Understanding the Factors That Affect Computer Science Primary Education Provision in Scotland

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Abstract

The project looks at the factors affecting the provision of computer science education in Scottish primary schools. Four different schools were visited and 46 pupils and 6 teachers were asked to provide their thoughts and opinions on the delivery of the computer science curriculum and, in the case of pupils, their enthusiasm for the subject and desire to take computer science further was gauged.

A computational skills workshop was developed and delivered in the four schools. There were a number of interactive activities that the children engaged with to give an introduction to the topic of algorithms.

It was found that most pupils enjoy computer science lessons but that most do not see themselves studying it further or working in a job with a focus on computer science. It was also found that there are inconsistencies in the provision of computer science across the four schools and that there is a greater focus on digital literacy, rather than computational skills.

An analysis and discussion of the data is provided alongside some suggestions of how computer science provision in Scottish primary schools can be improved. There is also a discussion of how further research could be undertaken to expand upon this project.

Research Ethics Approval

This project obtained approval from the Informatics Research Ethics Committee.
Ethics application number: 7949 Date when approval was obtained: 2023-12-11
Both the parental and child participant information sheets and consent forms are included in the appendices.

Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

(*Lloyd Dixon*)

Acknowledgements

I would like to thank the project supervisor Fiona McNeill for her support, guidance and feedback as well as Björn Ross for his time as the second marker and for his feedback. I would also like to thank others who provided feedback on the work undertaken including those who attended the project progress presentation and members of the computing and data science pedagogy group who gave feedback on the workshop. Perhaps most importantly, I would like to thank the teachers and pupils at the four schools who took part in the research.

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Chapter 1

Introduction

Computers are increasingly having a great impact on society. Many organisations are reliant on computers to function, automated decision making has the ability to affect lives and the social and environmental impacts of digital technology are increasingly being felt. Many activities in both work and personal contexts are now often performed using a computer: from meetings with clients using video conferencing applications, browsing the web to find the best insurance deal, online shopping and entertainment from within the home and working with spreadsheets and emails at the office.

Although many people interact with digital technology daily, not as many understand how this technology works or have the skills necessary for computing jobs which are becoming increasingly numerous. Therefore, it is vital that children are prepared for a future where technology is increasingly prevalent and have the skills that such a world demands. It follows that children must understand the importance of learning computer science, that their schools have the resources to teach it and that the process of learning computer science starts early on in a child's education.

There have been previous studies on computer science education that have looked at some of the factors affecting its provision. **Chapter 2** discusses some of these in more detail. It is important that these factors are understood so that computer science education can be the best that it can be so that the future generation has the skills it needs for life and for work. The work that this project consists of leads to a better understanding of the current state of computer science provision in schools and the attitudes of learners towards computer science as a subject.

The project's execution consisted of background research and literature review, study design, gathering data from schools and then analysing the data and writing this report. The aims of the project were achieved and there are some ideas for how the findings could influence education policy and how the study could be expanded further in **Chapter 6**. All stages were completed on time and within the time-frame that was set out before starting.

1.1 Research Questions and Objectives

The overall goal of the research was to gain an understanding of the factors that affect computer science primary education provision in Scotland. This was split into the following sub-questions:

- To what extent do pupils in Scottish primary schools enjoy computer science lessons?
- To what extent do pupils in Scottish primary schools see the importance of learning computational skills?
- To what extent are pupils in Scottish primary schools keen to pursue computer science further?
- To what extent do teachers in Scottish primary schools feel that they have access to adequate training and resources to deliver the computer science curriculum?
- What does computer science provision in Scottish primary schools involve?

When looking at what computer science provision "looks like" in a school, based on the fourth and fifth questions, this can then be compared to the answers to the first three questions to see if there is a correlation between computer science provision and attitudes towards computer science provision.

To answer these research questions, the following objectives were set and then met:

- Create survey questions to ask pupils and teachers that allow the research questions to be answered.
- Contact schools and arrange times to visit them to gather data.
- Develop a computational skills workshop to run at the schools as a thank you to them for taking part in the research.
- Visit the schools to run the workshop and gather responses to the survey questions.
- Analyse the gathered data to identify trends and to answer the research questions.

