Software for a better world

A World Leading SFI Research Centre

Science Foundation Ireland For what's next

CS Impact:

Exploring Students' Experiences of Leaving Certificate Computer Science

Joyce Borges, Clare McInerney, Chris Exton, Brian Harkin:

Lero, the SFI Research Centre for Software & University of Limerick,

Oliver McGarr: *School of Education, University of Limerick.*

HOST INSTITUTION

UNIVERSITY OF LIMERICK OLLSCOIL LUIMNIGH

PARTNER INSTITUTIONS

Ollscoil na Gaillimhe University of Galway · Maynooth University · Trinity College Dublin · University College Dublin An Coláiste Ollscoil, Baile Átha Cliath · UCC · MTU · DCU · SETU · Dundalk Institute of Technology · TUS · ATU

UNIVERSITY OF LIMERICK OLLSCOIL LUIMNIGH | School of Education

CONTENTS

ACKNOWLEDGEMENT

The writers of this report would like to express their appreciation to the students for their valuable input and to the teachers for their support and for encouraging students to engage with this project.

This work was supported with the financial support of the Science Foundation Ireland grant 13/RC/2094_P2 and co-funded under the European Regional Development Fund through the Southern & Eastern Regional Operational Programme to Lero - the Science Foundation Ireland Research Centre for Software (www.lero.ie).

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS LIST

ALT	Applied Learning Task
CS	Computer Science
DE	Department of Education
JC	Junior Cycle
LC	Leaving Certificate
LCCS	Leaving Certificate Computer Science
Lero	Science Foundation Ireland Research Centre for Software
PCK	Pedagogical Content Knowledge
TY	Transition Year

FOREWORD – SIMON HARRIS T.D., MINISTER OF FURTHER AND HIGHER EDUCATION, RESEARCH, INNNOVATION AND SCIENCE

At a time of rapid technological development, it is crucial that Ireland's educational system continues to evolve to equip learners of all ages to meet the changing needs of employers, industry and daily life. Computer Science education is an important cornerstone in developing the skills that are needed to be digitally competent in an evolving world. It also promotes skills that are valuable in a variety of career sectors and contexts, such as teamwork, creativity, logical thinking and communication.

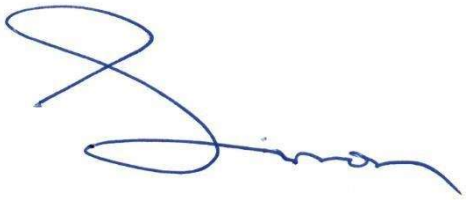
I am delighted to see this report by Lero, the SFI Research Centre for Software, on Leaving Certificate Computer Science. Lero's work is central to the development of Ireland's software and IT talent pipeline, building critical software skills at all ages for Ireland's current and future workforce.

Importantly, this in-depth report has the voice of student's front and centre. As Computer Science is a relatively new subject at Leaving Certificate, it is crucial for us to learn from the insights of students, and build on these to continue to refine and improve the learning experience. It is heartening to see that students have enjoyed the interactive and collaborative methods of learning piloted in the new subject.

The report also identifies some challenges that still need to be addressed, particularly in breaking down stereotypes about computer science and increasing the participation of female students. These are challenges that Lero is actively addressing through its education and public engagement work. I look forward to seeing broader participation in the years ahead and Computer Science going from strength to strength.

I congratulate Lero and University of Limerick on this important report, and look forward to seeing the education system at all levels continuing to nurture learning, innovation and creativity for the 21st century.

Yours sincerely,



Simon Harris T.D.
Minister of Further and Higher Education,
Research, Innovation and Science.

1. EXECUTIVE SUMMARY

Background

In 2018, the Department of Education (DE) introduced the Leaving Certificate Computer Science (LCCS) subject in the upper second-level curriculum in Ireland. The introduction of the subject was in response to industry concerns about increasing the supply of students into the IT sector and was also driven by wider beliefs about the need to have an educational system that was addressing the rapid technological developments in society.

LCCS aimed to develop students' understanding of computing technology, computational thinking, programming and its wider societal impact. In terms of key skills, the aim was to develop and foster students' creativity and problem-solving, as well as promoting the ability to work independently and collaboratively. The subject, which was initially introduced in 40 pilot schools, has now grown and is currently delivered in 220 schools which represents approximately 30% of the total number of second-level schools. There are approximately 4,200 students studying the course at Senior Cycle.

While there have been several research projects that have explored the roll-out of LCCS, very few studies have focused on students and their experiences of the subject in an in-depth manner. The current study aimed to explore 5th and 6th year students' overall experiences of studying LCCS by using a qualitative methodology and incorporating art-based methods as well as following participants and capturing their experiences over a period of time.

Methodology

This in-depth qualitative study consisted of interviews, online accounts and an art-based method. The first phase involved conducting pilot interviews to establish the suitability of the interview guide. The second phase involved conducting one-to-one semi-structured interviews with 5th and 6th year second-level Computer Science (CS) students. Phase three involved students

completing a fortnightly online account that captured their 'in-the-moment' thoughts and feelings over a three-month period. The final account included an art-based method that invited students to express what LCCS meant to them using an image of their choice. Phase four involved follow-up interviews with 5th year students. Thematic analysis was used to analyse the data.

Key Findings

- The research found that personal interest in the subject and past curriculum experiences, such as the taster course in Transition Year or the Junior Cycle short course in Coding, were important factors when choosing the subject. Teachers and family members also played a role in subject choice.

- Students enjoyed the way the subject was taught. The active and interactive nature of the subject were reported as unique and positive characteristics of the subject and students claimed that it was enjoyable, it enhanced their learning, engaged them in the subject and gave them the opportunity to actively influence their learning experiences. Teachers were described as approachable and were reported as promoting independence and maintaining a good learning atmosphere. Concerns about the scarcity of notetaking and how it could affect their revision of the subject were raised by students.

- Students also enjoyed the opportunities for collaboration and groupwork that the subject offered. While in some schools groupwork was reported as essential, in other schools the groupwork element was not adopted in class. The benefits and challenges of groupwork and collaboration were also discussed.

- Creativity was also reported as one of the core elements of CS. Students highlighted that creativity was necessary in coding and that the creativity in CS was different to the creativity associated with other subjects.

- A separation of practical and theoretical aspects of the course was experienced by students, with students indicating a clear preference for practical topics and often a dislike for aspects of the course that was delivered primarily through teacher-centred instruction. This type of learning they associated with 'Theory'. Overall, students presented concerns regarding the amount of content in the LCCS curriculum.

- The Applied Learning Tasks (ALTs) were viewed positively by students, although challenges were also acknowledged. Students enjoyed the social experience, the opportunities for creativity and for experiencing real-life scenarios, the opportunity for autonomy and creating projects that would be useful to others in the broader community. The challenges associated with the ALTs included not having enough time to fully engage with the tasks, lack of guidance from teachers and not being clear on the learning objectives of the tasks.

- A gender imbalance was discussed with students reporting a misrepresentation of females in the LCCS class. Female participants also pointed out the stereotypes that are frequently associated with certain subjects, one of them being CS. CS was said to be commonly considered as a 'male subject', which consequently discouraged other female students from choosing the subject. Female participants also commented on feeling hesitant about working with their male classmates. Wider school-level timetable arrangements were also said to have inhibited female students from choosing LCCS.

- Students recognised the advantages and relevance of CS in their future careers. The key learnings and skills that students believed they acquired in LCCS were seen as transferrable to other professions. Problem-solving, teamwork skills, analytical skills, and coding were often mentioned as key skills.

- Misperceptions and stereotypes associated with CS were highlighted by students. Some students discussed having stereotypical beliefs themselves before engaging with the

subject. The 'nerd' stereotype, commonly associated with CS, was mentioned by participants. Students commented on the inaccuracy of the perceptions often associated with the subject.

Recommendations & Conclusion

In discussing the findings, the study outlined several recommendations. These include ways to encourage the uptake of the subject, challenge the stereotypes and misperceptions associated with the subject, continue professional development for teachers, and address the issues related to groupwork and ALTs that were raised by students.

The study concludes that the introduction of the subject has been successful with a growing number of schools taking on LCCS. Students' experiences of the subject are very positive, both in relation to the pedagogical approach that the subject employs and also the opportunity for creative and collaborative work. However, negative and inaccurate stereotypes are still present, as well as a wider lack of understanding of what CS entails, and a lack of appreciation of its wide application in all aspects of society. Further work needs to be done to address the issues raised in the study, including the societal ignorance that exists in relation to what CS is and challenging the inaccurate and limiting stereotypes that are still prevalent when it comes to CS.

2. INTRODUCTION

In 2018, the Department of Education (DE) introduced the Leaving Certificate Computer Science (LCCS) subject in the upper second-level curriculum in Ireland. LCCS was described as the study of computers and algorithmic processes, including how programming and computational thinking can be applied to solve problems, and how computing technology impacts society (NCCA, 2018). While the introduction of a Leaving Certificate (LC) subject was explored decades before (O'Doherty et al., 2004), the impetus behind its recent introduction lay in the *Digital Strategy for Schools* policy (Department of Education, 2015), specifically the 2017 *Action Plan* (DE, 2017) which set out the goal of establishing a subject by 2018. The introduction of the subject was in response to industry concerns about increasing the supply of students into the IT sector and was also driven by wider beliefs about the need to have an educational system that was addressing the rapid technological developments in society. The introduction of LCCS in the curriculum also offered students the opportunity to move away from being passive consumers of technology to becoming active creators and producers of computer systems with the fundamental understanding of how technology works (Connolly & Kirwan, 2023).

While there have been several research projects that have explored the roll-out of LCCS (Connolly et al., 2022; Quille et al., 2018), very few studies have focused on students and their experiences of the subject in an in-depth manner. A previous Lero report (McGarr et al., 2020) which focused primarily on teachers and their experiences of the professional development programme, also reported the findings of an informal discussion with 6th year students. However, the engagement with students was limited due to the nature of the research. Connolly and Kirwan (2023) also investigated students' participation in LCCS and provided insight into the students' learning experiences, factors that motivated them to choose the subject and career expectations. The report on the early enactment review of LCCS, undertaken by the NCCA (2023b), also explored students' experiences of the subject, however, the focus was on 6th year

students of phase 1 schools, as well as on students who had already completed the course, LCCS teachers and stakeholders. The current study, therefore, builds on previous research by providing in-depth insights into 5th and 6th year students' experiences of the subject. The current study, however, is different from previous research as it adopted a qualitative methodology, it incorporated art-based methods as an alternative mode that helped capture students' insights, and it followed participants and captured their experiences over a period of time. Exploring students' experiences is important as they experience the subject at first hand and can therefore provide valuable insights that can help shape LCCS education into the future. Understanding students' learning experiences is therefore paramount to improving the subject's success and use of in-depth qualitative methods to capture their views is critical. For this reason, this study aimed to explore 5th and 6th year students' overall experiences of studying LCCS. By undertaking this study, it places the student voice front and centre and illuminates the experiences of students as they travel through the LCCS course.

3. OVERVIEW OF LEAVING CERTIFICATE COMPUTER SCIENCE

LCCS was introduced in September 2018 in 40 pilot schools. Set within the framework of the key skills for senior cycle, the specification aimed to develop students' understanding of computing technology, computational thinking (Wing, 2006), programming and its wider societal impact. It also had wider educational aims related to the key skills of senior cycle, namely to develop and foster students' creativity and problem-solving, in addition to promoting the ability of students to work independently and collaboratively. The LCCS specification focuses on how programming and computational thinking can be used to solve problems, and the influence of computing technology in our everyday lives.

LCCS comprises of three strands (see Figure 1). These strands are interwoven and should not be studied in a linear fashion but rather concurrently across the two years of the Leaving Certificate (LC). Strands 1 and 2 equip students with the skills and knowledge needed for completing the Applied Learning Tasks (ALTs) in Strand 3. These ALTs are completed in teams and students produce real or virtual computational artefacts. Students are encouraged to produce artifacts that closely relate to their own interests and that can also be beneficial to the community and to society, e.g., digital animations, web pages and robotic systems.

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

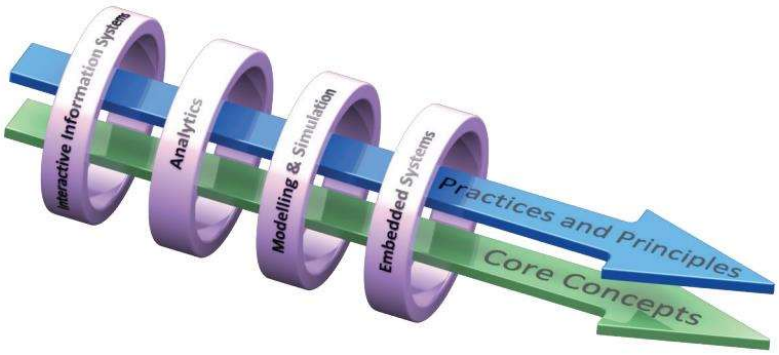


Figure 1 - *Leaving Certificate Computer Science structure*

LCCS was designed for 180 hours of class contact time plus two assessment components. The assessment components include an end-of-course computer-based examination which is worth 70% of the total grade, and an individual project consisting of a computational artefact plus a report worth 30%. LCCS can be studied at both Ordinary and Higher level, accommodating students of differing abilities and achievement levels. Since its original introduction in 40 pilot schools, it has now grown and is currently delivered in 220 schools (J. English, personal communication, January 30, 2024) which represents approximately 30% of the total number of second-level schools. There are approximately 4,200 students studying the course at Senior Cycle (NCCA, 2023b).

