doing it. (Teacher E)*

> *I suppose a lot of what they've had as homework has the more theory end of it. (Teacher B)*

One teacher recognised the importance of practice for programming and highlights that if students didn't receive and complete programming homework, they became forgetful about programming fundamentals very quickly;

> *… they need to actually be doing homework because I've definitely noticed that students hit the IF-ELSE plateau… they get to a stage where they're forgetting stuff as quickly as they are revising it in lessons… they don't do their homework and they're not exposed to enough Python. Every time they go to sit down to write a program, they relearn how to do an IF-ELSE statement. (Teacher E)*

In terms of addressing the lack of technical infrastructure at home, students in one school stay after school to complete group project work. In this instance, this activity is considered a positive replacement for traditional homework;

> *So we found the projects are the best way. We've actually have kids now in 5th year who stay back after school to keep working on their project, you know, which means that they're, it's almost, it's better than homework because they're actually, they're there hands on doing something. They're working as a team, they're figuring it out. So, yeah in terms of homework, it's not as, like, we wouldn't generally bother with too much written homework because, you know, you're just not gonna, well it's not even, it's very hard to prepare written work for Computer Science, barring obvious definition stuff (Teacher F)*

> *The homework has been very, very tricky they really, I suppose because most of the time they are doing their ALTs, I'll tell them to work on the reports at home. But then the group projects, it's very difficult to get them to do that at home. (Teacher L)*

To summarise this section, it appears that for some teachers, technical support was a challenge as they either had to undertake the responsibilities themselves or did not enjoy the freedom to make changes to accommodate their own technical requirements for the subjects. Suitable computer hardware did not emerge as an issue but access to a dedicated CS room did limit some teachers' abilities to have a dedicated project space for their students. The most significant issue to arise in relation to technical infrastructure related to some students' access to suitable computing devices at home.

5.6 The Professional Development programme

As mentioned earlier, the PD programme consisted of several components, which provided opportunities for teachers to learn, interact and collaborate in both formal and informal ways. This section outlines the teachers' reported experience of these key elements from both the teacher questionnaires and interviews and also from the Slack user data logs that recorded the teachers' use of the online platform.

5.6.1 Workshops

During the analysis of the teachers' questionnaire it was reported that, while teachers participated in all aspects of the PD provision, the national workshops and skill development workshops were the most frequently attended PD elements. The teachers also ranked these face-to-face elements as the most useful elements of the PD provision (see Figures 10 and 11 below).

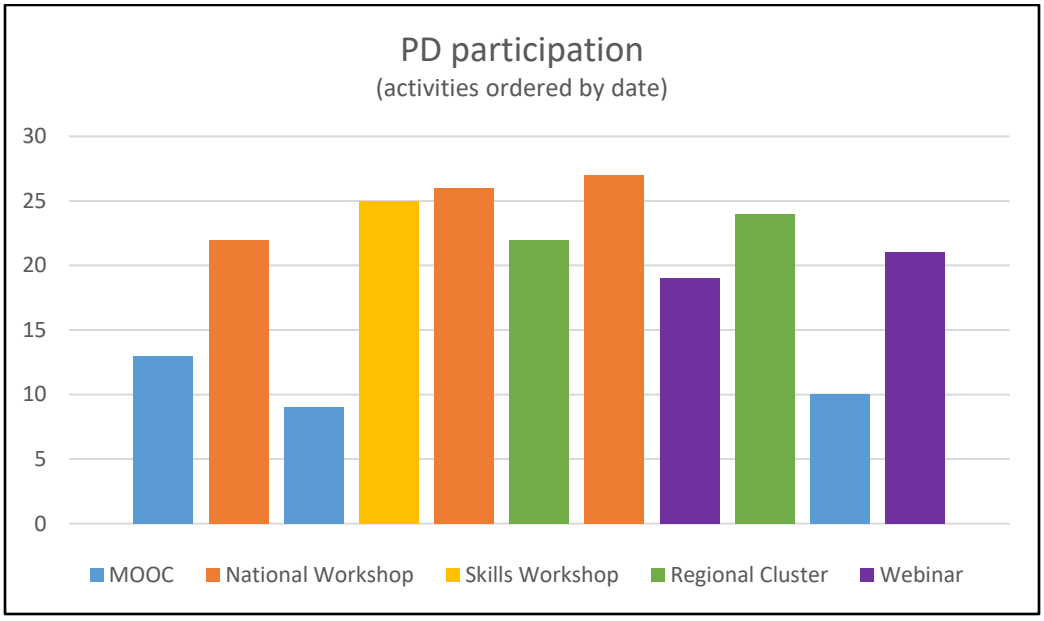

Figure 10 - PD participation (teacher questionnaire May 2019)

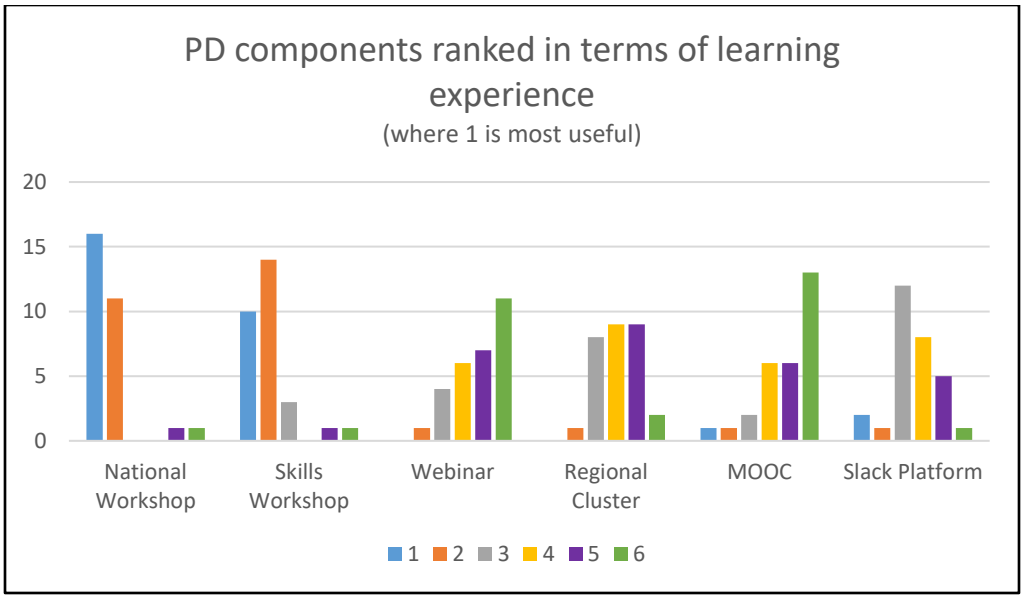

Figure 11 - PD components ranked (teacher questionnaire May 2019)

These preferences reported in the teacher questionnaires were also echoed in the teacher interviews, where the teachers reported a very high level of satisfaction with the workshops, as the sample of interview excerpts indicate;

> *The workshops are by far the best. (Teacher G)*
>
> *I have to say, I've definitely learned far more at my national workshops and learnt from talking to other people definitely on that, I have to say it's refreshing, kind of going to these [workshops] where they are a bit more collaborative and people are you know really supportive ... (Teacher B)*
>
> *I have to say they're great [the workshops] … I'm full of trepidation when I get down especially to Athlone… but once I'm there, it's fine because everybody's going through the same thing. (Teacher K)*

The workshops appeared to be favoured by the teachers for a number of reasons. The emphasis placed on developing the teachers' competence in CS and preparing them to teach the subject were two of the reasons provided, as the following two interview excerpts highlight;

> *… you know a group of students and you want to be confident in what you're doing but I wouldn't be fully confident in what I'm doing. I'd be worried at times that I don't know enough. So that's where the skills workshops really are needed with the PDST. (Teacher A)*
>
> *Um, I suppose like the first two ALTs, I felt the support was really excellent, you know and getting started with Python and all, for ALT1 I found myself a bit more lost … (Teacher C)*

In addition to the focus of the workshops, as they were residential, they provided an opportunity for teachers to escape from their day-to-day activities and immerse themselves completely with the course content and meet with their peers. These off-site elements were also valued;

> *… when we go up for the skills in Athlone, that's brilliant because, I'm taken away from all my other stuff that's going on in school and at home of course as well and when I'm there, I, you know, you can fully immerse yourself in. And so that really works for me. (Teacher C)*

Notwithstanding the very positive evaluations of the workshops, it became clear during the interviews that teachers had different and often conflicting priorities on both how the national workshops should be delivered and what the content of the workshops should be. In relation to the content of the workshops, some teachers also expressed a preference for the workshops to focus on developing their content (practical) knowledge;

> *I think one day of going through all the pedagogies that are available … is enough. We're teachers, we go research it ourselves and do you know what every one of us are facing a different classroom every day, different types like and it's not going to work for all of us … more practical base knowledge would have been way better. (Teacher D)*

However, given the diversity of the group, other teachers with more knowledge of CS, but less experience of teaching it, preferred the pedagogical elements of the workshops. This 'balancing act' for the PDST team was recognised by one teacher who observed that;

> *... some people are coming in like me ... they've got more technology and not so much on the teaching side and other people have got way more experience in the teaching and not so much on the technology side. So, I guess it's difficult to try and get that. But I think the balance they've had has been quite good, you know. (Teacher I)*

In relation to the pedagogical mode of delivery of the workshops, again reflecting the diversity of the group of teachers and their different priorities, some enjoyed a 'hands-on' approach whereas others preferred to be given examples of pedagogical approaches in a more didactic non-experiential way, as these two different perspectives indicate;

> *We normally break into our breakout groups and we do, we do little projects ourselves. We do it as if we are the students and that's fantastic because that's what we need to do… Because unless we know we can do it, I don't know how we're supposed to teach it. (Teacher L)*

> *Or so when you have your CPD, like they often treat you like students so they'll put you into the group and they'll get you to do the activity rather than, I'd prefer to just kind of talk about things in more abstract terms of, you could do it this way, this way or this way, this activity you could use for this or this. So, I mean CPD days are kind of valuable. You're not going to get too many. So, you always like to get as much in there as you can. (Teacher H)*

So, while the workshops were considered to be the most beneficial for the teachers, there were different preferences expressed both in terms of their focus (either on acquiring further knowledge of CS or developing pedagogical knowledge in CS), and different preferences in terms of how they should be delivered (as either very participative and experiential or as more informative and non-participative). It must be noted however, that this dichotomic representation of content and pedagogy is an artificial divide that does not recognise the complex and inter-connected nature of teachers' PCK.