1.2 Summary of the Work Undertaken

The first half of the project (September - December 2023) involved the project design, background research / literature review and getting ready for data gathering. A PVG application was made as it was thought that schools would be more comfortable to allow a researcher to visit who had this in place. Schools were then contacted with an outline of the project to ask if they would be willing to participate. A large number of schools were contacted as it was expected that many would be too busy to set aside the time required. A computational skills workshop was also developed as an incentive for the schools to take part (see **Chapter 3**) and was demonstrated to a computing and data science pedagogy group within the University of Edinburgh to get feedback. An ethics application was also submitted and accepted and the participant information sheets and consent forms were prepared. Parental consent forms and information sheets were sent to the schools who then sent them to parents to complete. Project progress was also presented to the additional project marker who then provided feedback.

In January 2024, visits to the schools took place. Data was collected from both teachers and pupils and the computational skills workshop was delivered. Project progress was then reported to a group of academics and other students for feedback. Data analysis and the write-up then took place in February and March.

1.3 Chapter Outline

This chapter provides the reader with an introduction to the project including the work carried out, the research questions and objectives as well as a summary of the work undertaken. **Chapter 2** provides a review of the current literature surrounding the topic and explains where this project fits in and builds upon previous work. **Chapter 3** details the design of the project including how the research was conducted, the methods used to gather data and the workshop that was run alongside. The results are recorded in **Chapter 4** and discussed in **Chapter 5**. The findings are presented in **Chapter 6** as answers to the research questions and suggestions are made, based upon these. Participant information sheets and consent forms can be found in the appendix.

Chapter 2

Background

Here, the previous research concerning computing provision in schools is discussed and the scene is set for this project. Its place within the context of existing studies shall be clarified and other relevant background documents will be explored.

There have been a number of studies which look at computer science provision in primary schools and also in secondary schools. These studies have had varying focuses and have taken place in various parts of the world. The situation in Scotland will be considered carefully, including the policy documents which, naturally, have a strong influence on computer science education in Scottish primary schools.

There are a number of problems with computer science education provision and these vary in magnitude across different schools. A report from 2012 published by The Royal Society looked at computer science provision in the UK and found numerous problems with the way computer science was taught in schools[7]. Scottish education is separate from other UK education systems so it is unclear which system this report refers to. It is still worth considering the issues raised in the report as many will be relevant in Scotland, even if written about other parts of the UK. The report emphasised the lack of qualified specialist teachers in the field, a lack of continuing professional development (CPD) opportunities, a lack of resources for teaching computer science and, perhaps most alarmingly, a lack of enthusiasm for learning computer science[7]. The report suggests dropping the term *ICT* (Information and Communication Technology) as this has "negative connotations" and can put people off studying the subject. It says that computer science should be treated as being equally important as mathematics or the traditional science subjects and should focus more on rigorous computing education, rather than basic IT skills such as using word processors[7]. It is worth considering, therefore, not just the ability of schools to teach computing science but how to drum up enthusiasm in pupils for the subject. It is worthwhile to determine the environmental factors of the classroom that positively or negatively affect the value that a child places on computer science and hence the desire to study it further.

The importance of learning computational skills from a young age is understood globally. Bulgaria, for example, has been teaching computation concepts to primary school pupils since the 1960s[9]. It was not taught as a subject in its own right until later, however, with other subjects - such as mathematics - covering computational topics[9]. The current Bulgarian curriculum contains many similarities to its Scottish counterpart with outcomes involving programming in visual programming languages, digital safety and digital literacy[9]. The schools are well equipped with free textbooks and computers that, in many cases, exceed the requirements for teaching the computing curriculum[9]. Some primary school teachers in Bulgaria have struggled to teach computer science classes after these were introduced, even after training courses were provided. In response to this, secondary school teachers have stepped in to teach primary computing classes and textbooks provide guidance to teachers in relation to teaching computer science[9]. This project will look at similar factors but in Scotland instead of Bulgaria. It is clear from the Bulgarian report that computer science education is highly valued there and that schools are equipped with the resources they need with the weakest link being the confidence of the teachers and their ability to learn computational concepts and keep up-to-date. Even when teachers do not have the knowledge, textbook and online resources can go a long way in filling in the gaps.