4. METHODOLOGY

4.1 Study Design

Previous research has explored the introduction of this new subject into schools, particularly from the perspective of the participating teachers and the professional development delivered as part of the initial roll-out of the subject (see McGarr et al., 2020). This current research was interested in exploring the students' perspectives as there has been limited research focusing on the experiences of students (Connolly & Kirwan, 2023; NCCA, 2023b). Because of the importance of capturing the student voice and their lived experiences, this research adopted a qualitative methodology which consisted of interviews and online accounts. This approach was adopted as qualitative research helps understand how individuals subjectively perceive, give meaning to and interpret their experiences (Atkins & Wallace, 2012). Interviews encourage participants to provide vivid descriptions of their personal experiences (Weiss, 2004), while also allowing the researcher to probe and clarify information in real time. Frequently used in educational research, interviews have the potential to give students a voice, as they are the ones who can accurately discern the education experience and what facilitates their learning (Saul, 2005). Online accounts were also used to collect data from participants. Online accounts were records of the participants' real time and ongoing experiences of LCCS, as reported by the participants themselves. An art-based method was also incorporated into the online accounts to capture students' perception of CS in a visual format. Figure 2 below outlines the study's approach and its phases.

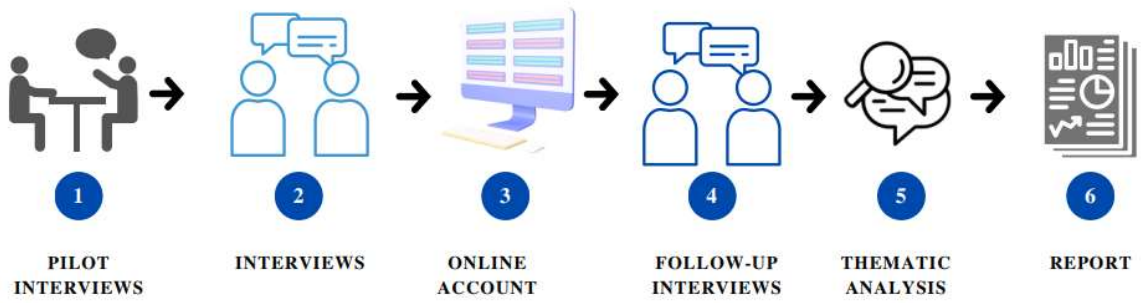


Figure 2 - *Qualitative approach used in this study*

4.2 Participants

The sample included 27 LCCS students (56% males, 44% females) from four Irish second-level schools. Twenty-two (81%) of these were 5th year students and five (19%) were 6th year students. Participants were invited to take part in the study via their LCCS teachers. LCCS teachers were contacted in order to recruit students for participation. Teachers were contacted via email, social media (poster) posts, word of mouth and posts in CS-related platforms (e.g., CESI and Slack). Teachers were encouraged to contact the researchers if they were interested in having their students participate in the research project. Students then volunteered for participation. Student participation and data collection took place from October 2022 to April 2023.

4.3 Procedure

The first phase involved conducting pilot interviews to establish the suitability of the interview questions and to determine if there were any flaws or weaknesses in the interview design (Majid et al., 2017). Participants for this phase were CS university students who had previously completed the LCCS subject. Three pilot interviews were conducted. Some modifications were made following the pilot interviews, as it was noticed that some questions were not easily understood or could be phrased differently. Questions were also added to the interview. The final version of the interview guide can be found in Appendix A. The modifications made post pilot interviews can be found in Appendix B.

The second phase involved conducting one-to-one semi-structured interviews with 5th and 6th year second-level CS students. Interviews took place in the participating schools with each interview lasting approximately 45-60 minutes. Prior to starting the interviews, participants provided informed consent and parental consent was also obtained. The first minutes of the interviews were used to build a rapport and establish a comfortable interaction to enhance the quality of the responses. The interview explored participants' subjective experiences and perceptions of LCCS. Open-ended questions and probes were used to facilitate discussion on how students experienced the subject. Topics covered in the interview included students' background and decision to study LCCS, learning experiences, perceptions of the content, pedagogy and assessment of the subject, and career expectations. The interview guide used for these interviews can be found in Appendix A.

Phase three involved students completing a fortnightly online record that captured in-the-moment thoughts and feelings for a three-month period following the initial interviews. Microsoft Forms was used for this, and it contained an open question which encouraged students to report on their ongoing experiences. Students were instructed to report on their real time engagement with LCCS, for example, what they were currently doing in class and how they were currently feeling about the subject. Students were contacted via email which contained a link to the online account. Completing these online accounts took on average three minutes and students did this in their own time. Reminders were sent to students who had not completed the account within five days. Students were asked to complete a total of six accounts. The template used for the first five online accounts can be found in Appendix C. The final online account employed a different format and invited students to express what LCCS meant to them using an image of their choice. Participants were open to submit photos, drawings, or comics and to include a short, written explanation for their visual data. This was provided to enable students to use an alternative mode of representation to help capture insights that may not have been possible through the other methods .

Phase four involved follow-up interviews with 5th year students. It was decided that the follow-up interviews would be conducted with 5th year students only for two main reasons. Firstly, it was understood that 6th year students would be particularly engaged with projects and deadlines, as well as with pre-exams which are conducted independently in schools as a means of preparing students for the LC examinations. Secondly, having two interviews with 5th year students at different time points allowed for insights from when these students were just starting the subject as well as when they had engaged with the subject for several months. This was not necessary with 6th year students as their initial interviews already proved to be more complete given that they had been doing the subject for over a full school year. Eight 5th year students (5 males; 3 females) took part in the follow-up interviews. These interviews aimed to explore students' continuous engagement with and experience of LCCS, as well as allowing the researcher to clarify any uncertainties or incomplete responses from the first set of interviews. Given that the first interviews were conducted early in the school year, some 5th year students had not yet experienced some aspects of the subject, for example ALTs and groupwork, therefore the follow-up interviews allowed for insights into these specific aspects. The follow-up interviews also allowed for students to expand on their online account entries and further discuss their visual data. All interviews, including the pilot interviews, were conducted by the first author.

The many data collection methods and different time points allowed for both method and data triangulation. This triangulation helped to achieve a more complex and complete understanding of participants' experiences as well as enhancing the validity of the research.

4.4 Data Analysis

Braun & Clarke's (2022) phases of thematic analysis were used to identify patterns within the data in relation to students' experiences of LCCS. An inductive approach to thematic analysis was utilised where coding and theme development were driven by the data content with no preexisting framework or preconceptions. All interviews were recorded, transcribed, and read

for familiarisation (phase one). The data was initially coded manually for an active engagement with the data, and then using NVivo Windows which helped organise and analyse the data (phase two). The written online accounts and visual data submitted by students were also coded. Codes were then arranged into clusters to generate initial themes and subthemes (phase three). The candidate themes were developed and reviewed by the research team (phase four). Overarching themes and subthemes were then refined and named and definitions for each overarching theme and subtheme were developed to identify each theme's core concept and how it contributed to the overall story of the data (phase five). Phase six involved writing up the report.

4.5 Ethics Statement

Ethics approval was granted by the University of Limerick's Faculty of Science and Engineering's research ethics board (reference no. 2022_05_04_S&E).

5. FINDINGS

The findings are presented in four sections. Section 5.1 outlines the paths students take to study CS as a LC subject. Section 5.2 presents the students' perspectives on the positive factors of the subject. Section 5.3 outlines how students experienced the subject and their views on how the subject was realised. Section 5.4 presents the students' views of what they learn and take from the subject.

5.1 Paths Students Take to Study LCCS

During the interviews, students spoke about the many motives and influences for choosing to study LCCS. While many students had a personal interest in the subject, there were also students who were influenced by more external factors. This separation between internal and external influences indicated that students who picked LCCS came from various backgrounds, through different pathways and with varying experiences.

Many students expressed a personal interest in the subject. While some students' interest was sparked by hobbies, such as videogames, *'I was always interested in like videogames and how they were like made'* (5th year, male), others were curious about technology and computers, and eager to understand more about *'how they work'* (6th year, male). Some students who already had a personal interest, also claimed to have their interest heightened by external influences.

Regarding external influences, many students were influenced by past curriculum experiences such as a CS taster course in Transition Year (TY) or the Junior Cycle (JC) short course in Coding. Students highlighted the importance of introducing CS earlier in second-level schools, especially in schools where the JC short course was not available.

> There is no Junior Cycle computer science in this school anyways. So, I feel like people generally don't want to branch out, you know, in case they make a

> mistake. So, I feel like it does have a bit of a disadvantage because it's not a Junior Cycle subject (6th year, male).

The value of introducing CS early was also reinforced by those students who had coding experience prior to the LC as they stressed the importance of such courses or programmes and their impact on students' choices when selecting the subjects, *'I picked computer science because when I first started in 1st year, there was an option to pick computer science in, inside with another subject, and I chose it then, I really enjoyed it'* (5th year, female).

In contrast, other students who had prior experience of coding from the JC claimed that improvements needed to be made to the short course in Coding as its content could mislead students going into the LC.

> ... you do it in third year as well, you do computers. Like that was just making games and all so I thought computer science was going to be like making games and stuff, but then when I went into it, it was just like making websites and coding, projects and stuff (6th year, female).

Although not all schools offered the JC short course, all participating schools did offer a taster or introductory course in TY, which was where most students initiated their CS journey.

> In TY like they just show you like, I guess like the basic parts of it, and then you choose if you want to do it or not, and I chose to do it (5th year, male).

> We did do some computer science in Transition Year. We did like web, HTML, CSS, a bit of Python, just to get the track running to see how most people will either choose a subject or not. And I chose it. I was interested in that (5th year, male).

Teachers and family members also played a role when it came to choosing LCCS. Some students were inspired by family members, *'my uncle does do computers, so he was like a big influence, kind of, on me wanting to do computers'* (6th year, female); *'... both of my parents are*

in computer science as well, so I have family background in it' (6th year, male), while others were encouraged by teachers who claimed to see potential in their students, *'I wasn't sure if I was going to pick it, but then my teacher kind of motivated me because [teacher] said that I had a spark for it'* (5th year, male). A larger number of male students mentioned being encouraged by teachers to pick the subject while both males and females were influenced by family members.

When asked why their friends or other students would not pick LCCS as one of their subjects, students presented a number of possible rationales including: lack of familiarity with the subject, *'like since it wasn't for Junior Cert, a lot of people wouldn't be as familiar, so they'd be kind of questioning it'* (5th year, male); other students not being *'tech savvy'* (5th year, male); being influenced by peers to choose another subject; or ultimately because they were presented with a timetable conflict and chose another subject instead, *'a lot of people that like I feel picked computer science, but not all of them got the subject, as they did have other subjects they were picking at the same time'* (5th year, male).

5.2 Students' Perspectives of the Positive Factors of LCCS

5.2.1 Active Learning

Students reported very positive views of the subject during the interviews, indicating that they enjoyed the LCCS class and looked forward to it, *'I always enjoy going to class anyway'* (5th year, male). One of the main reasons provided by students for why they had such a positive view of LCCS had to do with the way it was taught. The concept of active learning came up throughout the dataset in many instances. Students mentioned that there was a lot of *'learn[ing] by doing'* (5th year, female) which contrasted sharply with the teacher-centred approach where they normally took notes and listened to the teacher. Students commented how this active nature along with the interactive nature of the subject, engaged them and enhanced their learning, as well as allowing them to actively influence their learning.

> I find computer science subject so different and unique from other subjects. It's not like you're sitting down and you're writing, you're actually paying attention and you're learning visually and practically as well (5th year, male).

> I think most of the time I do work well if I'm like helping somebody else out because, like if I'm helping somebody then it like, I understand it more because I'm explaining it as well as like actually doing it. So, I think that that helps me (5th year, female).

> We're always kept involved. It's never just listening to someone talk for ages. [...] Other classes you're writing down what's on a board. But in computer science you can influence what you're doing. You're not just taking down other things off the board (5th year, male).

> I suppose with computer science you kind of know what you're doing, and you know why you're doing, so I find it's kind of easier to understand (5th year, male).

While students talked about the benefits of this 'new' learning approach, there were also instances where there seemed to be some insecurity with it, as the comfort of taking down notes in order to revise and in most cases memorise was no longer experienced by many students. Some claimed that most of the information was in the book, and they could simply highlight it, or the notes/information could be found online, but that pen-to-paper notetaking was still wished for. This lack of familiarity with this new learning approach brought about by LCCS, led to some insecurity where students thought that the lack of notes could affect their studying and revision.

> I don't really just learn from like just looking at something and like seeing computer science, just like, just learn the code. I don't really like, for me I write notes, so I'm the type of person that I just have loads of notes like in folders. So, I feel like in computer science, I wish I was able to like take down my own notes in

a way. Like not just be from the book, so like I have a better understanding of it myself (5th year, female).