5.6.2 Slack Platform

As Figure 11 has previously highlighted, while the teachers rated the Slack platform as helpful, it was not ranked as one of the highest components of PD infrastructure. The analysis of the Slack platform user data from year one, found that the use of the platform varied significantly across the users. For example, the top five users (two of whom were part of the PDST team) generated almost 60% of the posts while the bottom ten users generated only 1% of the posts and could, therefore, be classified as 'lurkers' (see Figure 12).

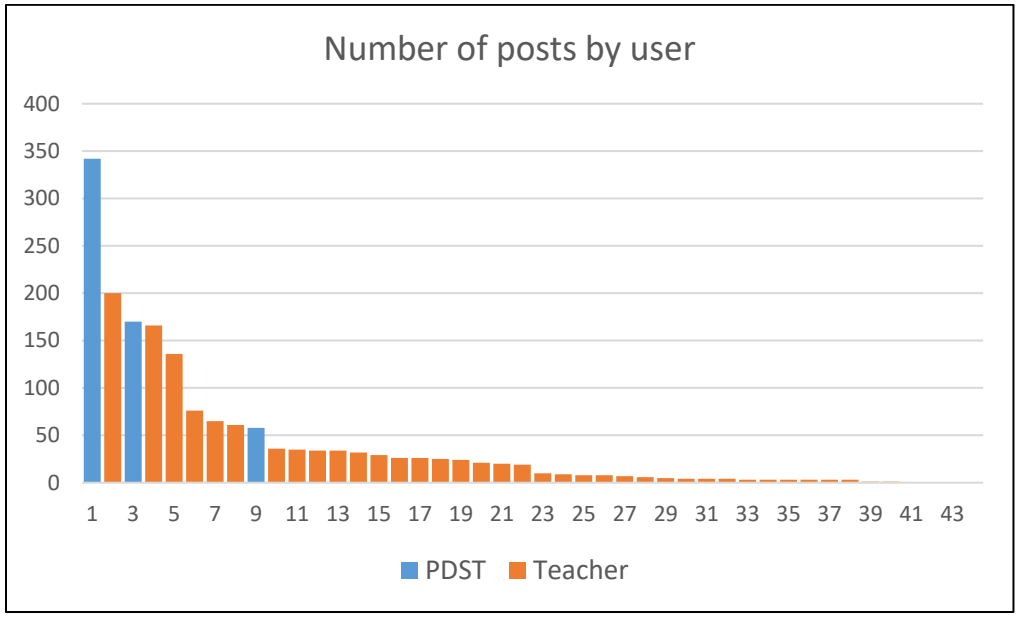

Figure 12 - Slack posts by user (data extract May 2019)

It also emerged from the analysis that the majority of posts to the platform were short contributions, again indicating that the majority of teachers used the platform to share/access resources rather than as a forum for discussion. (See Figure 13)

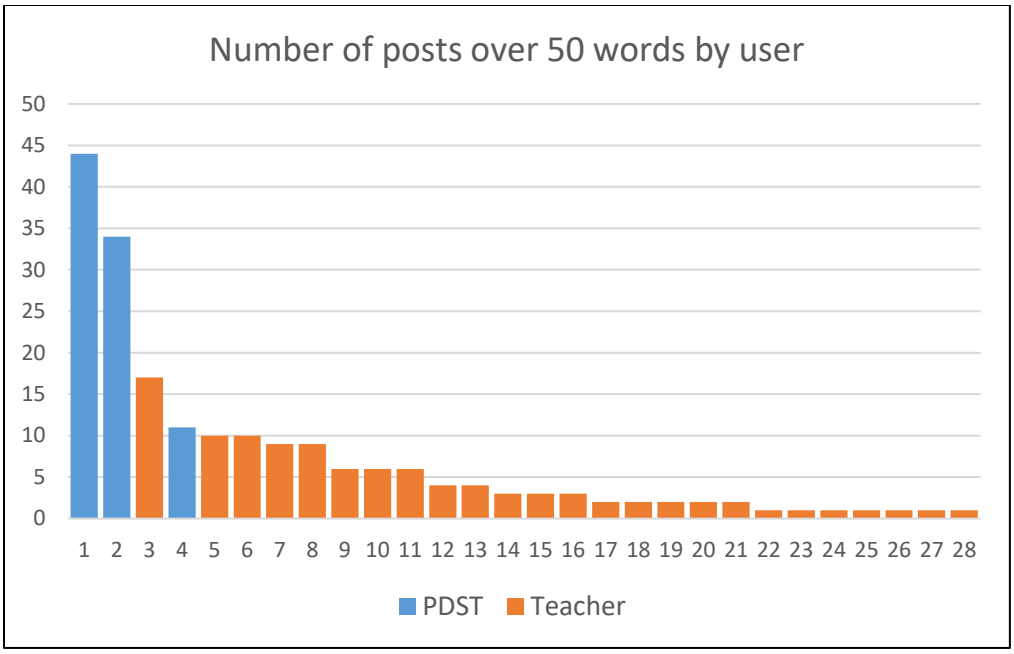

Figure 13 - Slack posts over 50 words by user (data extract May 2019)

This finding was also evident during the questionnaire analysis at the end of year one, when teachers were asked to rank their use of the platform and they reported that they primarily used it to view and access material (see Figure 14).

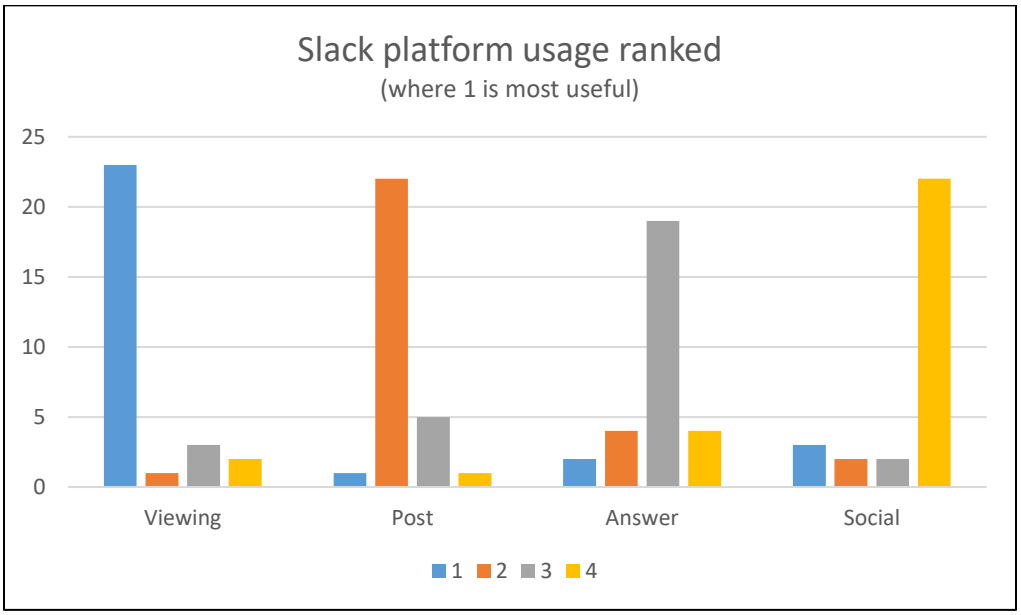

Figure 14 - Slack platform usage ranked (teacher questionnaire May 2019)

The comments made about the Slack platform by the teachers during the interviews reflected this pattern of usage. The teachers reported that they used Slack for general communications to *'make sure they're kept up to date with what's going on nationally or just to keep up to date with workshops and stuff'*

(Teacher A). They also felt that if they posed a question, they would get an answer from the other teachers or the PDST team, but there were varied responses regarding the posting of other resources on Slack.

Some of the teachers were very positive around the sharing/viewing of resources, although they ranged from active to passive participants;

> *Slack was probably the most useful in that, like it was an opportunity for teachers to share resources pretty well (Teacher F)*
>
> *So, Slack is kind of good for bridging that gap. … there are definitely things put up there that have been life savers and even just for communicating problems and checking these kinds of things (Teacher H)*
>
> *I think the Slack has been great as well as even though I don't get a lot of time to post stuff up in myself. I find some of the information we get from Slack is very, very useful for sharing amongst teachers. (Teacher I)*
>
> *Slack is great. I just thought the interactive thing about Slack is great. People are putting up stuff all the time, which you can use and not use. And it's a really rich resource. I'll go in there periodically and it's like, fantastic, great. (Teacher K)*
>
> *I could spend half an hour Googling this and never find it but if I put it into Slack, somebody will remember like so. (Teacher L)*
>
> *I keep in touch and I see what's going on. I will rarely contribute. But the fact that it's there and that it's out there and there are people coming up with things that can be quite reassuring. (Teacher G)*

However, other teachers were overwhelmed with Slack and have disengaged from it;

> *Slack, um, yeah, so it can be good and I know like certainly when I ask a question I get a lot of help, but sometimes I feel a bit overwhelmed by what's going on and a bit inadequate, I suppose, you know, people are talking about things and I don't know what they are talking about, so you can, you know, it's very easy to think I don't know what I'm talking about or what I'm doing. So sometimes I just kind of, I don't go on to that much for that reason. (Teacher C)*
>
> *The Slack stresses most of us out. Um, because there's just a bit of showboating going on on it and it can just put you into a complete state of panic. It did anyway for the first few months a few of us were like, what are they talking about and it just sent us into a tizzy. So a lot of us kind of disengaged with Slack and we have our own WhatsApp group to support each other. (Teacher A)*

While there were mixed views expressed by the teachers, the Slack platform has proved to be an important part of the overall PD architecture as it was seen as very useful communication and resource sharing tool. Even though there were significant variations in terms of how it was used by teachers as a central repository of information and advice, it appeared to play an important role in the overall delivery of the PD.