As mentioned above, the availability of resources is a key factor in the delivery of quality computer science education. Textbooks and teacher knowledge are hugely important but the computers themselves are seen by many as one of the most important parts of the equation. A school's IT resources including hardware, software and specific devices which can aid the teaching of computer science such as Raspberry Pis which are vital to allow learned computational skills and concepts to be put into practice and seen in real world scenarios. As discussed in the previous paragraph, Bulgaria's schools are well equipped with the computers they feel they need but this is not necessarily the case in Scotland[9]. This project will attempt to find out if primary school teachers in Scotland do or do not feel that their schools have the hardware and software available to them that they feel they need to meet their full potential when delivering the computer science curriculum.

An approach which aims to get around the issue of a lack of IT resources is CS Unplugged. CS Unplugged was first used in the early 1990s and attempts to provide a way of teaching computer science to children without computers[8]. Originally, it was intended to be used in outreach programmes and with larger audiences but has since been adopted by schools. It forms a key part of the Australian Digital Technologies curriculum for example[8]. CS Unplugged consists of activities and games which aim to teach computing science constructs as well as facilitating a wider discussion about the place of computing in society. There are "plugging it in" exercises which are practical activities using computers that follow on from the theoretical learning[8]. Some studies have suggested that CS Unplugged can have a negative effect on a child's impression of computer science[1]. This is because it is often difficult for children to make the link between an abstract concept such as sorting a list to a practical task involving computers[1]. The CS Unplugged activities do not consider a child's prior knowledge, so it is difficult for the child to determine the relevance of a CS Unplugged activity to this prior knowledge[1]. It is, however, sometimes necessary from a practical point of view and it is easy to see why some teachers may find it beneficial. Part of this project involved asking teachers what they thought of the unplugged approach.

Technical resources are not everything, however. In the late 1990s, new funds were introduced for ICT in schools in England which led to more computers, and other hardware such as interactive whiteboards and data projectors, in classrooms [2]. The use of IT equipment in schools is not always beneficial. There is a difference between using technology for learning computer science and using technology in the classroom more generally. Multiple studies (Beland and Murphy, 2015; Carter, Greenberg and Walker, 2016; Corder et al., 2015) found that it can actually decrease attainment levels in subjects such as maths due to computers being a distraction. This shows that it is important to not only look at the amount of IT resources that schools have but also that these are being used in the right way to benefit children and are not a distraction in the classroom[2].

There has been concern among graduate employers that graduates, although able to use information technologies, are not able to manipulate them and they do not have the skills required for technical job roles. This led to a greater focus on learning to write computer code and algorithmic constructs[2]. The difficulty which arises from this is that teachers do not necessarily have the skills and knowledge themselves to teach this. It has also been suggested that basic IT skills such as word processing and file management have been neglected in favour of more advanced computational skills[2].

It is important that children are taught the basic computer skills before learning the more advanced ones. Despite this, learners should be prepared for university study of computer science and not have to be thrown in at the deep end. Coding and algorithms should be taught in schools and learners should appreciate the large part that mathematical skills have in computer science too. Part of this study looks at whether computational skills or digital literacy are given the most attention in Scottish primary schools.

As has been touched on already, at a university level computer science is often taught alongside mathematical and logical constructs as these build the knowledge that is necessary to become comfortable with computational skills and concepts. Such an approach, if used at a primary school level, has the potential to discourage and deter pupils who do not enjoy maths from taking computer science further. An alternative is to use a game-based approach to improve the enjoyment of computer science lessons. This is known as “gamification.” A study was carried out which attempted to test the effectiveness of this approach when used to teach the concept of automata, a concept usually introduced at university level[5]. It was found that, although most children did not gain an in-depth understanding of the concept, some had the potential to gain a deep understanding of it. Although the game was not useful at drastically enhancing understanding of a certain concept, such an approach could be useful for some children. Crucially, nearly all children (98%) enjoyed playing the game which suggests that gamification has the potential to allow children to learn computer science in a way that is both effective at teaching key concepts and enjoyable[5]. Assessing whether or not a child is enjoying learning computer science may therefore be a good indicator that computer science provision in that particular school is good, although this cannot be relied upon completely as some children may just be very enthusiastic or not for other reasons.