Students who took part in the follow-up interviews reported an increase in notetaking in LCCS which increased their confidence when studying for class tests or exams, *'I like studying the notes and stuff. Yeah, I guess I have something to look back on more so. Before, I'd just try and figure out like try and remember, but now I actually have stuff written down'* (5th year, female).

5.2.2 Collaboration and Groupwork

Collaboration and groupwork were also predominating topics discussed by students in the interviews and also in the online accounts and visual representation of CS (Figure 3). There were contrasting perceptions of groupwork however, and also contrasting incorporation of groupwork activities depending on the school. Although groupwork and collaboration could be used as interchangeable concepts, it was clear from the interviews that these were actually distinct, where groupwork referred to students working together on the same task or project while collaboration referred to helping each other on their own separate work. While in some schools, groupwork was seen as essential, in other schools it was more of a case of collaboration where students worked individually in each task or exercise but could ask other classmates for help or would be free to talk to other students, *'it's individual, but we can help each other if we're stuck'* (5th year, male). In these schools, students had no experience of groupwork even though it was a mandated aspect of the curriculum. In the schools where students described LCCS as a groupwork-focused subject, the majority of the tasks and class exercises were completed in pairs or larger groups, *'I would say there is a big emphasis on like groupwork'* (5th year, female).

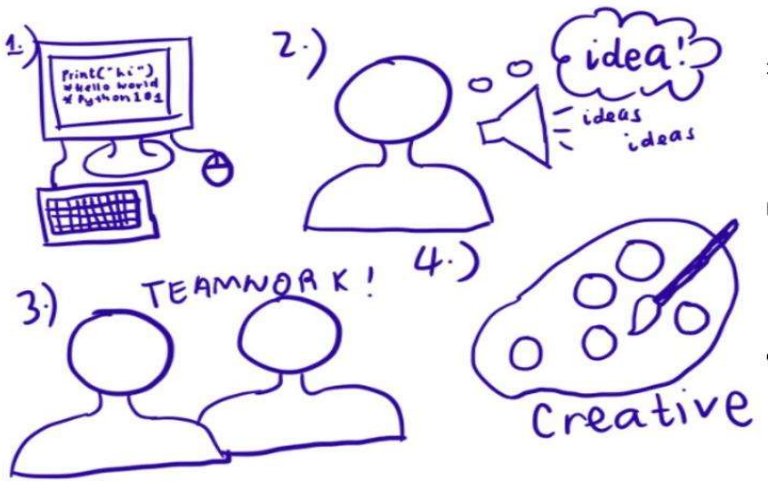


Figure 3 - *Participant's visual representation of computer science*

In relation to the students' perceptions of groupwork and collaboration, some varied opinions were reported. Students highlighted the benefits of groupwork stating that it was more productive, more efficient to get tasks completed, facilitated learning, helped peer learning, developed groupwork skills for future jobs, helped students bond with classmates, allowed students to work with friends and to have fun.

> I think you do learn a lot with other people because some people just work and see things differently. So, if you might be stuck on something, they might say 'oh look this is how you do it' and you probably learn it faster than you would yourself (5th year, male).

> I just feel like maybe groupwork like things get done quicker. So, like if you're doing it by yourself like you're probably going to be there for like a few days. But if it was just groupwork, like you'd get it done in like a day, cause everyone's working at one thing (5th year, female).

> But I do like working with other people because like they have strengths and I have strengths and they have weaknesses and I have weaknesses... It's better to have two brains working on the same thing (5th year, female).

Disadvantages of groupwork were also mentioned by participants. These included having to wait on other students to do their part and that some students might take control of the task. Groupwork was said to only be beneficial when students got along with group mates and that it could be difficult when students were absent. Participants also mentioned that some students would not put in the effort, that some students would only mess around with their friends, and some students were shy around others.

> Because if there's too many people it's kind of hard to keep track of what everything, everything that's going on (5th year, female).

> In groups, if people can find an excuse to do less work, they will take it. When working on your own, the teacher only expects your amount of work. So, when you really give your all, it really does show on your grade (5th year, male).

> It just depends on who you're working with, you know. If someone is not pulling their weight, you know, slowing you down, you're doing all the work and they're doing nothing. It kind of makes you like really annoyed, that like working in pairs is really bad because you have to do twice the work because they're not doing anything (5th year, male).

> But the problem that I had with it, though, is that like some people were out, so it was hard to catch up with them (5th year, female).

5.2.3 Creativity

Students also highlighted creativity as a contributing factor to their positive views of the subject. Creativity was described as a core element of CS and many students indicated how creativity was necessary in coding. Students claimed that, while they could copy the teachers' code, they could also create their own code to their own understanding and be creative in that way. Students described this as a different kind of creativity, suggesting that creativity in CS was

more *'logical'* (5th year, female) compared to the traditional artistic creativity associated with subjects such as Art and Music.

> And creativity, because in my experience when working on projects freely when given a prompt, you can be very creative with how you interpret that and what you can make when, you know, it's just you, a laptop and code (5th year, male).

> The creativity aspect. Because usually, like some people, just like do the same code as the teacher. And you are, like that's no problem, but like I think if you're like creative with it like you can make it to your own understanding; same code but like just different like different like words and like phrases that you would use in the code (5th year, male).

The concept of creativity was mentioned in greater detail in the second iteration of interviews, as students further recognised this creative aspect of CS after progressing in the subject *'I kind of realise you need to be more creative with coding'* (5th year, male). Creativity was also emphasised in the online accounts and visual representation of CS, as can be seen in Figure 3. The student who submitted the image (Figure 3) outlined that:

> Computer science allows me to be a bit creative. We have briefly explored game design and are currently working on Web Design. This is where the creative element really comes into play. Not only do you have to think of colour schemes, but you also need to think about font, formatting and creating a website with good UI (5th year, female).

Another student submitted their visual representation of CS in the form of a TikTok claiming that using a different tool like TikTok to complete the visual task *'reflect[ed] the creativity seen throughout computer science'. The student also suggested that CS was 'not all just numbers and binary but also abstract ideas which are commonly expressed to [them] through very colourful and creative scenarios'* (5th year, female).

5.2.4 Teachers

Students' engagement with their LCCS teacher was also portrayed as a bonus. Students described feeling pleased with the teaching approach and also feeling comfortable around their teachers. LCCS teachers were often described as accessible and relaxed, *'[teacher]'s like, it's easy to go up to [them], it's not like some teachers, you don't even want to talk to them'* (5th year, female). Some students mentioned the LCCS class had a good atmosphere because of the teacher's relaxed nature, some said the teacher made the class enjoyable and some felt the teacher would really connect with the students. Students indicated that teachers helped promote independence in the class but were still approachable when needed.

> I like my teacher, *[teacher]* teaches it well and *[teacher]* like helps if *'if'* you need help. And *[teacher]* doesn't give the answer to you right off the bat, *[teacher]* makes you like figure the answer out with the little bit help and I like that (5th year, female).

Although teachers were seen to promote independence, students also acknowledged their dependence on the teacher as LCCS was a new subject that they found themselves unable to learn without the teachers' guidance, *'but some things in computer science, you may not know how to do, so you have to like, you're really dependent on your teacher to tell you this information and then you can independently like learn it'* (5th year, female). Students were also aware of their teachers' developing content expertise in LCCS but claimed that this was a favourable aspect, as it meant that students and teachers created a bond as they worked through the content together.

> Sometimes if the teacher doesn't know something like because sometimes it is a new subject, so like some teachers may not know something from the book and like they get confused and then we get confused... not like in any way shape or

> form it's the teacher but like, I feel like it's like for everyone just cause it's really, really new (5th year, female)
>
> Like even our teacher, [*teacher*]'s new to computer science. [*Teacher*] doesn't know too much, [*teacher*]'s not experienced, you know, [*teacher*] only started studying the course. So [*teacher*] is with us, like every problem [*teacher*] struggles with, we struggle, so we like work it out together. It makes us, like, it makes it easier for us knowing that, you know, we're just not alone or something... I think that's a good thing, you know, it kind of, the teacher relates to the students more instead of the students just being alienated (5th year, male)

5.2.5 Content

In relation to the content of LCCS, there were a couple of specific topics that stood out at different times for students. In the first set of interviews, students' favourite topics were Python and Micro:bit while Web Design was portrayed as the new favourite during the follow-up interviews, indicating that preferences changed as students progressed and covered a greater amount of content. Students did indicate a clear preference for practical topics such as Python compared to more theoretical topics such as history of computers, *'I much prefer the actual, you know, coding and problem-solving aspect compared to like the history of coding'* (5th year, male).

5.2.6 Assessment

Regarding the assessment, there were many expectations for the LC examination. While a number of students were not fully aware of the examination structure or breakdown, students still presented a positive response to it. Students were pleased with the assessment breakdown, with 70% attributed to the examination and 30% attributed to the coursework assessment. While students did mention they would have preferred a greater percentage being attributed to the coursework, they also claimed to understand that it would make the grading of the subject more complex and challenging for examiners.

> I personally I feel it should be more, more 50/50 but I understand that that would be a lot harder for them to grade (5th year, male).
>
> I think it should be a bit more the project. Just... I suppose every student's going to say that though because you prefer the practical to the theory (5th year, male).
>
> Yeah, I think it's grand cause the project, like you can probably get some help with that. So I don't think it should be too much, but then it's important again at the same time. So I think it's fair like the breakdown (5th year, male).

Students reported feeling more confident going into the examination knowing they already had the coursework completed, and that alleviated some of the pressure as it was *'not all relying on the test'* (5th year, male). Students described this breakdown as *'quite comforting'* (5th year, female) and less stressful. As for the timeline, given that the LCCS examination takes place earlier than other LC examinations, students were also pleased with this as it allowed them to focus on other subjects and not have to worry about LCCS once the examination period for all other subjects commenced, *'you have an exam done and you can spend them two weeks worrying about other subjects then'* (5th year, male).

5.3 Students' Experiences of How the Subject was Realised

Students also raised a number of concerns and challenges about the subject. Students outlined that LCCS, although an appealing subject, could be quite challenging at the beginning. Students commented on the need to *'get past the first mental block'* and suggested that there was a *'big learning curve'* when starting LCCS that could be *'daunting'* (6th year, male), but once they progressed with the subject, they realized the subject was not as difficult and was actually enjoyable, *'at the start I actually... I wanted to drop computer science, like I think my first two weeks I was like 'no, I can't do this anymore' but then I actually ended up enjoying it'* (5th year, female).

5.3.1 Practical vs Theory

The main issue highlighted by students was the separation between the practical and theoretical content in LCCS, which resulted in students preferring the practical aspects and disliking the study of theorical aspects. When asked about favourite and least favourite content, the majority of students classified 'theory' as the least favourite aspect of LCCS. This dislike for 'theory' was also highlighted in the experience graphs completed by students, as can be seen in Figure 4, where 'theory' was commonly portrayed in the negative axis. When students made reference to 'Theory' this referred to more teacher-led instruction on aspects of the course content that encompassed content such as the history of computers and parts of the computer as well as elements of coding. Students outlined seeing the 'theory' and the practical aspects of CS as completely unrelated with one student even suggesting that it seemed like *'two completely different subjects just put into one'* (5th year, male). Many students disclosed not expecting to cover CS 'theory' as they expected it to be a fully practical subject, *'I just thought I would just be coding and stuff but didn't expect the history of it'* (5th year, female). The 'theory' was described by students as content that got in the way of the practical content and even disrupted the 'uniqueness' of LCCS.

> The theory, I felt like we kind of just pushed through the theory to get to the practical. So, the history that kind of stuff, I kind of think we just you know learn, we'll learn through it quickly and then we'll just, you know, the rest of the year we'll use to do practical, and I don't think we didn't really touch up on much of the history again or much theory (6th year, male).

> I don't think there should be a lot of theory. I think they should kind of cut down the theory, because you now, when people do computer science they want to code, they want to program, they don't want to sit there and take notes all day. That just ruins the whole purpose of this course. So obviously you have to have a

bit of theory, I'm not saying no theory, I just think a bit less theory and focus more on the coding side. (5th year, male).