5.6.3 Regional Cluster Meetings

The results from the teacher questionnaire at the end of year one indicated that the teachers reported the regional cluster meetings as helpful but not as helpful as the national workshops/skills development workshops or Slack (see Figure 11). In general, the teachers reported mixed views regarding the regional cluster meetings and these views may relate to the extent to which the groups had 'gelled'. For example, in the teacher interviews, one teacher described the meetings as 'brilliant' and added that they used their own cluster channel on Slack to collaborate. A couple of other teachers highlighted the benefits but one raised the possibility of using Slack for these conversations instead. Language such as 'grand' and 'nice' used to describe them by some of the teachers suggests that while they were of benefit, they did not appear to be critical in the overall PD framework;

> *They're grand, again most of the time you're just making sure everybody's on the same page and just kind of having a chat, they're nice but you'd probably get away with Slack if people were chatting more on Slack (Teacher L)*

In summary, the regional meetings were seen as helpful but not critical and indeed there was evidence from the teacher interviews that some of the teachers had established support groups through platforms such as WhatsApp that were not regionally based but rather on the teachers' level of experience or their relationship with other colleagues.

5.6.4 Additional peripheral elements

The other elements of the PD framework, which included the webinars and MOOCs did not feature significantly in the teacher interviews when asked about the PD. This reflects the relative value of these when the teachers were asked to indicate the educational value of the various elements in the teacher questionnaire (see Figure 11). For example, the MOOCs were only mentioned by two of the teachers in the interviews. Webinars were also rarely mentioned but when they were, while the teachers were appreciative of the new knowledge they acquired from participating in them, they questioned how they could transfer this knowledge to the classroom.

In relation to the CompSci resources website, the teachers were very appreciative of this resource, '*CompSci like it's a brilliant resource and we're all sharing resources and putting everything up on that' (Teacher B),* however, there were requests from some teachers for more classroom ready content and activities;

> *For this to be a real success, I think resources need to be seriously looked at. I think there's just too much pressure on teachers, because it's not our only subject as well so the department need to be mindful of that. (Teacher A)*

> *We need content and we need ideas and activities around the content. (Teacher A)*

In general, these views suggest that amongst the teachers there was a preference for 'classroom ready' resources and professional development, which may explain the preference for other elements of the professional development framework.

5.6.5 Additional voluntary support from other agencies

Additional support, external to the original PD infrastructure, was also provided by interested experts often from 3rd level institutions. These appeared to provide a significant amount of support to the teachers involving both face-to-face PD sessions and on-site school visits. This appeared to help teachers further develop their CS competence and confidence;

And then in my own time… I go to a lot of his [third-level lecturer] workshops. It's been very useful to kind of fill in say some of the gaps perhaps, because Python would have been good, but things like databases would have been a big, big jump. (Teacher H)

But I'm hoping that if I can get to a stage where I have the ALTs done, even if they're not properly working, that he [third-level lecturer] might be able to come in and show us where we might have gone wrong. (Teacher D)

So for example, this week we had one of their lecturers who does a module for their undergrads on the internet of things so in terms of programming micro:bits and stuff… what [they] have done, I have to commend them for it. It's really good. (Teacher G)

One teacher suggested that a regional mentoring system could be introduced where schools could avail of team teaching or class observations. He suggested the panel could be made up of Phase 1 teachers or third level researchers/educators/teacher trainers.

There was also evidence that the schools were harnessing the support opportunities made available by local industries and businesses. The subject is being rolled out a time where there is a prioritisation of STEM education in schools and could possibly benefit from this.

5.6.6 Summary of PD comments

In summarising the teachers' views of the professional development provided, there are a number of key issues to emerge. Firstly, the national workshops were the most valued part of the PD infrastructure with the teachers valuing the relevance of the content and the collegiality of the events. The Slack platform provided a helpful repository of resources and advice for the teachers and the regional cluster meetings were viewed as helpful but did not appear to be a critical part of the PD framework. The other elements of the PD, including the MOOCs and webinars, did not feature prominently in the teacher interviews or questionnaires and while seen as helpful did not appear to be central the teachers' experience of the PD programme. Additional supports from third level and industry advocates in the area of CS in schools were seen as a help to the teachers' professional development and particular external individuals were praised for their support of the teachers. That being said, this should not take away from the esteem and gratitude directed towards the members of the PDST team that were also highly praised, as the following teacher comments from the interviews highlight;

I suppose, yeah, it's important to say I do feel supported by the other teachers and certainly, um, Tony and Frank and Joe, yeah they're excellent. (Teacher C)

I think what the PDST have put together the Joe and Frank and Tony show is absolutely brilliant. (Teacher G)

PTSD, especially can't, I mean I can't praise Joe and Frank enough. Excellent. Tony as well. (Teacher K)

I'm very happy, like the official PDST stuff has been very good. It's very necessary, like I dread to be a teacher in phase two now if you weren't getting something similar (Teacher L)

5.7 SUMMARY OF KEY FINDINGS

- Participating schools were geographically dispersed throughout both rural and urban settings and reflected the broad range of school types and sizes in Ireland. The questionnaire results

from Stage 1 of the study found that less than a third of the schools reported offering the Junior Cycle short course in Coding (31%) and the short course in Digital Media (21%).

- The questionnaire also found that, of the 29 teachers that participated in Stage 1 of the study, this group was generally experienced, with over half having more than ten years teaching experience and only 17% having less than five years teaching experience. 38% of the teachers were female and the vast majority of teachers had previous experience teaching ICT or providing ICT support in their schools.
- The general shift towards more project-based, student-centred learning was commented on as one of the biggest characteristics of the new subject which brought challenges for some teachers and students. The greatest challenge for teachers related to the teaching of the specific subject and attempting to gauge the appropriate pacing of the subject and the depth of treatment required for particular topics. Catering for the range in students' previous experiences and interests of their classes was also reported as a challenge. Despite these challenges, when talking about their practice, the teachers' comments showed evidence that they were reflecting on their practice and had made many changes to how they approached the teaching of the subject based on their experience of the first year of the subject.
- Students enjoyed the applied nature of the subject and the real-life application of the tasks provided, but the novel pedagogical approach, requiring more self-regulated learning skills, was a challenge for some students to adjust to. Many of the students reported acquiring other skills beyond CS knowledge from studying the subject. In particular, they identified how they were able to apply the problem-solving skills, acquired in the subject, in other settings. Concerns about their performance in the Leaving Certificate examination was also mentioned.
- The level of female participation in the subject was low and this was recognised by many of the teachers, principals and guidance counsellors. There was an acknowledgement within the schools that female participation needed to be increased and that a wider range of students should be encouraged to undertake the subject (particularly beyond those wishing to pursue careers in CS). Despite this recognition, some comments by the teachers and school leaders suggests the presence of an implicit bias. Some teachers' comments showed an unconscious leaning towards traditional perceptions of the subject that associated it as a 'difficult' subject suited to particular students with an 'aptitude' for it. These perceptions were not evident in the students' comments.
- Teachers reported that the schools had adequate levels of computer resources to deliver the subject, but some had raised concerns about the level of technical support provided and the need to have a more suitable room to facilitate project work and group-work. Some teachers raised concerns about some students' level of access to suitable ICT resources for home study.
- In relation to the PD provided, the national workshops were the most valued, but differences emerged in relation to what they should focus on reflecting the heterogeneous nature of the group. The Slack platform provided a helpful repository of resources and advice for the teachers and the regional cluster meetings were viewed as helpful but did not appear to be a critical part of the PD framework. The other elements of the PD, including the MOOCs and webinars, did not feature prominently and while seen as helpful did not appear to be central the teachers' experience of the PD programme. Additional supports from third level and industry advocates in the area of CS in schools were also seen as helpful and the PDST team were highly praised.

6 DISCUSSION AND RECOMMENDATIONS

6.1 THE COHORT OF TEACHERS, TEACHER SUPPLY AND OUT-OF-FIELD TEACHERS

The teachers participating in the Phase 1 roll-out had a good level of ICT skills and knowledge with many having experience of teaching ICT and some also had experience of teaching coding. This first cohort of teachers reflect the pioneering teachers of CS that have been found in other countries. For example, Cutts et al. (2017) describes a similar cohort of CS teachers in Scotland noting that the teachers were often from a different subject, were self-taught in CS and largely learned to teach CS through trial and error. Being a cohort of teachers that have had an interest and commitment to CS for a long time, they may not reflect future cohorts of out-of-field teachers that opt to teach the subject. Future teachers may have lower levels of subject knowledge and pedagogical experience of teaching coding and CS and therefore professional development may need to take this into consideration. This challenge is likely to be offset somewhat by the presence of an established subject where completed projects by previous students can give teachers an indication of the level of competence expected in the subject. The uncertainty in relation to the pacing and scope of the subject emerged as a challenge throughout this study for the participating teachers, as since the programme was in its first year of implementation, there was uncertainty in relation to the depth of treatment of the various topics of the subject.

Staying with the theme of professional development, the issue of teacher supply emerged as a concern in the principal interviews where participants raised concern about the sustainability of the subject where its delivery is dependent on a single teacher in a school and where the availability of replacement teachers is a challenge. Looking at other countries, and in light of the substantial salaries that can be achieved in the computer industry, it is unlikely that there will be a significant supply of CS graduates directly into teaching. For that reason, the professional development of out-of-field teachers will likely be the main way in which CS teachers are prepared. While undergraduate programmes offering CS have now been launched by the various teacher education providers in Ireland, it is too early to determine whether they will supply a sufficient number of graduates to support the growth of the subject. Therefore, as out-of-field professional development will likely play an important role into the foreseeable future, the professional learning community established by the PDST team will prove to be an important vehicle to advance this agenda into the future. The professional development requirements of existing STEM teachers, who may have some grounding in CS principles, may differ from teachers of other fields such as Arts and Humanities where they are likely to have had limited experiences of CS-related topics. However, it must also be noted, that there are benefits to including teachers from non-STEM backgrounds as they can offer alternative perspectives and pedagogies to the teaching of the subject and facilitate collaboration and linkage to other subject areas not traditionally seen as related to CS.