Work is being done to try and improve computer science provision in Scotland. The

Scottish Government published 'Enhancing learning and teaching through the use of digital technology' in September 2016 which details their plans for the teaching of IT skills in schools[4]. The objectives listed in the document include the desire to "develop the skills and confidence of educators in the appropriate and effective use of digital technology to support learning and teaching" and to "improve access to digital technology for all learners"[4]. Whether this is happening in practice is something which should be researched.

The Curriculum for Excellence(CfE) - the framework of outcomes that Scottish teachers should cover - has three main areas in the computer science section[3]. These are "Understanding the world through computational thinking", "Understanding and analysing computing technology" and "Designing, building and testing computing solutions"[3]. There are then multiple different outcomes under each section with between one and three for each level. The idea is that learners move up through the levels as they move up through both primary and secondary school with outcomes at the higher levels being more advanced[3]. It is important that the computer science provision in Scottish schools is looked at in the context of the CfE as this is what schools themselves should be aiming to adhere to. It is worth noting, however, that different teachers and different schools may have different interpretations of the CfE. The outcomes are quite open ended so what is actually expected may not be clear to different schools. This, of course, is one of the reasons that computer science provision differs across the country. Whilst some variation is expected, and perhaps welcomed, it is important to ensure that certain skills are always covered and that the quality of computer science lessons does not vary wildly.

No matter how computer science education is implemented in primary schools, it is important that parents are also on board. A study undertaken in Japanese primary schools found that most parents are anxious about computer programming lessons in primary schools[6]. The main concerns were the inability of parents to provide guidance to their children at home and the inconsistency of programming lessons between teachers and schools[6]. The study only had a small number of participants so would need to be expanded to get a clearer picture but it does raise the concern that those who have parents who are themselves highly computer literate may cope better in programming classes than those who do not. It is also important to ensure consistency across the country so that there is a level playing field and pupils do not get left behind. Therefore, in this study, the consistency of computer science provision across schools is touched upon, both in terms of what sort of skills are being taught and what sort of access these schools have to IT resources.

To conclude, the quality and effectiveness of computer science education can be vastly different in different schools and the factors which affect this are numerous and complex. When attempting to improve computer science education in primary schools, the availability of hardware resources is not a silver bullet; how these resources are used and the confidence of teachers also play a part. The methods of teaching computational education must also be considered as children should understand the importance of it and, ideally, want to continue learning these important skills. This project aims to get a clearer picture of these factors by carrying out research on the ground to compare the differing experiences of computer science education in a number of different primary schools across Scotland. A key part of the research will also be to determine whether or not children enjoy learning computer science and have the desire to take it further, be that through studying or work. In addition, the different ways that computer science is taught will also be considered. This will allow for a comparison to be made between the factors affecting provision and pupil attitudes towards computer science.

Chapter 3

Project Design

3.1 Overview

The study consisted of surveys carried out in-person in schools across Scotland. There was a set of questions that teachers were asked and another that pupils were asked. Responses to the questions were recorded on paper (or digitally in a few cases) by the participants and collected in, along with the participant consent forms.

The questions were designed to generate answers regarding the attitudes of current primary school pupils and teachers towards computer science as well as what shape computer science provision took in a participant's school. This consisted of finding out what skills were learned in computing classes and questioning the level of resources for teaching computer science that a particular school had.

The pupils were asked the following questions:

- Do you enjoy learning about computers at school?
- What sort of skills have you learned?
- Why is learning computers important?
- In the future, would you be interested in working in a job related to computers?
- Would you choose to study computer science as a subject in secondary school? What about after secondary school?

The teachers were asked the following questions:

- Do you have the resources (staffing, equipment and time) that you feel are necessary to deliver the computing curriculum? Are there any challenges here? How could additional resources help?
- Do you think the curriculum (and its implementation in [this school]) helps to prepare learners for further study of computer science and for the need for these skills in everyday work and life?

- Is there enough support and guidance available for teachers to allow them to effectively deliver the computer science curriculum? Is there enough training? What does this training look like and do all teachers have it or only some?
- How do commercially available software packages affect the delivery of computer science education?
- How much of ICT involves learning key computational constructs and how much involves learning to use specific software packages or platforms?
- Does the use of technology in schools help or hinder the progress of learners overall? Can computer science be taught without computers and what do you see as the advantages and disadvantages of this?