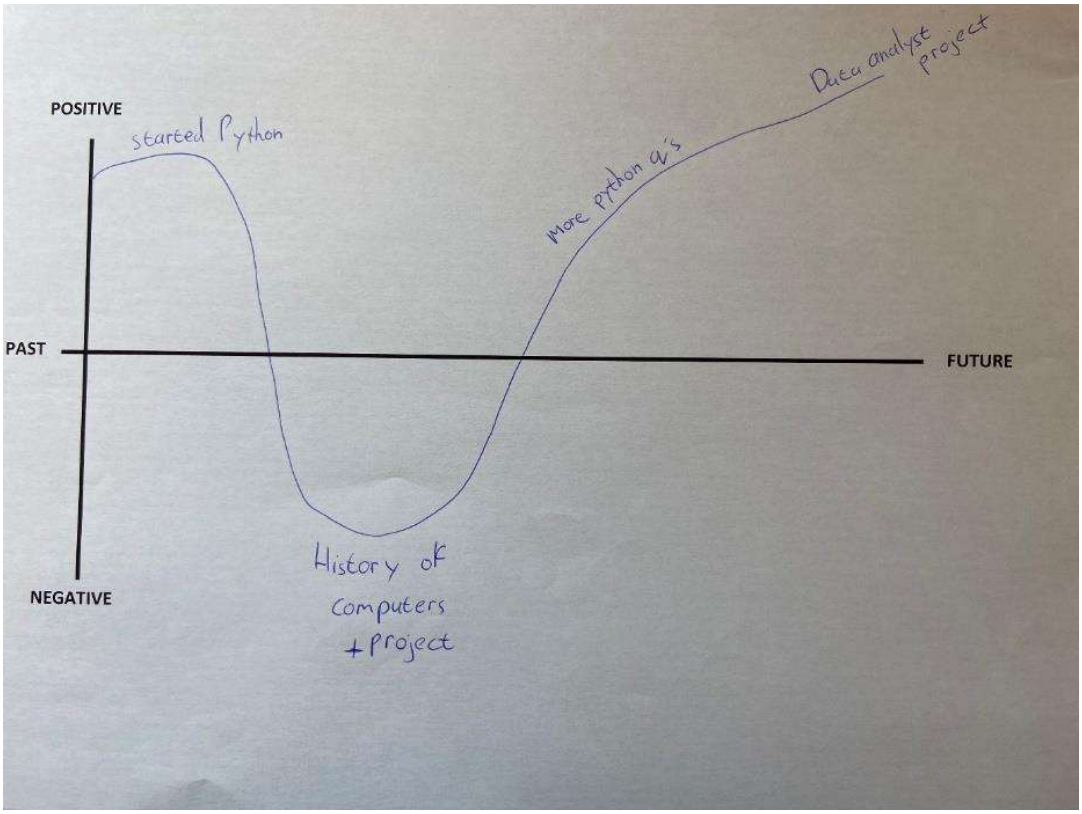


Figure 4 - *Experience graph example completed by participant*

Students indicated a clear preference for practical work with some even suggesting they did not see the point of learning about the theoretical aspects of CS, and some claiming it was just irrelevant and would not benefit them if they wanted a career in CS in the future.

And then with the theory side, I don't understand why there's theory in computers, if you understand what I mean, because with computers when you go in for a job at like Microsoft, they're not going to ask when the first computer was made, like [...] They're going to ask how good you can code (5th year, male).

There was mention that the theoretical aspects of CS were just like every other subject and that learning the 'theory' was similar to other subjects where memorisation of content was required. Practical content was characterised as understanding-based while the 'theory' content

was seen as learning off, *'with code and all that, it's you learn as you go along, with theory, you have to go back over it and study'* (5th year, male). In addition, students described a clear separation of 'theory' and practical classes, as detailed in the examples below.

> Well, for if it's theory class, just sort of open up the laptop, open up a Word document and then they have a PowerPoint slide, take down notes and that's kind of it for a theory class. As for like you know, coding-based class, it's more of like we're given, we're sat down, taught a bit of code, given questions to do, and we answer them, and we learn how to code a bit more (5th year, male).

> Like [*teacher*]'ll usually tell us if we're having a note-taking class or just coding (5th year, female).

A small number of students, however, demonstrated an interest for the 'theory' content from the onset or developed a liking for it by the time of the follow-up interviews, *'it's kind of, it's good to know the history of something you're studying, like'* (5th year, male); *'and eventually I started actually even enjoying the theory of it'* (5th year, male).

In relation to the overall content, students also presented some concern regarding the amount of content in the LCCS curriculum. Students claimed they *'did not expect it to be so heavy'* (5th year, female) given that it was a new subject. This was highlighted especially by students who had no previous experience of coding or CS or had not completed the taster course in TY or the short course in JC.

5.3.2 Subject Pacing

Participants also commented on the pacing of the subject with some claiming that it was being taught in a rushed manner while others believed the pacing was actually slow. There was general agreement that the subject was taught in a way that accommodated the different abilities and experience levels of the students, as some students came into the subject with some knowledge of coding while other students had no prior understanding of it. Students also acknowledged the

challenge it posed for teachers to engage students from different backgrounds and also students who could find the subject more difficult to grasp than others.

> But like for some people, they might think it's like too slow because they already know kind of what they're doing and then for others it's like you're going too fast cause I don't know what we're doing (5th year, female).

> I think the teacher we have, [*teacher*] goes through everything very like thorough. Like [*teacher*] makes sure everyone can understand. So, it's like good, but I guess some people are kind of forward in [*their*] class because some people have done coding things before. But I think it's good that [*teacher*] does that in case someone doesn't (5th year, female).

5.3.4 Applied Learning Tasks

Participants also raised concerns about the ALTs and outlined the time constraints and struggles with them. Although students did see the value of completing the ALTs and enjoyed completing these in groups, students also mentioned not having enough time to engage with these fully, *'I also think that it would have helped a lot more if we had a little bit more time to conduct it because you're in a very like a tight schedule'* (6th year, male). There was also a lack of clarity in relation to the objectives of the ALTs and some suggested a lack of guidance from teachers in this aspect, which resulted in students having a negative experience of the ALTs, *'honestly, that one project, that like last project, that was the only really big downside I had over computer science because it wasn't really explained well enough'* (5th year, male). This negative experience was also emphasised in the experience graphs (Figure 5) as many students included the ALTs in or around the negative axis of the graph, as can be seen in the example below. Figure 5 was explained as follows; *'and then the first ALT and it's kind of on the border between positive and negative because we struggled with it. And then the second one, we just really struggled with it, so I put it towards the negative'* (5th year, male). There were also comments that suggested

that students did not always understand the learning opportunities provided by the ALTs, especially if these were completed early in 5th year, *'I suppose there wasn't that much to learn from it, just like a project, so this was the first one, wasn't really as important, I guess'* (5th year, female).

Nevertheless, students did enjoy the ALTs because of its creative opportunity and the chance to experience a real-life scenario *'you get a glimpse of like oh this is what it is to be in like, a data analytic'* (5th year, male). The ALTs were also thought of as *'mini projects'* that would help prepare for and *'improve our main project'* (5th year, male), referring to the coursework that would take place in 6th year. The project management and autonomous aspects of the ALTs were also reported on positively by students as they liked having the opportunity to choose their group members and assign roles between them, which a female 5th year participant described as a *'fun social experience'*. Students also reported having the autonomy to work individually for the ALTs rather than in groups, which some preferred. In addition, the ALTs were described as an opportunity to create projects that would be relevant to the broader community, *'we decided to do [...] the Christmas lights, the lights would just turn on by themselves instead of like an elderly person having to like try and turn on the lights every night'* (5th year, female).

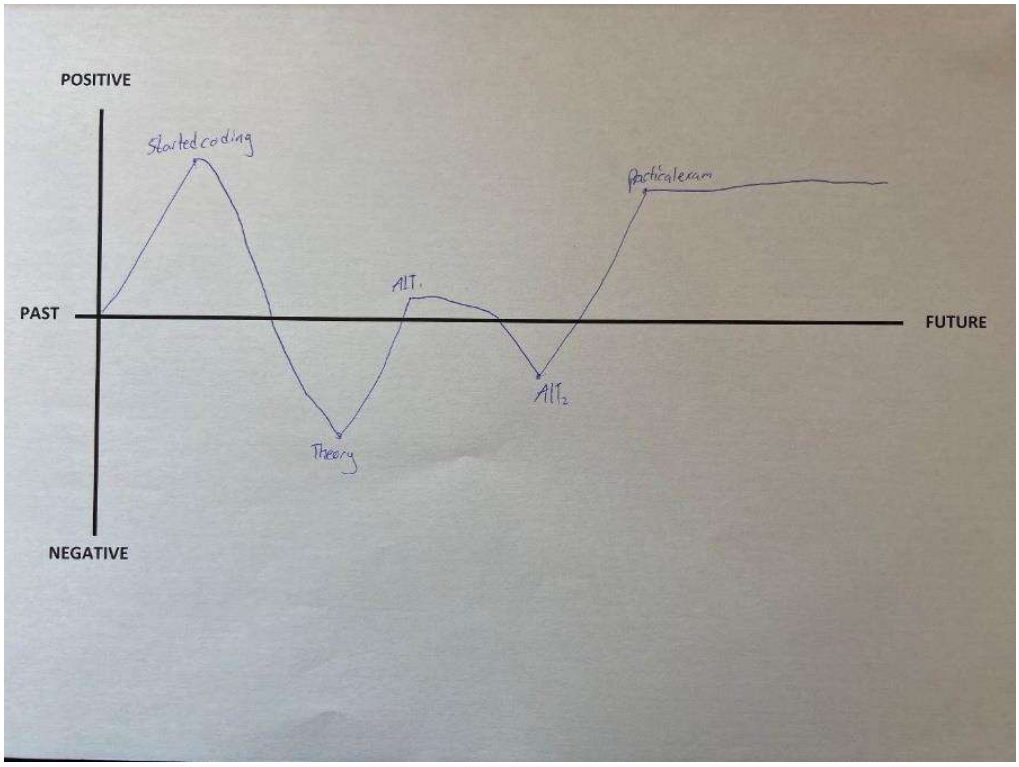


Figure 5 - *Experience graph completed by 5th year male participant*

5.3.5 Gender Misrepresentation

One final issue raised by students was in relation to the gender imbalance with a misrepresentation of females in the LCCS class. This gender misrepresentation was conveyed as more significant for the female students who were studying LCCS than for the males. When male students were asked about the gender ratio in class, they would acknowledge that there would be far less female students in the class but suggested that this would not have any influence in their learning or the classroom, *'I don't think it really matters like what gender you are. I suppose, it's still like the same subject, they [girls] still enjoy it'* (5th year, male). Students outlined that this was normal as males were typically more interested in CS than females. One student justified how males typically develop an early interested in CS because of hobbies, for example, while females are only introduced to it later in school, *'like because sort of boys are introduced to games and everything and all that, and girls are kind of left almost behind then. Like they have to discover a personal interest in it later usually'* (6th year, male).

For female students, there were some slightly different answers. Some appeared to conform with the misrepresentation, with some explaining that there were simply more boys in their year *'but also in my school I think we have more guys in general'* (5th year, female), and some emphasised that the ratio was better in LCCS than in other subjects where the male/female ratio was higher *'but it's like same with physics, I am the only girl in my physics class'* (6th year, female). Stereotypes were also pointed out suggesting that CS was commonly classified as a male subject, *'it's like they kind of say that computers and physics is more a boy's subject. Like the boys will do better in this subject and the girls will do better in chemistry and biology and business'* (6th year, female). Other female participants remarked how they wished more females would have chosen the subject. Some worked mainly with the other few female students in the class, while some expressed no problem working with other males. Comments about being hesitant to work with males were also made, the concern that they would simply not listen, with males being more outgoing and females being shy, *'I think all of the girls are quite shy and not so outgoing, but the boys are really outgoing. It might make the girls more shy because they're taking control'* (5th year, female). Students also explained this gender misrepresentation as being a result of timetable conflicts where female students chose other subjects that were timetabled at the same time, suggesting a wider school issue of how subjects were arranged in the timetable, *'a lot of girls didn't choose computer science because they chose French instead'* (5th year, male).

5.4 What Students Learn and Take from LCCS

Students commented on and outlined what they had learned from studying CS in school and what they expected to take from the subject moving forward. Students highlighted two main points: how their views of careers and third-level education were influenced by LCCS, and their perceptions of CS had broadened. Task 1 (Appendix D) summarized students' perceptions of CS by indicating the words they associated with CS the most.

5.4.1 Careers

While a small number of students were already interested in a CS career in the future, a large number of students developed a career strategy, an even an interest in CS career, once they engaged with the subject.

> Well I want to go on in college and do a computer science degree, so, I mean, just from coming from a point where I didn't want to do that (6th year, male).

> Now I know that I want to do something with computer science. Before I was still kind of like new to it. Now I've decided to do it (5th year, male).

Students who were interested in pursuing a CS career recognised the advantage they would have once in university compared to others who did not have a chance to study LCCS, *'I feel like I'd kind of be a bit ahead in a sense because I've the basics of coding and all that'* (5th year, female). Students who were interested in other careers, however, still acknowledged the advantages and the relevance of CS in other careers,

> If I do business, I feel like computer science would still come in handy with that. And if I do physics... And engineering maybe... Yeah, especially with engineering actually, I could code something on a micro:bit and then make it in engineering. Yeah, I think they all kind of connect or I can make them connect (5th year, female).

5.4.2 Misperceptions & Stereotypes

Students made observations of the misperceptions, and even stereotypical views, that other people would have about CS. Students suggested that others considered the subject *'very mathsy, very boring, very kind of repetitive, just kind of like dull kind of aspect'* but that this view was untrue and only occurred as people *'just haven't gotten enough exposure to the subject'* (6th year, male). Students also discussed having these misperceptions themselves before engaging with LCCS and how their perceptions had changed. The 'nerd' stereotype commonly associated

with CS was also mentioned by students both in the interviews and in the visual representation of CS. One student portrayed this 'nerd' perception in a visual representation (Figure 6), where CS students were illustrated as 'nerd' figures, claiming that this perception was also adopted by teachers, *'the students being represented as the anime class with the nerd emoji heads, because I feel like that's how the teacher might perceive the class due to their interest in computer science (nerds)'* (6th year, male). Another student admitted having a similar belief before studying LCCS until they realised their classmates did not fit the stereotypical image they had of CS, as can be seen below.