Recommendations:

1. Student project work that exemplifies the scope and diversity of the subject should be showcased into the future to: (i) demonstrate a standard of expectation for project work in the subject, (ii) encourage uptake amongst students, (iii) promote the subject to the wider public.
2. In attracting teachers to take on the subject in schools, efforts should be made to encourage teachers from non-STEM backgrounds to consider taking on the subject.
3. Develop a mechanism through which participation and successful completion of the professional development programme for CS teachers delivered by the PDST could be recognised by the

Teaching Council as part of the application process for recognition of an additional curricular subject.

6.2 PERCEPTIONS OF THE SUBJECT – THE DISCOURSE OF 'APTITUDE'

As CS is a new subject in Ireland with no previous history in schools, there is an opportunity to avoid the traditional gender stereotyping and negative perceptions that hinder the uptake of other STEM subjects (Kelly et al, 2019); however, despite the impressive percentage of female teachers, the early signs are that this stereotyping and the negative perceptions appear to be already present. For example, as the data presented in the findings highlight, the level of female participation is low. Further still, from the interviews with the teachers, principals and guidance counsellors, potentially damaging discourses were prominent in the views expressed about the subject. These relate to how the subject is perceived, and as a result, what 'types' of students are best suited for the subject. These discourses draw on traditional and outdated stereotyped views of the subject and have the effect of framing the subject for certain 'kinds' of pupils. Reference to having an 'aptitude' for CS was frequently mentioned. In fact, in one of the participating schools in Stage 2 of the study, an aptitude test was used to select students for the subject. The authors are not aware of the use of aptitude tests to determine suitability for any other Leaving Certificate subject and therefore question this policy and the long-term impact such approaches are likely to have at a school and wider level.

The language of 'aptitude' can create an elitist view of the subject creating a perception that it is suitable for a minority of students with an aptitude and interest in specific CS careers. Such an outdated view of CS disregards the broader reach of CS in all areas of life and work and the impact that digital technologies have throughout most careers in the 21st century (McGarr & Johnston, 2020). Although programming is certainly an area that has caused difficulty for some students (Lahtinen et al, 2005), it would be wrong to classify the new Leaving Certificate CS subject as only for 'brighter' students. As computing and technology has become a large aspect of all our lives, the CS curriculum should not be considered exclusively as a pathway to employment in the computer industry. Whilst acknowledging its role in attracting student to consider careers in this area, it should primarily be seen as an opportunity for any student to gain a deeper understanding of the role of CS in the world in which they live. For example, the role of Leaving Certificate Economics is not to create a generation of economists but to broaden and deepen a student's understanding of the world they live in. With ever-expanding notions of what it means to be 'literate' in the 21st century, the extent to which knowledge of CS principles and practices forms part of this understanding of literacy needs to be considered by the wider educational community. Such debates can help dampen such potentially damaging discourses.

Allowing such a discourse in relation to CS to develop in the schooling system not only limits the number of students that are likely to consider opting for the study, but it also highlights a wider lack of recognition of the pervasive and critical role CS plays in all areas of life. While teacher professional development will be an ever-present challenge to the ongoing development of CS in schools, the framing of the subject in this narrow way is perhaps the greatest threat to the long-term success of the subject in schools. For that reason, this is an issue that needs to be addressed as the roll-out in schools continues, particularly amongst principals, guidance counsellors and parents who play a significant role in influencing students' subject selection and subject groupings on the school timetable. The researchers are nonetheless aware of the paradox in relation to the subject status and perception. For out-of-field teachers taking on this new subject, the status and prestige of the subject is important for the teachers to identify with it. For

that reason, they may in the future unknowingly encourage and promote an elitist language associated with the subject to elevate its status. In the long-term, however, such language can have the effect of reducing participation in the subject, ultimately threatening its viability within individual schools. For that reason, teachers of the subject need to be equipped with alternative (more inclusive) language to promote their subject, and thus elevating its status, to ensure that they do not, unknowingly, limit student uptake through their talk and actions. To that end, the activities that focused on challenging the teachers' perceptions of the subject, that were undertaken with the participants as part of the professional development programme, could be extended to the wider group of stakeholders in the process, particularly school leaders to address these issues. In addition, the emphasis of reflective practice as part of the professional development programme could be used as a vehicle to enable teachers to interrogate their assumptions in relation to this area throughout the professional development programme and throughout the subject's roll-out in schools. Teachers should, therefore, be empowered to take a more proactive role in widening participation within their schools, specifically targeting student cohorts that would not traditionally opt for such a subject.

Recommendations:

1. Further work should be undertaken in relation to widening participation within the schools, specifically targeting students of all cohorts and levels, particularly students that would not traditionally opt for such a subject. The reflective practice cycle of inquiry used in the professional development is an ideal vehicle to achieve this amongst the participating teachers. In particular, further work should be undertaken in relation to the promotion of the subject in schools to address the perceptions of all stakeholders (i.e. school leaders, guidance counsellors, teachers and parents) that can limit female participation in the subject.
2. Schools should consider how the subject is scheduled and what subject offerings CS is grouped with in order to avoid further gender stereotyping of the subject.

6.3 PEDAGOGICAL CHALLENGES

In line with the international research literature in the area of CS in schools, teachers reported challenges in implementing the subject. This is to be expected as all out-of-field teachers initially struggle with taking on a new subject where they are unfamiliar with both the content and the pedagogies associated with the subject (Menekse, 2015; Yadav et al, 2016). The shift to a more project-based student-centred approach, as required for the ALTs, was a significant shift for some teachers. While managing and facilitating this more self-directed learning may have been a change in their practice (compared to other subjects they taught), the students' comments in the interviews highlighted that the teachers had embraced this new pedagogical philosophy and had created student-centred problem-based experiences for their students.

While the teachers sought more 'classroom-ready' resources, much of the challenges faced by the teachers appeared to be overcome by classroom practice and learning from it; reflecting the critical importance of teachers professional classroom practice in developing pedagogical knowledge (Cochran-Smith & Lytle, 1999). For example, in visiting the schools in the second stage of the study, some of the teachers were eager to show examples of their 5th year students' work rather than their 6th year student work and acknowledged that they had learned a lot in the first year of the roll-out of the programme. The focus on reflective practice by the PDST team was important in this regard given the important role it can

play in developing teachers' PCK (Loughran, 2004). The unique pedagogical knowledge and expertise developed by this Phase 1 group will be a powerful resource for future teachers taking on this subject and over time the expertise of the group is likely to develop further. The PDST's plans to link this now experienced group of teachers with new teachers into the future will be of enormous benefit in this regard.

While much of teachers' PCK is developed through reflection on professional classroom practice and interaction with colleagues, there were a number of challenges outside the teachers' control that are worthy of note. For example, it was noted by a number of teachers that their subjects were timetabled for single (40-minute) lessons. While this may be necessary for wider logistical reasons at a school level, such short periods of time do not facilitate the type of project-based learning that the subject aims to promote and can result in a 'splash and dash' type exposure to problem-solving rather than a sustained engagement with problems. This type of timetabling also seemed to contribute to the artificial demarcation of theory and practice where 'theory' was addressed in shorter lessons whereas practical work was assigned to 'double' lessons. This dichotomic way of perceiving the subject may also reflect the teachers' level of PCK, in that they have a limited understanding of how theory and practice can be addressed simultaneously through carefully designed tasks and teacher input. It may also have been a result of the teachers' concern over the final Leaving Certificate examination and the need to 'cover' all the relevant material. In this regard, one can see a tension between the more project-based pedagogy of the subject specification and the need to prepare students for the high-stakes nature of the Leaving Certificate examination.

In addition to these pedagogical challenges, technical support and classroom layout and access also emerged as an issue in some of the schools. In relation to technical support, for some schools that did not have adequate technical support, the teachers were often expected to fix technical problems. Whereas in other schools, that had contracts with external providers, the teachers did not have the autonomy to address minor technical challenges themselves that needed to be addressed relatively promptly. Classroom layout and access was also reported by some teachers as the rigid linear layout of some classrooms did not facilitate the type of group-based work frequently called upon as part of the subject. In addition, sharing the room with other teachers also caused some challenges as classrooms had limited space to store ongoing project work. Therefore, while the level of technical infrastructure was more than adequate to cater for the subject in the participating schools examined in this study, wider timetabling and resourcing issues need to be taken into consideration in some school settings to maximise the learning experience for students.

Recommendations:

1. Further work needs to be undertaken as part of the professional development of the teachers to deconstruct the artificial demarcation of theory and practice that was evident in the teachers' comments.
2. Continue the establishment of the teacher mentoring scheme where experienced teachers from Phase 1 can mentor new teachers.
3. In offering the subject, schools should aim to timetable the subject in double class periods, and as much as possible, avoid single period timetabling of the subject.

4. Schools should also consider the accommodation requirements of the subject and the extent to which existing facilities can cater for more collaborative project-based learning that includes unplugged activities and adequate space to store equipment and project work.