The "[this school]" was substituted for the name of the school in which the teacher answering the questions worked.

3.2 Gathering Data

School visits took place in January 2024 and the surveys were carried out during these visits.

Pupils, in a classroom setting, were asked to write their answers to the questions on a blank sheet of A4. Each question was read aloud - and displayed using a data projector where possible - and the pupils given time to think of and write an answer to each. Most pupils wrote their answers by hand, although some typed their responses or had a scribe. One pupil responded outwith a research session and the response was sent by the school at a later date due to him being absent on the day but still keen to take part.

When asking the questions verbally, the wording was changed to add clarity. For example, the term "high school" was used to refer to secondary education when conducting the survey in the central belt but "academy" was used when conducting the survey in the north-east where this is the term that is usually used there.

The children were verbally encouraged to consider the reasons for their answers and discouraged from simply writing "yes" or "no". Whilst it was important not to influence the children's responses, it was also necessary for some children to be given some suggestions of what could be written, although most of these suggestions came from the teacher and it was made clear that the questions were purely to gauge the opinions of the children with no correct or incorrect answer.

Most teachers chose to respond to their questions in their own time and then sent their responses in by email. Often, there was not the time within the school visits to conduct these interviews and the teachers preferred to have time to consider the questions on their own. This also meant that other teachers who only worked on certain days, and so were not present during the visits, could respond. Two teachers were interviewed in-person which allowed them to ask for clarity regarding certain questions and it was a two-way conversation which allowed for more detailed answers. They did this at the same time which meant that they could bounce ideas off each other.

3.3 Workshop

A computational skills workshop was developed which was delivered in schools alongside the interview as an incentive for the schools to take part. The workshop aimed to provide a lesson on algorithms at a difficulty which would be appropriate for primary five, six and seven pupils. It was demonstrated to a computing and data science pedagogy group within the University of Edinburgh to get feedback. The workshop was then updated accordingly.

The workshop consisted of four interactive algorithm activities which were designed to be taught using only slides and an HTML / JavaScript web-page, displayed using a data projector, a whiteboard to go through one of the activities as a class and paper for the pupils to work on the exercises or take notes. This could be considered an "unplugged" approach (as discussed in **Chapter 2**) and this was chosen as the availability of IT resources in the schools was not yet known at this stage. Additionally, broader computational topics were discussed and suggested online resources for further study were shared for pupils who were keen to take things further in their own time.

The workshop was very well received in the other schools, however, and its delivery is going to be used as evidence at two of the schools to achieve a digital award and that they are making progress with computer science provision as this is on their school improvement plans. There was one boy who particularly enjoyed the workshop and who was obviously very interested in computers, having learned Python and HTML coding in his own time. His mother was in touch with the school afterwards to express how much he had enjoyed taking part and was very appreciative of the school's involvement in the research and the delivery of the workshop.

The first exercise in the workshop consisted of following an algorithm that had to be followed to work out the positioning of a butterfly in a maze. The second exercise encouraged the children to consider the limitations of an algorithm and ask questions about its behaviours. The third asked the children to follow an algorithm to solve a mathematical problem and the fourth demonstrated how algorithms should be written efficiently and won't necessarily behave as a human programmer would expect them to. The exercises were themed around characters from popular children's books and TV programmes to make them more appealing. The children were encouraged to work on each exercise individually or with others before the class discussed it together.