> Before I started like especially computer science like the only people I knew that were into computer science were also kind of nerds. Like not in a bad way, I don't think being a nerd is necessarily a bad thing, it's just like commonly associated. Now that like I see in my class like there's lots of people that I wouldn't think would be in that class, like usually associated with like I don't know the nerds. But there's a lot of people that aren't like that in the class and so that's definitely changed a bit (5th year, female).

Figure 6 - *Participant's visual representation of computer science*

The view that LCCS was suitable for certain people was reinforced by some students' beliefs that CS was a subject suitable for those who liked problem-solving, those who liked

computers, for those with a genuine interest in it, those who liked coding, those with the right attitude, those considered *'more brainy'* (5th year, female), those with a *'logical side'* (5th year, female) who were more logically creative rather than artistically/musically creative, or simply those willing to put in the work.

5.4.3 CS for All

When asked if they would recommend LCCS to other students, a large number of students believed it was a subject for all students, regardless of their interest in maths and regardless of having prior knowledge or experience of CS. Students also commented on how other students were sceptical about the subject, believing that they assumed it was too difficult or that prior knowledge of coding was important. They argued, however, that such a belief was misplaced and that LCCS was an accessible subject that any student could do.

> So, I feel like... yeah, everyone should do computer science. Well not everyone should do, everyone could do computer science (5th year, male).

> Yeah, I don't think it's suited to anybody, just because I didn't do anything with it and like I enjoy it and like, I can do it. So, I feel like everybody can do it. It's not just for one person (5th year, female).

The accessibility of LCCS was emphasised by students in many instances. Students claimed finding the curriculum appropriate for LC, *'it's kind of the right amount of difficult, like, that you actually have to focus to complete it and understand it'* (5th year, male). Students also viewed the subject as appropriate for students who had no prior experience of coding or CS, *'we're starting off like very basic so that's good for me, and then we're building it up'* (5th year, female). Students described the content of the subject as manageable and straightforward, *'very interesting, like easy to grasp and learn'* (5th year, male). The accessibility of the subject also led students to believe that it was a good 'fill in' subject for any student, *'if you have, like an empty*

slot like you don't know what to choose and you think computer science could come in useful I'd recommend doing it' (6th year, male).

5.4.4 Subject Differences

Students claimed that LCCS was quite different to other subjects available in schools. Differences were mentioned in respect to the content, the way it was taught, the learning approach, the way it was assessed, the ALTs and other concepts. A summary of the responses from Task 2 can be found in Appendix E which summarises the differences and similarities of the subject when compared to other subjects, as reported by students. Students viewed LCCS as a unique subject that did not belong to any established category of school subjects, but that did resemble maths in some respects.

> I mean, you have technology and engineering [...] Then you have your languages, then you have your sciences. You're kind of, you know, it doesn't fall into a category. It's its own thing. And I think in that way it's unique [...] I would have to say the biggest connection would be probably with maths, just because there is some involved in computer science, but it's... I wouldn't say it's heavily connected. Again, I think it's very unique (6th year, male).

> So, it's kind of similar to maths in that way. Like you sit down in the class, and you do a lot of problems until you really understand it, so (6th year, male).

5.4.5 Key Learnings

This distinction between LCCS and other subjects was portrayed in a positive way as they reported being able to apply more of what they learned in LCCS to outside the classroom than other subjects, *'so I feel like everything you kind of do in computer science kind of links back to the real world, and I don't find that with other subjects, so I think that's kind of good'* (5th year, male). This was reinforced by the key learnings and skills that students reported having acquired, or expected to acquire, from studying LCCS. Students mentioned gaining transferrable skills

including internet safety awareness, understanding of how certain devices and processes worked, problem-solving, repairing devices, teamwork skills, analytical thinking, thinking outside the box, basic computer skills, persistence, and coding skills. Some expected that such skills would provide career opportunities for them as the world was becoming increasingly digitised. They also believed that they could apply their knowledge and skills in other careers, as can be seen in the examples below. Other students did not identify transferrable skills and noted that what they learned in LCCS would only be relevant in CS careers.

> Like yeah, because I think it's like one of the most important and valuable skills to have today. So, it's needed in literally every aspect of like, like healthcare, business, law. Everything needs computer science and applications of it, so (6th year, male).

> You know like if you do computational thinking in computer science, that might help you solve problems outside, by thinking outside the box. And working your way around the problems instead of diving deep in headfirst and all of that (5th year, male).

> Being able to communicate with others is such an integral part of computer science as in the workplace, it is such a necessary skill to be able to work and communicate with colleagues (5th year, female).

Summary of Key Findings

- Internal and external factors influenced students' decision to study LCCS. Personal interest in the subject and past curriculum experiences, such as the taster course in TY or the JC short course in Coding, were important factors when choosing the subject. Teachers and family members also played a role in the decision-making process.
- Students claimed to enjoy the way LCCS was taught. The active and interactive nature of the subject were reported as unique and positive characteristics of the subject and students claimed that it enhanced their learning, engaged them in the subject and gave them the opportunity to actively influence their learning experiences. Teachers were described as approachable and were reported as promoting independence and maintaining a good learning atmosphere. Although the students were pleased with the teaching of the subject and acknowledged the benefits of the active learning approach, there was also the concern about the scarcity of notetaking and how it could affect their revision of the subject.
- Students also enjoyed the opportunities for collaboration and groupwork that the subject offered. While in some schools groupwork was reported as essential, in other schools the groupwork element was not adopted in class. The benefits and challenges of groupwork and collaboration were also mentioned.
- Creativity was reported as one of the core elements of CS. Students highlighted that creativity was necessary in coding and that the creativity in CS was different to the creativity associated with other subjects. Students further recognised the creative element of CS in the follow-up interviews when they had experienced the subject for a longer period of time.
- A separation of practical and theoretical aspects of the course was experienced by students, with students indicating a clear preference for practical tasks and often a

dislike for teacher-centred methods used to teach the more theorical aspects of the content. This type of learning they associated with 'theory'. Students commented on the differences of learning practical topics compared to 'theory' topics. A separation of practical and 'theory' classes was also described by students. Overall, students presented concerns regarding the amount of content in the LCCS curriculum.

- The ALTs were viewed positively by students, although challenges were also acknowledged. Students enjoyed the social experience that the ALTs provided as most students completed these in groups. The ALTs were described as providing opportunities to be creative, allowing students to experience real-life scenarios, preparing for the coursework, and giving students an opportunity for greater autonomy. In addition, students enjoyed creating projects that would be useful to others in the broader community. However, the ALTs were not always seen in a positive light as some students outlined the challenges they encountered. The challenges included: not having enough time to fully engage with the tasks, lack of guidance from teachers and not being clear on the learning objectives of the tasks.
- A gender imbalance was discussed with students reporting a misrepresentation of females in the LCCS class. Female participants also pointed out the stereotypes that would be frequently associated with certain subjects, one of them being CS. CS was said to be commonly considered as a 'male subject', which consequently discouraged other female students from choosing the subject. Female participants also commented on feeling hesitant about working with their male classmates. Wider school-level timetable arrangements were also said to have inhibited female students from choosing LCCS.
- Some students were interested in pursuing a CS career while other students were interested in alternative careers. However, regardless of the career expectations, students recognised the advantages and relevance of CS for their future careers. The key learnings and skills that students believed they acquired in LCCS were seen as

transferrable to other professions. Problem-solving, teamwork skills, analytical skills, and coding were often mentioned as key skills acquired in LCCS.

- Misperceptions and stereotypes associated with CS were highlighted by students. Some students discussed having some stereotypical beliefs themselves before engaging with the subject. The 'nerd' stereotype, commonly associated with CS, was mentioned by participants both in the interviews and in the visual representation of CS. Students commented on the inaccuracy of the misperceptions associated with the subject.

6. DISCUSSION AND RECOMMENDATIONS

This study explored 5th and 6th year students' experiences of the CS subject in Irish second-level schools, using a qualitative approach. Overall, the study indicated that students have a predominantly positive experience of the subject, with some challenges and concerns that were also discussed.

Section 1: Pre-requisites matter! And context matters.

The study demonstrated that students chose to study CS in second-level school because of personal interest or due to external influences. Many of those who already had a personal interest in the subject, due to hobbies and natural curiosity about technology and computers, also had their interest enhanced by external influences. Other students developed an interest solely based on external factors, such as the JC short course and/or TY initiatives. The findings suggested that early initiatives did encourage students to choose the subject. This finding was consistent with what has been reported in previous studies, for example, Samarasekara et al. (2022) highlighted the importance of early exposure to CS in second-level schools in New Zealand, in order to raise awareness of and increase enthusiasm for the subject. The JC short course in Coding and TY programmes were presented by students as highly influential factors when deciding to study LCCS. While a small number of the students interviewed did not engage in these early initiatives, the majority of students had completed either the JC short course in Coding or a TY taster course, or both, suggesting that such initiatives played an important awareness-raising role that subsequently influenced students' decisions to choose LCCS.

In line with previous research (Kiernan et al., 2023), the study stressed the significance of contextual factors in subject decision making. Factors included parental influence, teachers' perceptions, availability of early initiatives, subject offering and subject perceptions. Regarding parental influence, what could be noticed from the findings was that this influence was relatively small, with only a few students claiming that their parents played a role in their subject choices.

This challenged previous literature that has suggested that parents were a significant influence in their children's subject choices, particularly in STEM subjects (Ekmekci et al., 2019). LCCS could therefore be unique in this regard as most parents may not be familiar with what CS entails, and therefore would not be in a position to encourage or indeed discourage their children in relation to this specific subject.

Teachers also play a role in students' subject choices (Hand et al., 2017) and this was noted by the students in this study, with more males being encouraged by teachers to pick the subject. Students also reported being encouraged by teachers who commented on their capability for the subject. This raised the concern of educators having potentially damaging stereotypical view of LCCS being more suitable for males or students with specific abilities, and how this can affect the subject's uptake and to whom the subject is being promoted to. Such an outdated perception of LCCS being an elite subject for specific students could also inhibit teachers from undertaking the teaching of the subject, which would further contribute to the national shortage of qualified LCCS teachers.

The study also highlighted the critical role of schools in influencing subject choices. Factors such as the availability of early initiatives in the school and subject offering were highlighted by students. As mentioned above, taking part in past curriculum experiences such as the JC short course in Coding or TY taster courses appeared to play an important function in raising awareness of the subject and debunking stereotypes, and therefore appear to play and important role in encouraging uptake amongst students not already familiar with CS. The manner in which the school offered LCCS was also influential. Students reported knowing fellow classmates who were prevented from doing LCCS because of timetable conflicts demonstrating the care needed by schools when setting optional subject groupings.

Recommendations:

1. Continue/enhance the JC short course and TY taster courses in schools as these are influential in encouraging subsequent participation at LC level. A targeted initiative to introduce the JC short course in schools that do not currently offer it and the further promotion of it in existing schools is likely to have immediate impact on uptake at LC level.
2. Further work should be done at a national and school level to educate parents about CS, particularly challenging the stereotypes associated with the subject.

Section 2: Pedagogy of the subject

As the findings have highlighted, students reported experiencing a 'novel' pedagogical approach in LCCS, suggesting that LCCS teachers were moving away from the traditional teacher-centred approach and adopting a student-centred approach. Student-centred practices aim to help students develop independence and autonomy by increasing the students' responsibility for their own learning (O'Neill & McMahon, 2005), and the findings of the study supported this as students mentioned having a greater sense of independence in LCCS classes compared to other subjects. In student-centred practice, active learning, where students are actively involved in their learning, is strongly encouraged. This contrasts with the traditional teacher-centred approach that is often seen in classrooms, where students are passive receivers of the information generated by teachers (Gilleece et al., 2009).

The student-centred approach adopted by LCCS was viewed in a positive light and students reported being pleased with their active engagement in the subject. Student-centred strategies, such as active learning, have consistently been shown to have significant effects on student learning and motivation (OECD, 2018), therefore it was not surprising that students had such a positive view of it. Students outlined an enhanced engagement with and learning of CS

material as well as acquiring a set of skills, including problem solving, analytical thinking and communication skills. This is in line with previous studies that have suggested that active learning practices promote skills that are increasingly relevant in the modern world and that have many benefits for students, including improved understanding of what is learned, increased engagement with the material, critical thinking and development of interpersonal skills (OECD, 2018).

Although many benefits are associated with the student-centred approach, these practices have traditionally not been common in Irish classrooms. A 2009 report concluded that, in Ireland, student-oriented practices were used relatively infrequently in classrooms (OECD, 2009). Almost a decade later, similar findings were reported, with student-oriented practices still being used less frequently (Schleicher, 2016). This was discussed by students in the current study as they highlighted the comprehensive differences in how other subjects, that make use of teacher-centred strategies are taught, and how LCCS was unique for using active learning strategies. This shift from the teacher-centred to a student-centred approach in LCCS was also highlighted by teachers in the NCCA report (2023b) where teachers commented on the challenges of 'letting go' of their traditional role as the experts in the classroom and giving students the opportunity for self-directed learning. Implementing active learning practices in the classroom was assumed to carry risks as it would mean that teachers would have to abandon the traditional ways of teaching and potentially lose control of the class and risk students not learning sufficiently (OECD, 2018). However, the current study demonstrated that this does not appear to be the case. Instead, it suggested that students were more involved in their learning and had stronger connections with their teachers.