6.4 ACCESS TO SUITABLE TECHNOLOGY RESOURCES IN THE HOME

Staying with the issue of technology resources, as the study has previously mentioned, the level of technical infrastructure in the schools appeared to be more than sufficient to cater for the subject. This is to be expected given that the schools had applied to participate in Phase 1 and therefore had the necessary technical infrastructure to take on the subject. However, it emerged in the study that many teachers expressed concerns about some students' access to suitable technology in the home to practice coding. Schools have made great progress in the past number of decades to address the digital divide by building the technical infrastructure in schools to ensure that all students have access to technology to develop their digital competence. This study, however, has exposed the challenge of addressing this inequality in the home, where the ability to address the digital divide is beyond the reach of the school. While the teachers reported that the students had access to smartphones and tablet devices, it appears that many did not have access to a traditional desktop or laptop computer that would have been a more appropriate technology. If ownership of such a device is required for students to succeed in the subject, and these devices are becoming less common in the home due to the dominance of portable handheld devices, this raises issues of equality of access. If students are advised to purchase hardware that is beyond the reach of some families, a school-based borrowing scheme could address this inequality. The cost of such a scheme could be reduced further through the sourcing of alternative low-cost devices that are now available for the education market.

Recommendations:

1. The DES should consider recommending a specification for a basic laptop or a compatible low-cost device that would fulfil the criteria (in a similar manner to scientific calculators).
2. Schools should consider a rental/borrowing scheme for students that may not have appropriate access to suitable hardware technology to practice coding and continue project work in the home.
3. With greater use of learning management systems in schools to link school and homework, appropriate internet access is required for the student to fully participate in the subject. While this cannot be guaranteed, schools need to take this into consideration when delivering the subject to students that do not have appropriate access.

6.5 IMPORTANCE OF PRE-REQUISITE ICT KNOWLEDGE AND SKILLS

As the findings have highlighted, teachers reported challenges dealing with the diverse skills and experiences of their students. While some students had completed some coding experience prior to senior cycle, there was a considerable level of variation amongst the students. Hence, it is not surprising that many of the students did not have an understanding or experience of CS content. While it is expected that students beginning a Leaving Certificate subject will have varying levels of past experience, it was not anticipated that some students lacked basic ICT skills. These fundamental ICT skills are important for all students but are of even greater importance for students opting to study CS at Leaving Certificate level where one would expect that students have basic skills of file management and information retrieval. For that reason, schools need to ensure that all students have adequate exposure at Junior Cycle level to ICT

practices where appropriate digital literacy skills can be developed. There is a misconception that younger students, being born into a digital world, have the necessary ICT skills, however, the skills they possess are often quite narrow in their focus and a result of engagement with very specific digital practices such as social media use or games consoles, thus largely dispelling the myth of the digital native (Selwyn, 2009). The absence of these important basic ICT skills was evident in some teachers' classrooms where the teachers reported having to teach basic skills such as file management and retrieval at the start of the year to some students. This challenge was exacerbated by the fact that other students had experience of coding and had more advanced levels of digital competence. While it is acknowledged that students' level of digital competence may improve as greater levels of digital practices develop from primary school level onwards, one cannot assume that all students presently have a minimum basic threshold of ICT competence.

In addition to the study highlighting the importance of ensuring that students have the necessary pre-requisite ICT skills, it has also highlighted that they are not the only pre-requisite skills that can benefit students. As the subject is underpinned by a strong social constructivist philosophy that emphasises the importance of independent learning and problem-based approaches, prior knowledge of such pedagogical practices is perhaps the most important prior skills needed by students. Our analysis of the data has to some extent highlighted the importance of pre-requite pedagogical experiences as much as pre-requisite content knowledge and skills. For this reason, the debate as to whether students need to have completed a pre-requite Junior Certificate equivalent of CS or coding does not appear to be a critical issue. While exposing students to coding at lower secondary school level has many benefits for the uptake of CS at Leaving Certificate level, what appears as important is that the students have basic levels of digital competence and important teamworking skills and self-regulated learning skills to engage effectively in the subject.

Recommendations:

1. While the short courses in coding or digital media should not be a requirement for the study of Leaving Certificate CS, schools must ensure that all students have basic pre-requisite ICT skills.
2. The teaching of self-regulated learning skills should be integrated into the teaching of the subject to equip students with the skills to engage in the independent study that will assist them in mastering this subject. This focus can also address the problems experienced by some schools in relation to students' engagement with homework and independent study.

6.6 The Professional Development programme

In their review of 35 methodologically rigorous studies demonstrating a positive link between teacher professional development and student outcomes, Darling-Hammond et al (2017) found seven widely shared features of teacher professional development. They included a content focus to the professional development, the use of active learning, emphasis on collaboration, the use of models of effective practice, the provision of coaching and expert support, the offer of feedback and reflection and a sustained provision. The professional development framework delivered as part of this programme contains almost all these elements and therefore it is not surprising that the teachers' feedback was very positive. For example, the programme was sustained in nature starting in the summer of 2018 and continuing for almost two years. The emphasis on reflective practice throughout the teacher workshops also provided an opportunity for the teachers to reflect and learn from their professional practice (McGarr

& McCormack, 2016). It also placed a strong emphasis on the development of a community of practice which is not only important for teacher professional development but is also particularly important for the professional development of out-of-field teachers who are forming a new subject identity in CS (Ryoo et al., 2015; Hobbs, 2012; Du Plessis et al., 2014). This collaboration is also needed to address the isolation felt by many CS teachers who can frequently find themselves as the only CS teachers in their schools (Yadav et al., 2016; Cutts et al., 2017).

In saying that, the communities of practice did not necessarily develop as originally designed. The Slack platform which was envisaged as an online platform for discussion and debate was used more as a resource sharing repository. In addition, while the regional cluster meetings were valued, the teachers appeared to establish their own support groups based on levels of experience rather than geographical location. Therefore, the establishment of these regional clusters may not be a critical component of future provision as such collaboration and support appear to naturally develop as a result of the teachers' engagement with the national workshops.

In relation to the use of models of effective practice and the provision of coaching and expert support, the teachers' views of the national workshops differed depending on their experience. Some teachers welcomed the focus on understanding the overall subject specification and the different ALTs, whereas others expressed a preference for more specific classroom pedagogy focus. These differences in needs reflect the challenge of meeting the diverse range of experiences and expectations of the group of teachers. While some could be considered out-of-field teachers, as they had come from other STEM subject areas where they had had some previous exposure to CS, others could be considered 'out-of-discipline' in that their core backgrounds in Arts and Humanities did not provide them with a similar grounding in CS. For that reason, it is understandable that there were different needs and expectations from this heterogeneous group. Despite these differences in experiences, the PD programme was still viewed positively by the participants which points to the professionalism and dedication of the PDST team.

Calls for more classroom resources was an ongoing request from the teachers, and this perhaps reflects the immediate needs of the group as they commenced teaching the subject. While the professional development team aimed to address these needs, the ongoing roll-out of the subject will likely generate further classroom-specific resources that will have direct application in the teachers' classrooms. Being the first iteration of the subject, and as it is new to the Irish schooling system, it is not surprising that these resources were not readily available. What is important for future roll-out however, is that these teacher-generated resources are shared widely with new teachers to address the 'praxis shock' (Ballantyne, 2007) that some of the teachers were experiencing. For example, while the teachers welcomed the provision of the MOOCs and webinars, they expressed a preference for resources that addressed the demands of the classroom. As the teachers' experience of teaching the subject develops it is likely that their professional development requirements will also change and that these peripheral components of the PD framework, that explore broader professional issues, may become more relevant.

Notwithstanding the importance of the professional development framework, as the teachers' comments in the findings section highlights, some of the most valuable insights about their pedagogical practice were obtained through their classroom practice and in this regard, it could be argued that any professional development framework can only ever support and scaffold this learning from practice and is not a substitute for it.

Recommendations:

1. Rather than geographically assigning teachers to groups, a more organic formation of communities of practice could be encouraged so that teachers could self-organise by shared interests or stages of professional development.
2. Future iterations of the professional development may need to consider the balance between modelling specific classroom pedagogies and broader curriculum planning at a macro subject and ALT level based on the needs of the teachers.

6.7 EXTERNAL SUPPORT

During the second stage of the study, involving the school visits, many of the teachers commented on the additional support and professional development they had received on a voluntary basis from third-level institutions and other organisations. It is rare in curriculum implementation in Ireland that such voluntary support is provided on both the scale and commitment reported by the teachers. This support reflects the broad enthusiasm and support amongst those in the CS community in Ireland for this curriculum innovation.

Perhaps the most impressive aspect of this additional voluntary professional support was the way in which the PDST embraced the opportunity and harnessed this collective interest in CS to enhance the professional development provision for CS teachers into the future. The CS community in Ireland is a vibrant and collegial community typified by the support provided by CESI and others for this curriculum initiative. This support will undoubtedly sustain the momentum of this curriculum innovation and contribute to a strong professional community of CS teachers into the future.

7 CONCLUSIONS

As the research findings of the study have highlighted, this was a very successful launch of a new Leaving Certificate subject where no previous subject had existed on the curriculum in the past. The dedication and interest of the participating teachers in this first phase of implementation has undoubtedly contributed to the success of this subject launch. However, the comprehensive professional development framework put in place by the PDST, and the quality of the input from the PDST team has also been pivotal to its success.

As the implementation moves into the second phase and incorporates more schools, it will be important to ensure that the promotion of the subject remains a priority and that, in the long-term, the subject does not become perceived as a specialist subject for those 'good' at mathematics or for those aiming to pursue careers in the ICT sector. If it does become viewed in this way, there is a possibility that the subject will be offered to a minority of students.

As the study has highlighted, there is already evidence that female participation is low and that perceptions amongst teachers and school leaders may inhibit wider uptake of the subject. Because of these challenges, the ongoing promotion of the subject and encouragement of all students needs to be prioritised. Further work needs to be done to encourage greater female participation and greater participation amongst students that would not have traditionally considered the subject.

As the student feedback highlights, the wider set of skills and competencies that the students have acquired in studying the subject attests to its universal value for all students. Further still, the ever-increasing reach of digital technologies in society means that an understanding of CS, and how it infiltrates all aspects of our lives, is needed now more than ever. This promotion, both within schools and the wider society, needs to be prioritised in the short-term to ensure that traditional views of the subject do not become entrenched in the educational system, similar to how other STEM subjects are perceived by students.