Figure 3.1: Workshop being delivered to a small class

Figure 3.2: Workshop being delivered to a small class

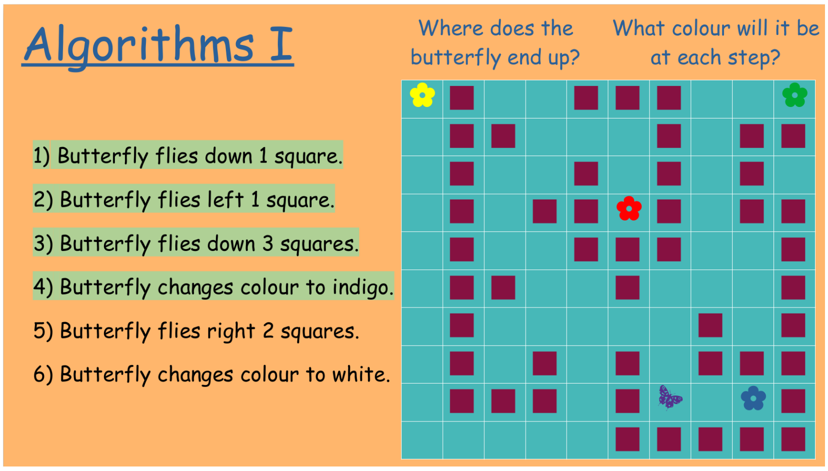


Figure 3.3: Butterfly algorithm exercise which featured in the workshop

3.4 Analysis of the Data

A relatively small amount of data was gathered so the data could be analysed manually, without the need for data analysis software. Nevertheless, a Jupyter notebook was used with Python and Pandas to perform some quantitative analysis as explained in the next chapter.

The paper responses were digitised and saved into a spreadsheet of pupil responses and a spreadsheet of teacher responses. The spreadsheet package was then used to filter the data and create a new spreadsheet with pupil answers being assigned to a category so that they could be easily analysed. This was converted to a Pandas data frame so that it could be easily worked with.

The teacher responses are listed in the next chapter, as they were recorded, and the key points from these are summarised.

Where appropriate, software was used to generate graphs from the data to aid clarity. Tables are also used to present data to the reader.

Chapter 4

Results

4.1 Scope of Results

In total, four schools took part in the research with responses collected from 6 teachers and 46 pupils. Not all pupils present were able to take part in the research as consent had to be obtained from all participants as well as the parent(s) or guardian(s) of the pupils taking part.

The four schools were of different sizes and factors such as class size, room size and whether or not consent was obtained meant that the number of responses from each differed. The school with the most pupil responses had 25 and the school with the least had 5. Each school had at least one teacher response. Two of the schools work closely with each other, sharing staff members, and so one of the teacher responses is applicable to two schools. The most teacher responses for a single school was 3 but one of these responses applied to two schools.

The vast majority of pupils who took part were in Primary Seven (the final year of primary school) but there were a number of Primary Six pupils and a very small number of Primary Five pupils who also took part. The numbers of each were not recorded. Most of the schools had composite classes so it was thought that involving all stages within these classes in the research would be appropriate given that these pupils would have similar experiences of computer science, despite them being at different stages. The ages of all children taking part would have been in the 9-12 range.

Information about the teachers who took part is shown in the below table:

Teacher Alias	School Alias
T1	S1
T2	S2
T3	S2
T4	S3
T5	S3
T6	S3 and S4

Table 4.1: Teachers who took part in the study

4.2 Pupil Attitudes Towards Computer Science

The results in this section are intended to be used to answer the first three research questions. To reiterate, these are:

- To what extent do pupils in Scottish primary schools enjoy computer science lessons?
- To what extent do pupils in Scottish primary schools see the importance of learning computational skills?
- To what extent are pupils in Scottish primary schools keen to pursue computer science further?

Although the data gathered was qualitative rather than quantitative, many of the answers yielded could easily be grouped into different categories such as positive or *yes* responses, negative or *no* responses and indifferent responses. Although the children were encouraged to give reasons behind their responses, these were stripped from the data set so that a high level overview of attitudes towards computer science could be seen and because the reasons given were not thought to be particularly insightful. This was a post-hoc decision.

For this task, the following questions were considered as these were the ones that were relevant to pupil attitudes:

- Do you enjoy learning about computers at school?
- Why is learning computers important?
- In the future, would you be interested in working in a job related to computers?
- Would you choose to study computer science as a subject in secondary school? What about after secondary school?

For the first question, each response was labeled as *yes*, *no*, or *sometimes / unsure*. This was an easy task for this question as most responses included words or phrases such as “I do”, “I enjoy computer science” or “no” so it was very clear which category each response belonged to.

It was clear that most of the answers to the second question concerned the benefit of learning computer science in employment. Because of this, it was felt that it would be interesting to see just how important the pupils consider learning computer science is for the world of work. The responses were labeled to state that they suggested learning computer science is important for *some* jobs, *lots of* jobs or *most* jobs. Responses that gave other reasons for its importance were labeled as *other* if another reason or no reason was given and *unimportant* if the respondents did not consider learning computers to be important.