In addition to the study highlighting the 'novel' teaching approach in LCCS, it has also highlighted the role of teachers as facilitators in the classroom. The traditional image of a teacher is that of one who is the source of knowledge and has the full control of the classroom and learning activities, which are characteristics of the teacher-centred approach (Serin, 2018).

In the student-centred approach, however, students' view of the teacher as a facilitator is paramount (Brandes & Ginnis, 1986). The findings indicated that LCCS teachers were considered facilitators who were themselves on a learning journey, given that LCCS was a new subject and teachers generally had less CS teaching experience compared to their primary subject area of expertise. However, this developing content expertise allowed students to connect with teachers, as they collaborated to acquire a deeper knowledge of the content. Nevertheless, this assertion that teachers are still developing their pedagogical content knowledge (PCK) in relation to this new curriculum, stressed the need for continuous professional development to ensure the success of the subject.

It emerged in the study that this novel teaching approach, however, was only applied to the practical content of the subject. Students discussed that active learning was adopted when teaching practical content, while a more traditional passive learning approach was then used in teaching more theoretical content. This resulted in students having a preference for the practical content, and consequently its active teaching method, while disliking the 'theory' content and the passive learning behind it. It is important to highlight that students perceived the practical project-based content as detached from the 'theory' content, and this perception was reinforced by the timetabling of classes where single class period lessons were often used for 'theory' and double class periods lessons were used for practical, project-based work. While it is understandable that double class period lessons are more convenient for practical work, as short lesson times would not facilitate the student-centred collaborative learning strategies adopted by the subject, it also brings to light the wider school-level logistics that should be considered in schools that offer the subject. These findings are in accordance with findings reported by McGarr et al. (2020) where LCCS teachers also suggested a demarcation of 'theory' and practice. Together, these findings demonstrate the importance of teachers developing their PCK in order to address this current disconnect between 'theory' and practice, and the corresponding teaching practices.

Peer learning, an element of the student-centred approach, was also highlighted in the findings. Although there were some concerns about groupwork and collaboration, students agreed that engaging in these practices enhanced their learning of the subject. Students in this study emphasised how collaborating with classmates facilitated their learning and increased their productivity in tasks. While a small few preferred working individually and noted the disadvantages of groupwork, the vast majority of students valued the opportunity of working with friends. The findings indicated that groupwork and collaboration were beneficial for LCCS students by improving productivity, efficiency and developing relationships with classmates, although some difficulties and challenges were also raised by students. These findings are in line with previous literature where peer learning was suggested to enhance learning and increase attention in an introductory programming course (Porter et al., 2016).

The results, however, suggested a discrepancy between intended aspects of the curriculum and how it was being operationalised in relation to groupwork. The LCCS curriculum specification outlines groupwork as a mandated aspect in the subject in order to support students to gain groupwork skills (NCCA, 2018, 2023a), yet this was not reported in every school. While in some schools groupwork was essential, in other schools, students had no experience of groupwork per se, only of collaboration. While collaborative work was important and beneficial, students who did not engage in groupwork could potentially miss out on the groupwork-specific skills set out in the curriculum specification, including negotiating, conflict resolving, identifying, and evaluating collective goals. This concern was previously raised by Milwood and Oldham (2017), where they questioned if the intended pedagogy for the subject would actually be implemented in Irish classrooms, specifically, if teachers would adopt the novel groupwork model. It should be considered that not all teachers might feel comfortable with or have the skills necessary to adopt this 'relatively novel' nature of groupwork (Millwood & Oldham, 2017), which calls for continuous professional development and instructions in this area.

Another issue raised by Milwood and Oldham (2017) was if the assessment format for LCCS matched the intended pedagogy, as this would have an impact on the teaching approach. This was previously seen in similar post-primary CS studies (Bell et al., 2014), where the teaching was driven by the nature of the assessment, and in the recent NCCA report (2023b) where LCCS teachers highlighted that their planning for the subject was indeed influenced by the assessment. Further research focusing on LCCS teachers would be necessary to determine if the lack of groupwork in some schools was due to the pressure and nature of the examinations, or insufficient skills to implement it.

Overall, the pedagogical approach experienced by students in this study reflected the practices proposed for teaching CS internationally. Ryoo (2019) concluded, based on teachers' and students' testimonies, that engagement in CS learning is supported by teaching practices that connects the CS learning to everyday life, that addresses social issues and that welcomes students' voices and perspectives. All these elements were reported by participants in the current study, for example, students commented on how the ALTs reflected real-life scenarios in specific CS careers, how artefacts created for the ALTs would be relevant for the community, and how they had the freedom to share their ideas in the classroom.

Findings from this study emphasised the importance of providing clear instructions and outlining the aims of the tasks being completed. While the students enjoyed the collaborative nature of the ALTs, they also discussed not being clear on the objectives of the tasks and how it was relevant to their learning of the subject. Students suggested a lack of guidance from teachers and not having enough time to complete these tasks. It is concerning that students were not clear on the objectives of the ALTs, suggesting that more effort is needed from teachers to make the links between the ALTs and the learning outcomes more explicit. Many students recounted having negative experiences with the ALTs, mainly because of the time pressure and not fully understanding how to or why they were completing the tasks. A small minority of the students understood the ALTs to be a preparation for the final coursework, yet a

lack of familiarity with the coursework and examination format made it difficult to establish how exactly the learning achieved through the ALTs would be applied to the examination and overall learning.

Students also questioned the breadth of the curriculum, as was found in the NCCA report (2023b), indicating that having four ALTs as well as covering all the required content was impractical. Students lamented not having enough time to fully immerse themselves in the ALTs and noted that the curriculum was quite demanding for a newly established subject – raising the question as to whether the specification is overly ambitious. If this is the case, it could mean that the pressure to 'cover' content is stifling deep engagement in the content. This could also explain why some teachers did not adopt groupwork in class, as it may be seen as impeding progress in 'covering' mandatory content.

Recommendations:

1. Continuing professional development is necessary as it was highlighted that teachers were still developing LCCS content expertise.
2. It is important to identify and address the reasons for why not all teachers adopt the groupwork aspect in their classes.
3. Outline the objectives of the ALTs so students have a clear understanding of what they are doing and why they are doing it.

Section 3: Creativity

The study has identified three dimensions of creativity that students experienced in LCCS: creativity in terms of ways of expressing their learning, opportunities for aesthetic creativity, and creativity in coding. Creativity in coding featured as the dominant dimension as it was heavily emphasised by students. Although the LCCS curriculum specification outlines that one of the

aims of the subject is to cultivate student creativity, students were not initially aware of this creative element in CS. This is not surprising as CS is not typically promoted as a creative subject, as most people tend to think of subjects such as Art, Music and Design and Communication Graphics when thinking of creative subjects. Yet, the findings of this study challenged the common perceptions of creative subjects.

It can be noted that students emphasised the creative aspect of CS more during the follow-up interviews, suggesting that students started to recognise this creative aspect as they were further exposed to the subject. These results are consistent with previous research literature. Yardi and Bruckman (2007), for instance, investigated perceptions of CS and suggested that the teenagers who were interviewed were not interested in CS as they believed it did not allow for creativity. In contrast, graduates of a college of computing were also interviewed and emphasised the creative opportunities in CS. Similarly, Grover and colleagues (2014) found that, compared to middle-school students, university students completing a CS course increasingly associated CS with creativity. This is in line with the current study, as participants who were not yet fully exposed to CS did not recognise how creativity was applied to CS, yet those who were already engaged with the subject for a longer time appreciated its creative component. This finding indicated that one had to experience the subject in order to understand the creativity associated with it, suggesting that it can be difficult to communicate its creative aspect to someone with no experience in CS.

Creativity is described as "the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints)" (Sternberg & Lubart, 1998, p. 3). This definition precisely aligns with the creativity in coding mentioned by participants, as they produced code that was original (different from the teacher's code) and also appropriate (obtaining the expected result). Creativity is believed to be in the top 5 most demanded skills for jobs of the 21st century and is considered one of the key human competencies that cannot be automated or substituted by digitalisation (Vincent-Lancrin et al.,

2019). Students in this study acknowledged the value of developing their creative skills in CS, as it could be transferred to other subjects, as well as to their future careers. Creativity is also thought to bring about a deeper understanding and learning of information (Vincent-Lancrin et al., 2019), which the students highlighted experiencing as they completed coding tasks in class. Creativity has been increasingly associated with CS (Bresnihan et al., 2015), and coding specifically (Siegle, 2017), and the findings of this current study also provided an insight into the link between creativity and coding.

Recommendations:

1. Emphasise the link between CS and creativity so other students, as well as parents and teachers, can understand that CS provides opportunities for creativity.

Section 4: Careers and Stereotypes

The results indicated that many students entered LCCS with no career strategy. Instead, many developed an interest in CS, or understood the benefits of CS in other careers once they were engaged in the subject. In addition, students acknowledged the misperceptions and stereotypes associated with CS, and suggested that such views might discourage others from taking up LCCS, although it did not prevent them from picking the subject themselves. Students admitted having carried stereotypical beliefs about CS themselves but acknowledged that later they discarded such beliefs as they experienced LCCS. Similar to the current study, past research has also shown that participants who had no experience of CS often generated more stereotypical views of the subject than those who were already familiar with it (Cheryan et al., 2013). This supports the argument that current stereotypes of CS might simply be a lack of familiarity with the subject.

Past research reports that individuals have a stereotypical view of the CS profession and that computer scientists are often described as geeky, unattractive, highly intelligent, introverted, white males (Cheryan et al., 2013; Vasconcelos et al., 2022). Stereotypical portrayals

of CS and of computer scientists can affect engagement with the subject at second-level education, as such portrayals are often incompatible with how students envision themselves. Females, especially, are inhibited from engaging with the subject and subsequently pursuing a CS career because of these stereotypes. Such views of CS dominate the media and can potentially influence how people think about the subject and CS careers in general. A lack of role models would also be a contributing factor to students' narrow view of CS. Although some studies suggest that perceptions of computer scientists may be improving with people having less stereotypical views (Pantic et al., 2018), other studies suggest that little has changed when it comes to perceptions of CS and CS careers (Berg et al., 2018).

The 'nerd' stereotype is also commonly associated with those who work in the CS field. However, this commonly held belief that CS was a subject for 'nerds' was challenged by students in this study, with the majority of students claiming that LCCS was a subject for everyone, regardless of gender, previous experience or abilities. These findings contradict the popular conception that CS is suitable for a specific group of people with specific interests. However, there was a small number of students who maintained an elitist view of CS being more suitable for students with specific preferences or 'aptitude'. Although some elements of CS, such as programming, has been considered difficult and challenging to learn, (Abesadze & Nozadze, 2020), it would be wrong to assume that the subject is only appropriate for the 'brainy' students. Debunking these beliefs is important to encourage more students to engage with the subject and promote a more realistic view of CS as a school subject and as a career. LCCS should not be considered only for those who want to pursue a CS career, but to prepare students with the fundamental CS knowledge and skills that are needed in this digital age and for the jobs of the 21st century.

Recommendations:

1. It is important that schools and educational policy makers continue to work to remedy the misperceptions that people have of CS and promote the importance of CS skills in this digital age.

Section 5: Wider implications for senior cycle reform

The introduction of LCCS needs to be seen within the wider context of curriculum reforms at senior cycle. Building on the reforms at Junior Cycle, it was one of the first subjects that adopted the language of specifications and learning outcomes that were features of the Junior Cycle reforms. It was also one of the first to embed project-based learning experiences as part of the pedagogy of the subject as opposed to being used only as an assessment element. As a pioneering subject in this regard, there are broader insights and learnings that can inform the wider curriculum reforms at senior cycle level. One key aspect is how project-based components are integrated within revised subjects. While the introduction of a project-based component to all subjects is a key feature of reforms at senior cycle, this study has found that the project-based components are frequently experienced as separate from the 'theory' of the subject. In effect, the project-based components, that were designed to act as a vehicle through which the students experienced the course content, are instead presented as somewhat separate tasks. As reforms at LC continue, and as project-based components are included in all subjects, it cannot be assumed that these changes will lead to substantial changes in pedagogy and assessment. Given the dominant modes of teaching within upper second-level schooling and the stifling influence of high-stakes senior cycle examinations, there is the possibility that these project-based components could be treated as separate components. In effect, they could run in parallel to the traditional teaching of the course content and have little influence on the broader teacher-centred pedagogy employed in the subject. Wider assessment influences are

therefore likely to limit the extent to which more student-centred practices are woven into the ongoing experience of the subject.

Also of wider relevance for senior cycle reform is the students' preferences for student-centred, collaborative learning. Their preference for problem-based learning and peer interaction in the form of cooperative learning was also evident. While such pedagogical practices are somewhat novel in the context of senior cycle, where high-stakes testing has led to a repository form of teaching, the findings of this study would indicate that students enjoy opportunities to engage in this form of learning and respond to it positively. Coupled with changing teaching practices at junior cycle level, it is likely that such changes can be adopted by students with relative ease.