In relation to further research work, there are a number of studies that could be undertaken arising from this research, they include, but are not limited to:

- Exploring students' experiences of the CS programme and what subsequent career decisions they had made following completion of the course.
- Following female students' journey through the programme (and beyond their schooling) to see what their experiences of the subject was and how it has contributed to their education and career choices.
- Examining the attitudes towards the subject of CS in schools and the wider community to determine what needs to be put in place to help increase uptake of the subject amongst all students.
- Researching the participating teachers' experiences beyond the first two years of implementation to see how their professional pedagogical knowledge has developed and how they have engaged with the wider professional learning community established as part of the initiative.
- Exploring the ways in which future cohorts of teachers taking on the subject differ from the initial cohort of teachers and what implications does this have for their professional development
- Examining the capacity of the system to up-scale the professional development infrastructure to cater for growing numbers of teachers and the broader roll-out of the subject.

- Examining the applicability and transferability of the new constructivist teaching approaches, that have been successfully applied in the new CS curriculum, to new and revised Leaving Certificate subjects.

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9 APPENDICES

APPENDIX 1: LCCS DEVELOPMENT GROUP

Role	Name
Chair	Oliver McGarr
Association of Community & Comprehensive Schools	Paul Behan
Association of Secondary Teachers Ireland	Geraldine O'Brien
Association of Secondary Teachers Ireland	Mark Walshe
Computers in Education Society of Ireland	John Hegarty
Co-opted	Cornelia Connolly
Co-opted	Padraig Cunningham
Co-opted	Kevin Marshall
Department of Education & Skills	Tony Weir
Education & Training Boards Ireland	Stephen Gallagher
Irish Business Employers Confederation	Claire Conneely
Irish Universities Association	Monica Ward
Joint Managerial Body	Alan Kinsella
National Parents Council Post Primary	Geoffrey Browne
Quality & Qualifications Ireland	Joe English
State Examinations Commission	Hugh McManus
Teachers' Union of Ireland	Aengus Byrne
Teachers' Union of Ireland	Ciaran Callaghan

APPENDIX 2: LCCS SPECIFICATION

The Leaving Certificate Computer Science specification[8] was designed for all students and involves 180 hours of class contact time. It assumes no prior knowledge of Computer Science and aims to develop and foster the learner's creativity and problem-solving, along with their ability to work both independently and collaboratively.

The LCCS is made up of three strands that are interwoven and can be completed in any order. Strand 3 consists of four Applied Learning Tasks (ALTs) which the students work in teams to complete over the two years. They each result in the creation of a real/virtual computational artefact that should be relevant to the students, their peers and their community or to society in general.

Strand 1: Practices and principles	Strand 2: Core concepts	Strand 3: Computer science in practice
▸ Computers and society ▸ Computational thinking ▸ Design and development	▸ Abstraction ▸ Algorithms ▸ Computer systems ▸ Data ▸ Evaluation/Testing	▸ Applied learning task 1 - Interactive information systems ▸ Applied learning task 2 - Analytics ▸ Applied learning task 3 - Modelling and simulation ▸ Applied learning task 4 - Embedded systems

Figure 15 – The Leaving Certificate Computer Science strands

There are two assessment components, an end-of-course computer-based examination (CBE) constituting 70% of the student's total grade and an individual project completed in school which constitutes the remaining 30%. Although there is no restriction on the choice of programming languages used for the Applied Learning Tasks, Python and JavaScript are the languages used for both the coursework assessment and CBE and this will be reviewed on an ongoing basis.

The end-of-term examination, which was scheduled to take place in May 2020, did not take place due to Covid-19. Teachers' predictive grading was used as a substitute.

[8] https://curriculumonline.ie/Senior-cycle/Senior-Cycle-Subjects/Computer-Science

APPENDIX 3: PHASE 1 SCHOOL SELECTION CRITERIA

In November 2017, schools were invited to apply to participate in the Phase 1 programme based on the following criteria[9]:

- Support from the Board of Management and senior leadership within the school, in consultation with the school community, for offering the subject;
- A willingness to offer Computer Science as a Leaving Certificate subject on the timetable from September 2018;
- The school was able to identify a teacher (or teachers) with relevant experience and/or qualifications who are willing to teach Computer Science and participate in professional development within school time;
- Consideration of a requirement for teachers to participate in some professional development in their own time;
- Identification of a viable number of students interested in studying Computer Science as a Leaving Certificate subject.

[9] https://www.education.ie/en/Schools-Colleges/Information/Curriculum-and-Syllabus/Senior-Cycle-/leaving-certificate-computer-science-faq-s.pdf

APPENDIX 4: PHASE 1 SCHOOLS

	Name	Address
1	Abbey Vocational School	The Glebe, Donegal Town, Co. Donegal
2	Adamstown Community College	Station Rd, Adamstown, Co. Dublin
3	Breifne College	Cootehill Rd, Cavan, Co. Cavan
4	Bush Post Primary	Riverstown, Dundalk, Co. Louth
5	Carrigaline Community School	Waterpark, Carrigaline, Co. Cork
6	Castleblayney College	Dublin Road, Castleblayney, Co. Monaghan
7	Christ King Girls Secondary School	Half Moon Lane, South Douglas Road, Cork
8	Clongowes Wood College	Clane, Co. Kildare
9	Coláiste an Chraoibhin	Duntaheen Road, Fermoy, Co. Cork
10	Coláiste Bríde	New Road, Clondalkin, Dublin 22
11	Coláiste Chiaráin	Croom, Co. Limerick
12	Coláiste Choilm	Ballincollig, Co. Cork
13	Coláiste Mhuire	Mullingar, Co. Westmeath
14	Coláiste na Ríochta	Listowel, Co. Kerry
15	Colaiste Phadraig	Roselawn, Lucan, Co. Dublin
16	Coláiste Pobail Setanta	Phibblestown, Clonee, Dublin 15
17	Creagh College	Carnew Road, Gorey, Co. Wexford
18	Dominican College Sion Hill	Sion Hill, Blackrock, Co Dublin
19	Ennistymon Vocational School	Ennistymon, Ennis, Co. Clare
20	Gaelcholaiste Mhuire AG	An Mhainistir Thuaidh, Corcaigh
21	Le Chéile Secondary School	Hollystown Road, Tyrellstown, Dublin 15
22	Loreto College	Swords, Co. Dublin
23	Luttrellstown Community College	Porterstown road, Clonsilla, Dublin 15
24	Mayfield Community School	Old Youghal Road, Mayfield, Cork
25	Moate Community School	Church Street, Moate, Co. Westmeath
26	Mount Sion CBS	Barrack Street, Waterford
27	Mount Temple Comprehensive	Malahide Road, Dublin 3
28	Presentation Secondary school	Clonmel, Co. Tipperary
29	Rice College	Castlebar Road, Westport, Co. Mayo
30	Sacred Heart Secondary School	Convent of Mercy, Clonakilty, Co. Cork
31	St Aidan's Comprehensive School	Cootehill, Co. Cavan
32	St Brigids Mercy Secondary School	Convent Of Mercy, Tuam, Co. Galway
33	St Eunan's College	Letterkenny, Co. Donegal
34	St Finian's Community College	Swords, Co. Dublin
35	St Joseph's Secondary School	Convent Lane, Rush, Co. Dublin
36	St Mary's CBS	Millpark Road, Enniscorthy, Co. Wexford
37	St Vincent's Secondary School	Seatown Place, Dundalk, Co. Louth
38	Stratford College	1 Zion Road, Rathgar, Dublin 6
39	Synge St CBS	Synge St., Dublin 8
40	Terenure College	Templeogue Road, Terenure, Dublin 6W

APPENDIX 5: GEOGRAPHICAL SPREAD OF PHASE 1 SCHOOLS

Figure 16 - Map of Phase 1 schools[10]

[10] https://www.google.com/maps/d/viewer?mid=1-oKzmF9wF78Hv4DjpTPuQ57V2MLZVu0m&ll=53.43630870063433%2C-7.175965896874914&z=7

APPENDIX 6: TOPICS COVERED AT NATIONAL WORKSHOPS

#	Session Title	Topic
NW1	Introduction	Culture and Growth Mind-set
		Community of Practice
		LCCS Curriculum Specification
	Subject Specification	LCCS Curriculum Specification - Learning Outcomes
		Constructivist Pedagogical Orientation
		LCCS Curriculum Specification - Applied Learning Tasks
	Experiencing Problem-solving (through the lens of a learner)	Metacognition (Models of Learning + Modelling Metacognition)
	Pedagogy, Reflection and Resource Development	Learning Challenges faced by Novice Programmers
		The Teacher's Perspective (and successful strategies)
		Designing tasks to elicit metacognitive skills
		Resource Development
NW2	Curriculum Planning & Assessment, LCCS Promotion & Resource Development	Promotion and Resource Development
		Curriculum Planning and Assessment
	Teacher Critical Reflection & Pedagogies suitable for CT	Teacher Critical Reflection (part 1)
		Computational Thinking - Theory and Examples
		Computational Thinking - Pedagogies
		Computational Thinking - Activity
	Introduction to the micro:bit and Programming Pedagogies	Teacher Critical Reflection (part 2)
		Programming Pedagogies
		Introduction to micro:bit Programming
	ALT4 Embedded Systems (Part I)	ALT4 Embedded Systems - investigate/plan/design
	ALT4 Embedded Systems (Part I)	ALT4 Embedded Systems - create/evaluate/document
NW3	ALT2 - Analytics	Welcome and Introduction to Data Analytics - Specification
	ALT2 - Analytics	ALT2 Data Analytics - Theory/Demos/Resources
	ALT2 – Project Design and Development	ALT2 Data Analytics
		Curriculum and Assessment
	Computational Thinking	Computational Thinking - Theory (2 viewpoints)
		Computational Thinking - Activities
	ALT3 – Modelling and Simulation	ALT3 Modelling and Simulation - Spec/Background Theory
		ALT3 Modelling and Simulation - Tutorial
	ALT3 – Project Design and Development	ALT3 Design Briefs (Brexit routes)
		ALT3 Presentations