7. CONCLUSIONS

This study has found that the introduction of the subject has been successful with a growing number of schools taking on the subject beyond the initial group of 40 pilot schools in 2018. That being said, the sustainability of the subject and its capacity to gain a wider reach is at a critical point. As these findings highlight, students' experiences of the subject are very positive, both in relation to the pedagogical approach that the subject employs and also the opportunity for creative and collaborative work. However, its development appears to remain dogged by negative and inaccurate stereotypes, a wider lack of understanding of what CS entails, and a lack of appreciation of its wide application in all aspects of society. It could be argued that the establishment of LCCS on the curriculum does not mark the final stage in establishing the study of CS in Irish schools but is instead only the first step. There is now a significant job of work to do to widen participation amongst the school-going population, address the wider societal ignorance that exists in relation to what CS is and educate the wider public in relation to how it influences all aspects of our lives. Perhaps most importantly, the most challenging job of work is in challenging the inaccurate and limiting stereotypes that exist about who should study CS. This appears to be the biggest challenge to the long-term success of the subject. If work in this area is not addressed, LCCS may remain on the curriculum but only as a specialist subject for a very small cohort of students – thus denying other students an opportunity to explore this area of knowledge. It must also be noted however that associating the study of CS in schools with employment opportunities in the CS sector may in the long run result in lower levels of uptake within schools as this will only ever attract a small percentage of students. In a technology-rich society, an understanding of coding and the wider aspects of CS is no longer a specialist body of knowledge required by key professionals. It is arguably an essential part of what it means to be digitally competent in the 21st century and therefore has relevance for all future careers and citizens. Framing CS in this context liberates it from the narrow vocational rationale that it is currently set within. As this study has found, it is a subject that promotes creativity, enables

student collaboration, and achieves many of the important learning outcomes required in the 21st century. It is therefore a unique vehicle to achieve many of these educational goals regardless of whether a student ultimately decides to pursue a career in this area. For that reason, framing it as an essential skill for all rather than being part of the STEM portfolio of subjects may prove more advantageous in the long-run.

Concluding remarks: Unintended consequences of subject adjustments

Recent covid-related adjustments to LCCS and other changes to the subject (DE, 2022, 2023) show a responsiveness to schools' pressures and such flexibility is essential to help a new subject become established and sustainable in the longer-term. That being said, reductions in project-based components through changes to ALTs (DE, 2023) may have the unintended consequence of reducing opportunities for students to engage in project-based learning as the space created as a result of the adjustments may not be necessarily used to deepen students' engagement with existing applied learning tasks. It instead could be used to increase time devoted to more teacher-centred pedagogies due to pressures to prepare for high-stakes examinations. This not only has the potential to widen the theory-practice divide experienced and reported on by students, but it also has the potential to erode the unique characteristics of a subject that has project-based learning as a central aspect to how the subject is experienced. The collective effect of these changes could, unintentionally result in the diminution of the distinctive project-based and problem-based aspects of the subject, aspects that the students commented most favourably on in relation to the subject.

REFERENCES

Abesadze, S., & Nozadze, D. (2020). Make 21st century education: The importance of teaching programming in schools. *International Journal of Learning and Teaching*, *6*(3), 158–163. https://doi.org/10.18178/ijlt.6.3.158-163

Atkins, L., & Wallace, S. (2012). *Qualitative Research in Education*. SAGE Publications Ltd. https://doi.org/10.4135/9781473957602

Bell, T., Andreae, P., & Robins, A. (2014). A case study of the introduction of computer science in NZ schools. *ACM Transactions on Computing Education*, *14*(2), 1–31. https://doi.org/10.1145/2602485

Berg, T., Sharpe, A., & Aitkin, E. (2018). Females in computing: Understanding stereotypes through collaborative picturing. *Computers & Education*, *126*, 105–114. https://doi.org/10.1016/j.compedu.2018.07.007

Brandes, D., & Ginnis, P. (1986). *A guide to student-centred learning*. Oxford: Blackwell.

Braun, V., & Clarke, V. (2022). *Thematic analysis: A practical guide*. SAGE Publications Ltd.

Bravington, A., & King, N. (2019). Putting graphic elicitation into practice: Tools and typologies for the use of participant-led diagrams in qualitative research interviews. *Qualitative Research*, *19*(5), 506–523. https://doi.org/10.1177/1468794118781718

Bresnihan, N., Millwood, R., Oldham, E., Strong, G., & Wilson, D. (2015). A critique of the current trend to implement computing in schools. *Pedagogika*, *65*, 292–300. http://userweb.pedf.cuni.cz/wp/pedagogika/

Cheryan, S., Plaut, V. C., Handron, C., & Hudson, L. (2013). The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex Roles*, *69*(1), 58–71. https://doi.org/10.1007/s11199-013-0296-x

Connolly, C., Byrne, J. R., & Oldham, E. (2022). The trajectory of computer science education policy in Ireland: A document analysis narrative. *European Journal of Education*, 1–18. https://doi.org/10.1111/ejed.12507

Connolly, C., & Kirwan, C. (2023). *Capacity for, access to, and participation in computer science education in Ireland*. University of Galway. https://doi.org/10.13025/bccm-2c38

DE. (2017). *Digital strategy action plan 2017*. https://www.gov.ie/en/publication/f8990-digital-strategy-for-schools-2015-2020/#digital-strategy-for-schools-2015-2020

DE. (2022, August 9). *Assessment arrangements for Junior Cycle and Leaving Certificate examinations 2023*. https://www.gov.ie/en/publication/50564-leaving-certificate-2023/#assessment-arrangements-for-junior-cycle-and-leaving-certificate-examinations-2023

DE. (2023, September 18). *Assessment arrangements for Junior Cycle and Leaving Certificate examinations 2024*. https://www.gov.ie/en/publication/fdc21-assessment-arrangements-for-junior-cycle-and-leaving-certificate-examinations-2023/

Department of Education. (2015). *Digital strategy for schools 2015-2020*. https://www.gov.ie/en/publication/f8990-digital-strategy-for-schools-2015-2020/#digital-strategy-for-schools-2015-2020

Ekmekci, A., Sahin, A., & Waxman, H. (2019). Factors affecting students' STEM choice and persistence: A synthesis of research and findings from the second year of a longitudinal high school STEM tracking study. In A. Sahin & M. J. Mohr-Schroeder (Eds.), *STEM Education 2.0* (pp. 279–304). Brill. https://doi.org/10.1163/9789004405400_015

Gilleece, L., Shiel, G., Perkins, R., & Proctor, M. (2009). *Teaching and learning international survey (2008): National report for Ireland*. Educational Research Centre Dublin. https://www.erc.ie/programme-of-work/talis/?highlight=teaching%20and%20learning

Grover, S., Pea, R., & Cooper, S. (2014). Remedying misperceptions of computer science among middle school students. *Proceedings of the 45th ACM Technical Symposium on Computer Science Education*, 343–348. https://doi.org/10.1145/2538862.2538934

Hand, S., Greenlee, L., & Greenlee, E. (2017). Exploring teachers' and students' gender role bias and students' confidence in STEM fields. *Social Psychology of Education*, *20*. https://doi.org/10.1007/s11218-017-9408-8

Kiernan, L., Walsh, M., & White, E. (2023). Gender in technology, engineering and design: Factors which influence low STEM subject uptake among females at third level. *International Journal of Technology and Design Education*, *33*(2), 497–520. https://doi.org/10.1007/s10798-022-09738-1

Majid, M. A. A., Othman, M., Mohamad, S. F., Lim, S., & Yusof, A. (2017). Piloting for interviews in qualitative research: Operationalization and lessons learnt. *International Journal of Academic Research in Business and Social Sciences*, *7*(4), 1073–1080. https://doi.org/10.6007/IJARBSS/v7-i4/2916

McGarr, O., McInerney, C., Exton, C., & Power, J. (2020). *Exploring teachers' professional development to support the roll-out of Computer Science in Irish second-level schools*. Final report of the SFI-funded project (Discover programme). https://lero.ie/

Millwood, R., & Oldham, E. (2017). Computer science in schools in England and Ireland – Context and current developments in 2017. *Redin - Revista Educacional Interdisciplinar*, *6*(1), Article 1. https://seer.faccat.br/index.php/redin/article/view/779

NCCA. (2018). *Computer science: Curriculum specification*. https://www.curriculumonline.ie/Senior-Cycle/Senior-Cycle-Subjects/Computer-Science/

NCCA. (2023a). *Computer science: Curriculum specification*. https://www.curriculumonline.ie/Senior-cycle/Senior-Cycle-Subjects/Computer-Science/

NCCA. (2023b). *Report on the early enactment review of leaving certificate computer science*. https://ncca.ie/en/senior-cycle/curriculum-developments/computer-science/

O'Doherty, T., Gleeson, J., Moody, J., Johnston, K. T., & McGarr, O. (2004). *Computers and curriculum—Difficulties and dichotomies.* University of Limerick. https://researchrepository.ul.ie/articles/report/Computers_and_curriculum_-_difficulties_and_dichotomies_/19819459/1

OECD. (2009). *Education at a glance 2009: OECD indicators*. OECD Publishing. https://doi.org/10.1787/eag-2009-en

OECD. (2018). *Teaching for the future: Effective classroom practices to transform education*. OECD Publishing. https://www.oecd-ilibrary.org/content/component/9789264293243-6-en

O'Neill, G., & McMahon, T. (2005). Student-centered learning: What does it means for students and lectures? In G. O'Neill, S. Moore, & B. McMullin (Eds.), *Emerging issues in the practice of university learning and teaching* (pp. 27–36). All Ireland Society for Higher Education (AISHE). https://www.aishe.org/aishe-readings-2005-1-emerging-issues-in-the-practice-of-university-learning-and-teaching-geraldine-oneill-sarah-moore-and-barry-mcmullin-editors/

Pantic, K., Clarke-Midura, J., Poole, F., Roller, J., & Allan, V. (2018). Drawing a computer scientist: Stereotypical representations or lack of awareness? *Computer Science Education*, *28*(3), 232–254. https://doi.org/10.1080/08993408.2018.1533780

Porter, L., Bouvier, D., Cutts, Q., Grissom, S., Lee, C., McCartney, R., Zingaro, D., & Simon, B. (2016). A multi-institutional study of peer instruction in introductory computing. *ACM Inroads*, *7*(2), 76–81. https://doi.org/10.1145/2938142

Quille, K., Faherty, R., Bergin, S., & Becker, B. A. (2018). Second level computer science: The Irish K-12 journey begins. *Proceedings of the 18th Koli Calling International Conference on Computing Education Research*, 1–5. https://doi.org/10.1145/3279720.3279742

Ryoo, J. J. (2019). Pedagogy that supports computer science for *all*. *ACM Transactions on Computing Education*, *19*(4), 36:1-36:23. https://doi.org/10.1145/3322210

Samarasekara, C. K., Ott, C., & Robins, A. (2022). Barriers to New Zealand high school CS education—Learners' perspectives. *Proceedings of the 53rd ACM Technical Symposium on Computer Science Education V. 1*, 927–933. https://doi.org/10.1145/3478431.3499344

Saul, D. (2005). Education unplugged: Students sound off about what helps them learn. *Education Canada*, *45*(2), 18–20. https://eric.ed.gov/?id=EJ736079

Schleicher, A. (2016). *Teaching excellence through professional learning and policy reform: Lessons from around the world*. OECD Publishing. https://doi.org/10.1787/9789264252059-en

Serin, H. (2018). A comparison of teacher-centered and student-centered approaches in educational settings. *International Journal of Social Sciences & Educational Studies*, *5*(1), 164–167. https://doi.org/10.23918/ijsses.v5i1p164

Siegle, D. (2017). Technology: Encouraging creativity and problem solving through coding. *Gifted Child Today*, *40*(2), 117–123. https://doi.org/10.1177/1076217517690861

Sternberg, R., & Lubart, T. (1998). The concept of creativity: Prospects and paradigms. In R. Sternberg (Ed.), *Handbook of Creativity* (pp. 3–15). Cambridge University Press. https://www.cambridge.org/core/books/abs/handbook-of-creativity/concept-of-creativity-prospects-and-paradigms/B3EEB5ABC238243FD033AA45D96B3EBF

Vasconcelos, L., Ari, F., Arslan-Ari, I., & Lamb, L. (2022). Female preservice teachers stereotype computer scientists as intelligent and overworked White individuals wearing glasses. *Computers & Education*, *187*, 104563. https://doi.org/10.1016/j.compedu.2022.104563

Vincent-Lancrin, S., González-Sancho, C., Bouckaert, M., de Luca, F., Fernández-Barrerra, M., Jacotin, G., Urgel, J., & Vidal, Q. (2019). *Fostering students' creativity and critical thinking: What it means in school*. OECD Publishing. https://doi.org/10.1787/62212c37-en

Weiss, R. S. (2004). In their own words: Making the most of qualitative interviews. *Contexts*, *3*(4), 44–51. https://doi.org/10.1525/ctx.2004.3.4.44

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 33–35. https://doi.org/10.1145/1118178.1118215

Yardi, S., & Bruckman, A. (2007). What is computing? Bridging the gap between teenagers' perceptions and graduate students' experiences. *Proceedings of the Third International Workshop on Computing Education Research*, 39–50. https://doi.org/10.1145/1288580.1288586

APPENDIX A

Interview Guide

Background	Studying LCCS, how did you get here/ how did that come about? *Probing questions:* • Why you became interested in LCCS. • What attracted you to LCCS? • Did you participate in any CS-relevant course in TY/Junior Cycle? If so, would that influence your subject choice for the LC?
Content	What are your views on content? *Probing questions:* • What has been your favourite/least favourite aspect of LCCS? • What do you like/enjoy about LCCS? • What are the challenges of LCCS? • Are there any downsides to studying LCCS? • Was there anything you didn't know about/didn't expect before starting the subject? • If you were to describe CS to someone who is interested in studying the subject/lay person, how would you describe it?
Pedagogy	What are your views on how it's taught? *Probing questions:* • How has the teaching of the subject impacted on your learning of CS? • What are your views on the way LCCS is taught compared to how other subjects are taught? In JC and LC. • Comparisons with other subjects?
Assessment and ALTs	What do you think about how it is assessed? *Probing questions:* • Does the on-going assessment help you learn? (formative), • Does the assessment capture the depth of your learning and what you understand (summative) • Tell me about your group work experiences in LCCS. • What is your opinion of the assessments in LCCS? • How does assessment help you learn?

	• Does the assessment mode (way it is assessed) capture the depth of your learning? (ALTs feedback) • How does the group work help with your learning?
	INTERACTIVE TASK 1
LCCS vs other subjects	INTERACTIVE TASK 2 What are your views on CS compared to your other LC subjects? *Probing questions:* • Are they similar or do they differ in some way? • How does LCCS compete with other subjects assigned at the same time?
Key learnings	What are the key learnings you will take away with you after completing LCCS? *Probing questions:* • Knowledge • Skills, • Attitudes • valuable/relevant/applicable to the outside world?
	INTERACTIVE TASK 3
Improvements/ Changes	Would you suggest any changes/improvement to LCCS? • How can LCCS be improved? • How can the uptake of LCCS be improved? In your opinion, why do other students not choose to study LCCS? • What could be done to help promote CS to students going into LC? Would you recommend CS to future LC students?
Future plans	What are your plans after the LC? Is CS in the mix?

Interactive Task 1

Please circle 3 words you associate with Computer Science

GAMER

CONFUSION MONEY

GEEK ALT

CODING FUN MEN WORKLOAD

CAO/POINTS COLLABORATION NERD

PROBLEM-SOLVING PARENTS SUCCESS

WOMEN PYTHON DIFFICULT ETHICS

ALGORITHM INDIVIDUALISTIC PROGRAMMING

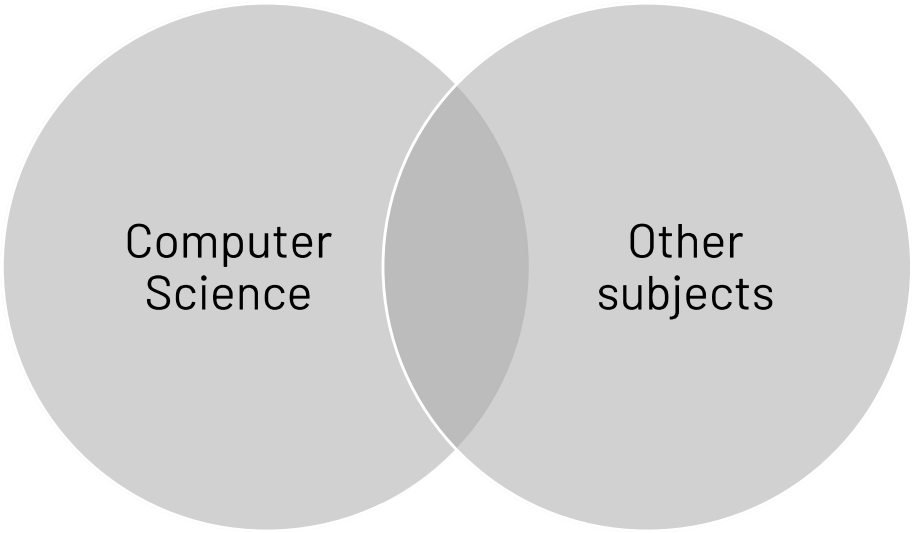
CREATIVE SUSTAINABILITY

BORING HACKER INTERESTING OBS

Interactive Task 2

Differences/similarities between Computer Science and other subjects

Please name the differences and similarities between Computer Science and other Leaving Certificate subjects



Interactive Task 3

Graphing your LCCS experience

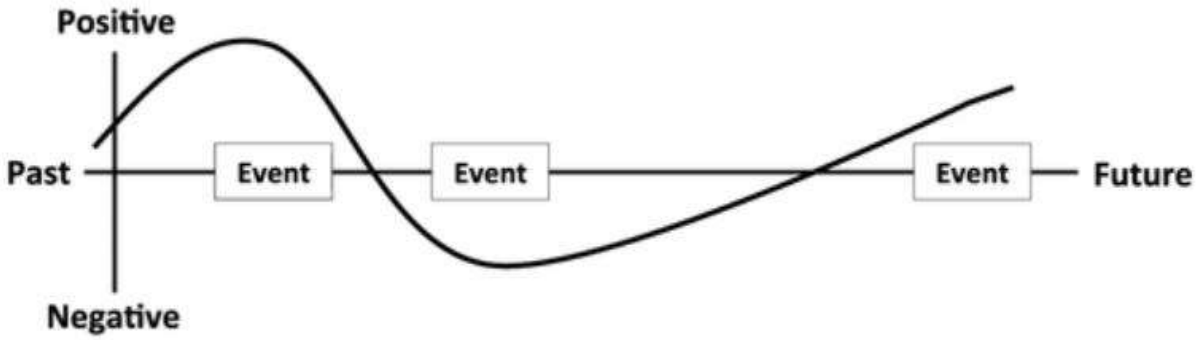


Figure 4. Using an axis to elaborate a timeline.

**Graph example retrieved from Bravington and King (2019).*

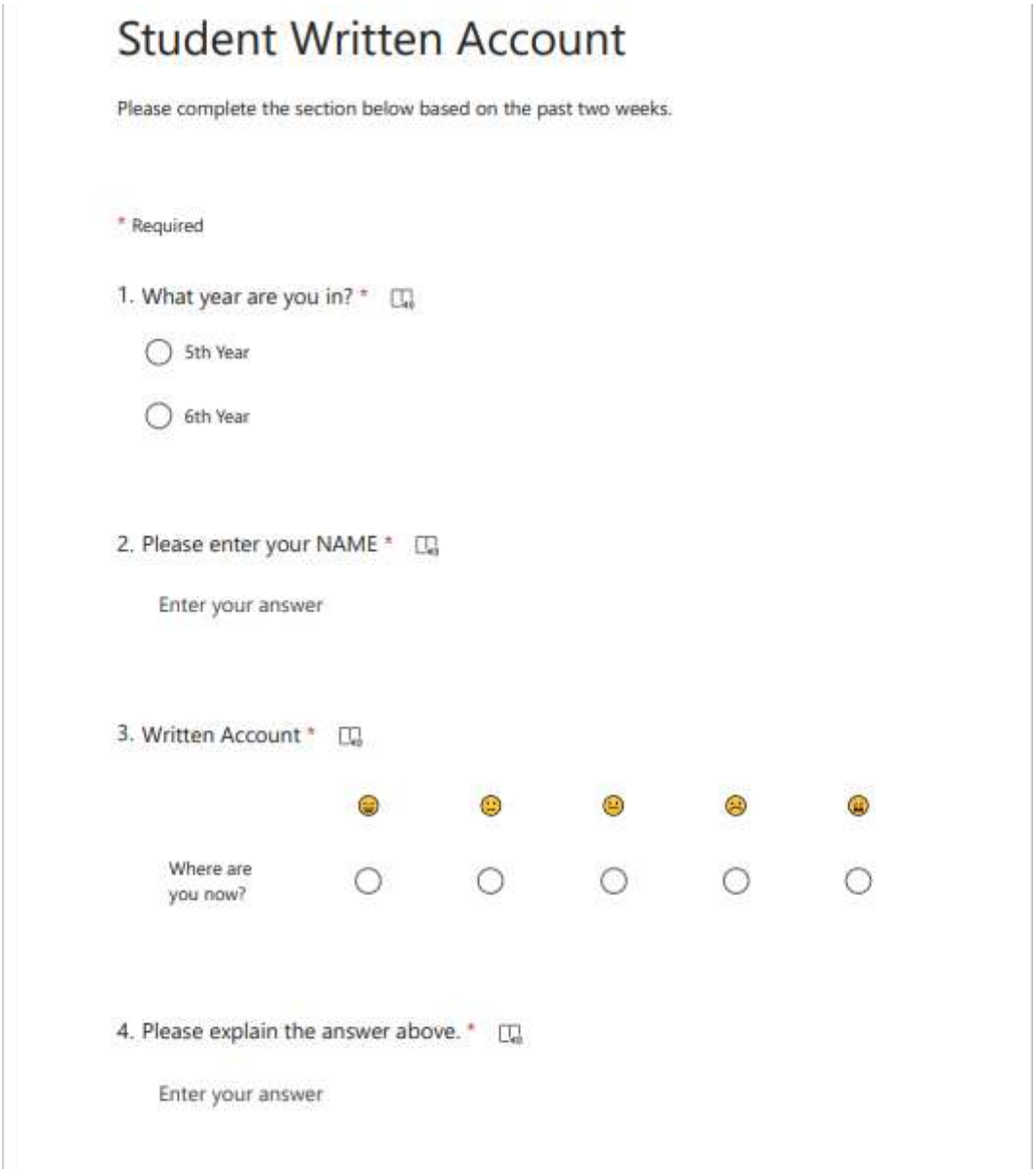
APPENDIX B

Interview Guide Modifications

Questions modified	
<u>Pre-pilot interviews</u>	<u>Post-pilot interviews</u>
How can the uptake of LCCS be improved?	Did many students pick computer science in your year group? How can that be improved?
How does LCCS compete with other subjects assigned at the same time?	Is there a timetable/schedule clash with other subjects?
Questions added	
What are your other Leaving Certificate subjects?	
Is there a mix in the class (males and females) *for mixed schools only	

APPENDIX C

Online Account Template



Student Written Account

Please complete the section below based on the past two weeks.

* Required

1. What year are you in? *

- ◯ 5th Year
- ◯ 6th Year

2. Please enter your NAME *

Enter your answer

3. Written Account *

Where are you now?	◯	◯	◯	◯	◯

4. Please explain the answer above. *

Enter your answer

APPENDIX D

Task 1 Responses - Words Associated with Computer Science

6th years (n=5)		5th years (n=22)	
Words	**Mentions**	**Words**	**Mentions**
Problem-solving	4	Coding	13
Programming	3	Problem-solving	12
Interesting	2	Python	10
Money	2	Programming	6
ALT	1	Algorithm	5
Python	1	Interesting	4
Coding	1	Creative	4
Hacker	1	Success	3
		Fun	2
		Nerd	1
		Jobs	1
		Gamer	1
		CAO	1
		Collaboration	1
		Ethics	1
		Women	1
		Confusion	1

Overall number of students (n=27)	
Words	**Mentions**
Problem-solving	16
Coding	14
Python	11
Programming	9
Interesting	6
Algorithm	5
Creative	4
Success	3
Money	2
Fun	2
Nerd	1
Jobs	1
Gamer	1
CAO	1
ALT	1
Hacker	1
Collaboration	1
Ethics	1
Women	1
Confusion	1

Follow-up 5th years (n=8)	
Words	**Mentions**
Problem-solving	6
Coding	4
Creative	3
Collaboration	2
Algorithm	2
Programming	2
Interesting	2
Python	1
Jobs	1
Individualistic	1

APPENDIX E

Task 2 Responses – Subject Differences and Similarities

Computer Science (only)	#	Other subjects (only)	#	Similarities	#
Access to/ using computers/technology	6	Lengthy notes/ more writing	6	Practical	3
Coding	5	Memorisation	3	Problem-solving	3
Practical hands-on learning/ applied	4	(only) Theory	3	A lot of learning/studying	3
Collaboration/groupwork	4	Text-heavy	2	Maths/ maths elements	3
Freedom	3	Less teamwork	2	Long-term projects	3
Interaction with teacher	2	More studying	2	Teaching	2
Slower	1	Rushed	2	Gain knowledge	1
Creative	1	Set way of doing things	1	Critical thinking	1
Logical thinking	1	Categorised	1	Groupwork	1
Programming	1	More exams	1	Work on computers	1
Homework online	1	Lengthy exam questions	1	Tests	1
Barely any homework	1	More homework	1	Writing	1
Problem-solving	1	Concentration	1	Cannot learn just by living your life	1
Flexibility	1	Harder to understand	1	Class length	1
30% of test is practical (coursework)	1	Older courses	1	Productivity	1
New course	1	Set course	1	Follows a set course	1
Not an emphasis on textbooks	1	More text-book usage	1	Learn from book	1
More detailed	1	Less work on computers	1		
ALTs	1	Given the answer (less thinking)	1		
Less tests	1				
Shorter course length	1				
Dependent on teacher	1				
On the spot (trial and error)	1				
Total	**41**		**32**		**28**

FUNDED BY:

European Union
European Regional Development Fund