#	Session Title	Topic
NW4	Computers and Society	LCCS Curriculum Specification - Computers & Society
		Computers & Society - Pedagogies
		Computers & Society - Activity
	Computational Thinking	Computational Thinking - providing a full solution
		Computational Thinking - Google CT resources
	Computer Systems and Computers and Society	LCCS Curriculum Specification - Computer Systems
		Computer Systems - activities
	ALT1 Interactive Information Systems (Part I)	ALT1 - Glitch / server-side development / databases / SQL
	ALT1 Interactive Information Systems (Part II)	ALT1 - project design and presentation of ideas
NW5	Digital Portfolios and Coursework Video	Introduction to Digital Portfolios
		Digital Portfolio Platform Showcase
		Coursework Video
	Evaluation and Testing	Brainstorming of Prior Knowledge/Case Studies
		Types of Testing
		Designing and Implementing a Test Plan
	Algorithms	Unconscious Bias and Algorithmic Bias
		Introduction to Algorithms (Activity #1, Stable Marriage Problem)
		Searching and Sorting Algorithms (Activity #2)
		Analysis of Algorithms (Activity #3)
	Coursework Assessment	Investigate/Plan/Design
	Coursework Assessment	Dissection of Brief - home expert activity
	Coursework Assessment	Presentation of Ideas (from session 4)
NW6	Higher Level Topics	Algorithmic Complexity
		Heuristics
		Turing Machines
	Creating an Inclusive Classroom: SEN in LCCS	Inclusion, Policy and LCCS
		Inclusion SEN Guidelines and Resources
		SEN Approaches for Teaching CS
		Post Phase One CPD
		Exploration of Themes through Formative Assessment

APPENDIX 7: MOOC RECOMMENDATIONS TO TEACHERS

Date	Recommendations
March 2018	▪ Computational Thinking for Educators (Google) ▪ Introduction to Computer Science (Harvard) ▪ Introduction to Python: Absolute beginner (Microsoft)
May 2018	▪ Micro:bit videos for ALT4 (NCCA) ▪ Raspberry Pi and Python (Raspberry Pi Foundation and Google) ▪ Introduction to Python: Fundamentals (Microsoft)
April 2019	▪ Developing SQL Databases (Microsoft) ▪ JavaScript introduction (W3C) ▪ HTML5 and CSS Fundamentals (W3C)

APPENDIX 8: REGIONAL CLUSTERS

Red Cluster - Monaghan Education Centre

- Abbey Vocational School Donegal Town
- Breifne College
- St Vincent's Secondary School
- Bush Post Primary School
- Castleblayney College
- St Eunan's College
- St Aidan's Comprehensive School

Green Cluster - Dublin West Education Centre

- Adamstown Community College
- Coláiste Mhuire
- Le Chéile Secondary School
- Coláiste Bríde
- Coláiste Pobail Setanta College
- Coláiste Phádraig

Orange Cluster - Drumcondra Education Centre

- Synge Street CBS
- Mount Temple Comprehensive School
- St Joseph's Secondary School
- Loreto College
- Dominican College Sion Hill
- St Finian's Community College

Purple Cluster - Cork Education Centre

- Mayfield Community School
- Christ King Girls School
- Colaiste Choilm
- Sacred Heart Secondary School Clonakilty
- Coláiste an Chraoibhin
- Carrigaline Community School
- Mount Sion CBS Secondary School
- Gaelcholáiste Mhuire
- Presentation Secondary School

Yellow Cluster - Galway Education Centre

- Colaiste Chiarain
- Moate Community School
- Rice College
- Coláiste na Ríochta
- St Brigids School
- Ennistymon Vocational School

Navy Cluster - Dublin West Education Centre

- Luttrellstown Community College
- Creagh College
- Stratford College
- Terenure College
- Clongowes Wood College
- St Marys CBS

Figure 17 - Map of regional clusters[11]

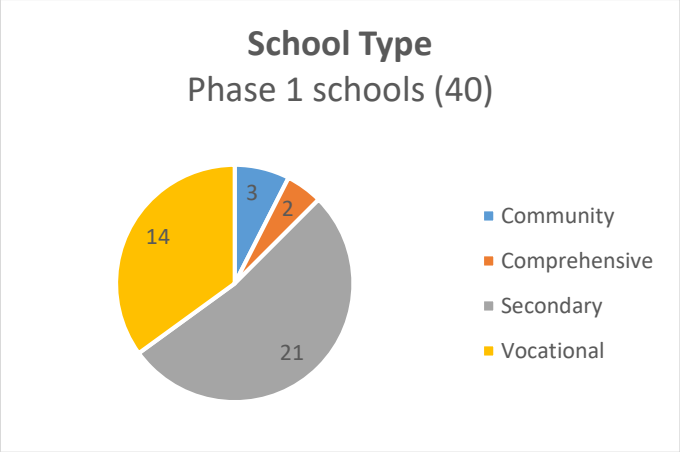
11

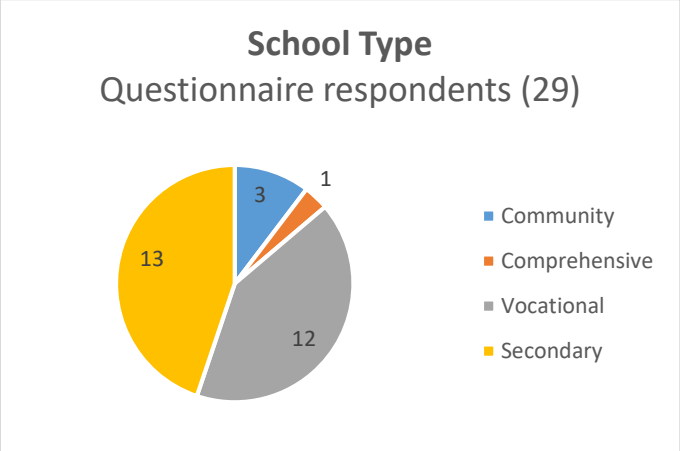
https://www.google.com/maps/d/viewer?mid=10cwKQBaqvMQN12lqzfi7PrjiwOWuHNeB&ll=53.32171795079704%2C-7.801870799999961&z=7

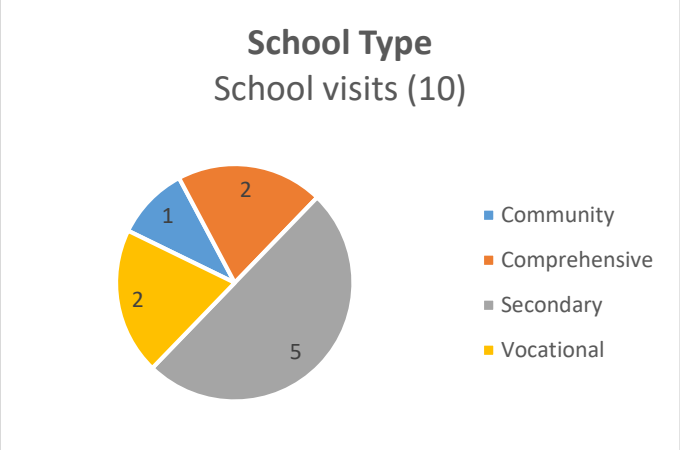
APPENDIX 9: PD ACTIVITIES

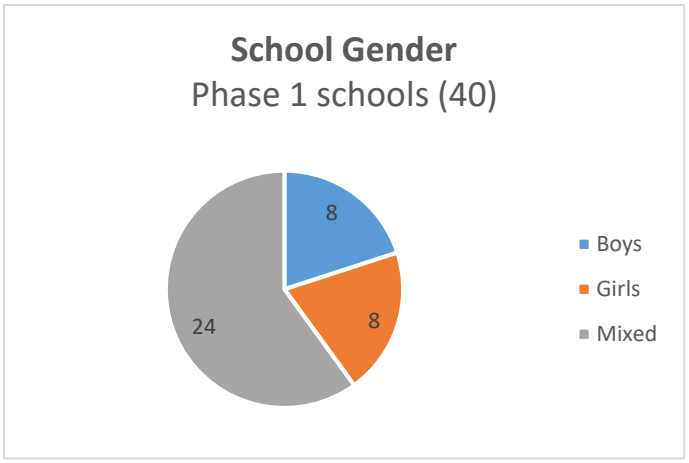
Start Date	End Date	Duration	Event	LCCS Teachers
Mar 2018	N/A	N/A	MOOC Resources #1	All
30-Apr-18	01-May-18	2 days	National Workshop #1	All
May 2018	N/A	N/A	MOOC Resources #2	All
09-May-18	09-May-18	1 day	Leadership Support	Principals
23-May-18	25-May-18	3 days	Skills Development #1 (Python 1)	Cohort 1
28-May-18	30-May-18	3 days	Skills Development #1 (Python 1)	Cohort 2
06-Sep-18	07-Sep-18	2 days	National Workshop #2	Cohort 1
10-Sep-18	11-Sep-18	2 days	National Workshop #2	Cohort 2
Oct 2018	Oct 2018	2 hours	Regional Cluster Meeting #1	All
10-Dec-18	10-Dec-18	1 day	Skills Development #2 (Python 2)	Cohort 1
11-Dec-18	11-Dec-18	1 day	Skills Development #2 (Python 2)	Cohort 2
09-Jan-19	10-Jan-19	2 days	National Workshop #3	Cohort 1
16-Jan-19	17-Jan-19	2 days	National Workshop #3	Cohort 2
28-Jan-19	28-Jan-19	2 hours	Webinar #1 (Dr Sue Sentence)	All
Feb 2019	Mar 2019	2 hours	Regional Clusters Meeting #2	All
Apr 2019	N/A	N/A	MOOC Resources #3	All
29-Apr-19	29-Apr-19	2 hours	Webinar #2 (LCCS Dev Group Panel)	All
21-May-19	23-May-19	3 days	Skills Development #3 (Web)	Cohort 1
27-May-19	29-May-19	3 days	Skills Development #3 (Web)	Cohort 2
04-Sep-19	05-Sep-19	2 days	National Workshop #4	Cohort 1
09-Sep-19	10-Sep-19	2 days	National Workshop #4	Cohort 2
Oct 2019	Oct 2019	2 hours	Regional Clusters Meeting #3	All
25-Nov-19	25-Nov-19	2 hours	Webinar #3 (Dr Colleen Lewis)	All
30-Nov-19	30-Nov-19	1 day	Industry day (Microsoft)	All
07-Jan-20	08-Jan-20	2 days	National Workshop #5	Cohort 1
08-Jan-20	09-Jan-20	2 days	National Workshop #5	Cohort 2
Feb 2020	Mar 2020	2 hours	Regional Cluster Meeting #4	All
22-Apr-20	24-Apr-20	1.5 days	National Workshop #6	All

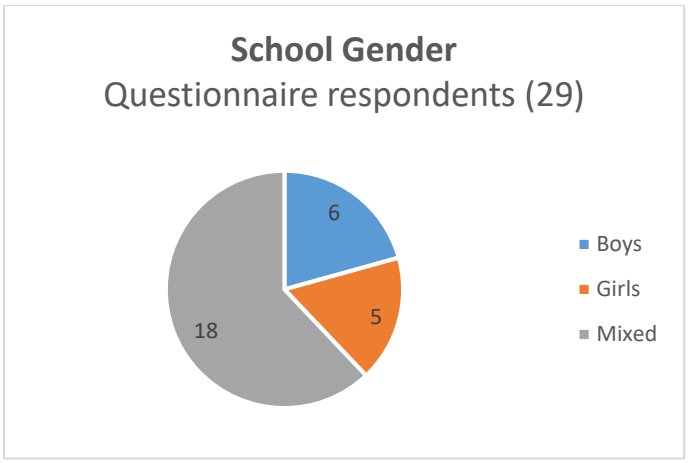
APPENDIX 10: SCHOOL DEMOGRAPHICS

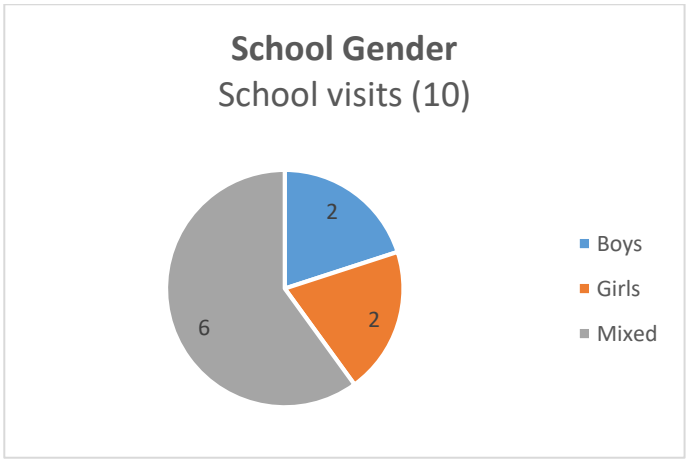


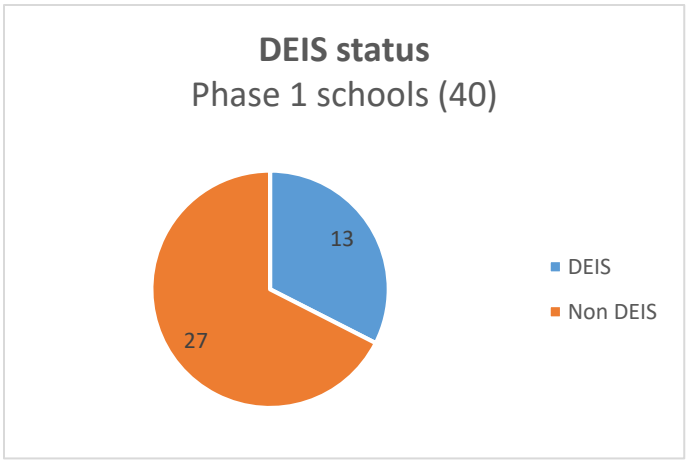


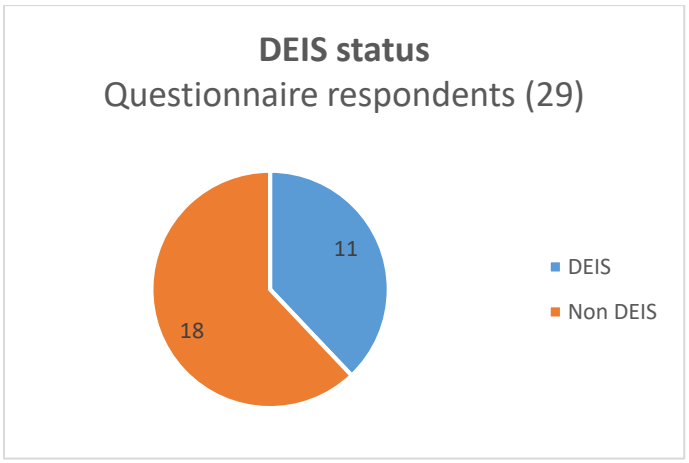


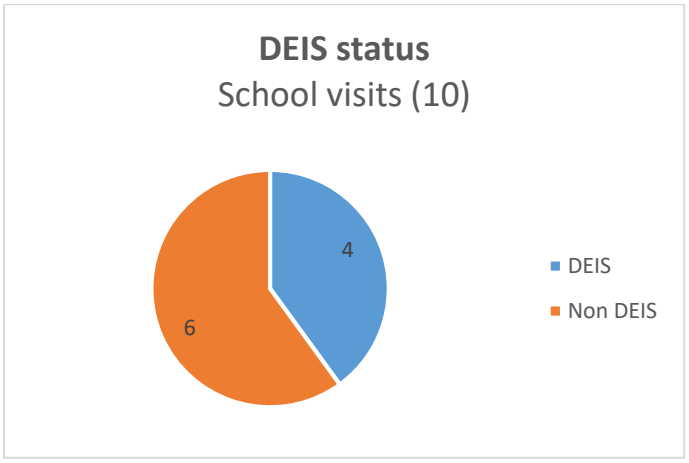

School Gender
Phase 1 schools (40)
8
8
24
Boys
Girls
Mixed

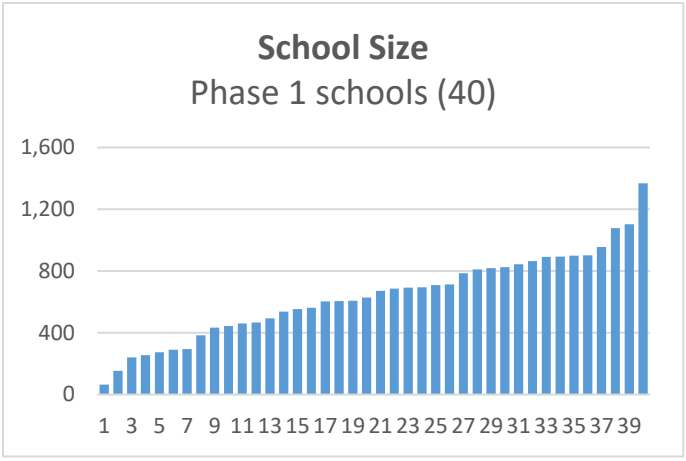

School Gender
Questionnaire respondents (29)
6
5
18
Boys
Girls
Mixed

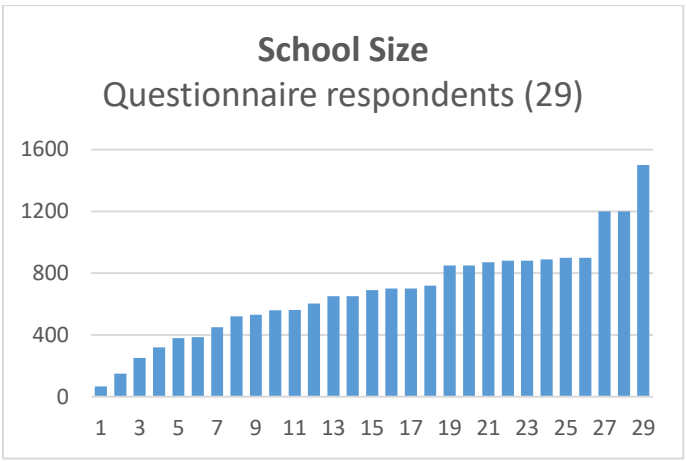

School Gender
School visits (10)
2
2
6
Boys
Girls
Mixed


DEIS status
Phase 1 schools (40)
13
27
DEIS
Non DEIS


DEIS status
Questionnaire respondents (29)
11
18
DEIS
Non DEIS


DEIS status
School visits (10)
4
6
DEIS
Non DEIS


School Size
Phase 1 schools (40)
1,600
1,200
800
400
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39


School Size
Questionnaire respondents (29)
1600
1200
800
400
0
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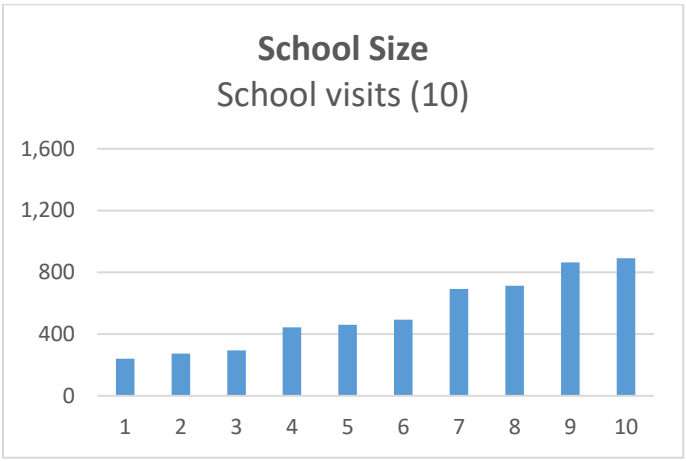
School Size
School visits (10)
1,600
1,200
800
400
0
1 2 3 4 5 6 7 8 9 10