Responses to the third and fourth questions were slightly more challenging to categorise as there were lots of ambiguous answers. It was decided that responses that leaned more one way (e.g. "probably not") would be counted in the category they leaned towards whereas responses without any leaning (e.g. "maybe") would be categorised as *unsure*. Few people answered the second part of the fourth question specifically (regarding the desire to study computer science after secondary school) so that part of the response was ignored when present.

The results are shown in the below graphs with the number of participants answering a certain way represented on the x-axis and the response types on the y-axis:

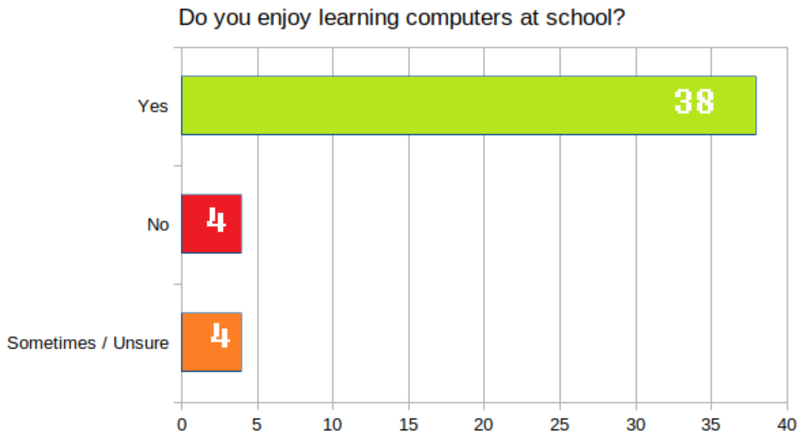


Figure 4.1: Do you enjoy learning computers at school?

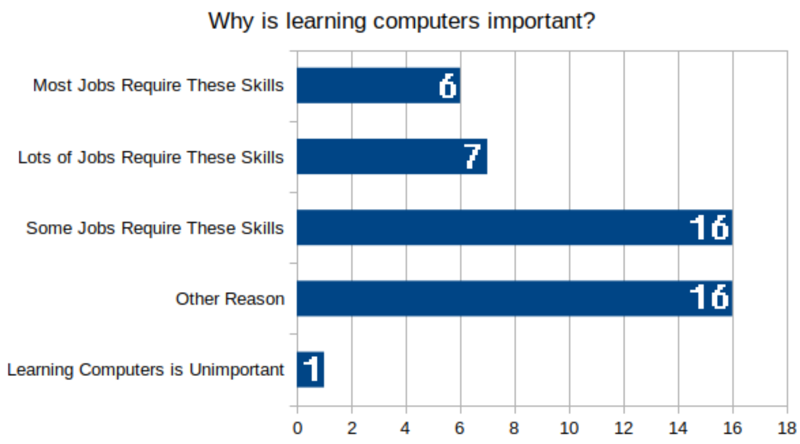


Figure 4.2: Why is learning computers important?

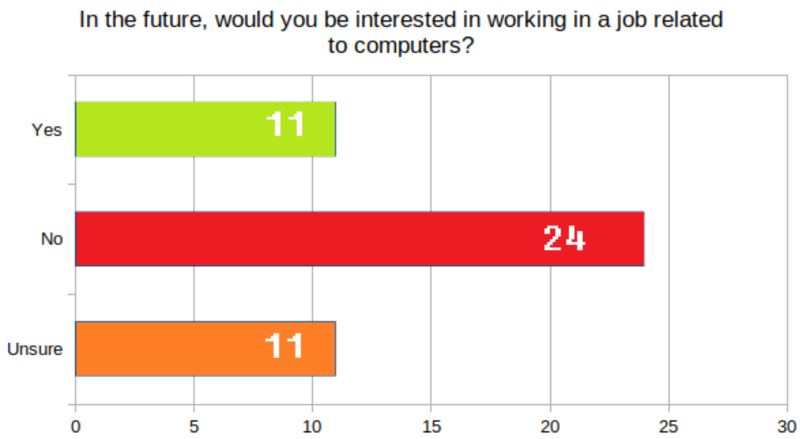


Figure 4.3: In the future, would you be interested in working in a job related to computers?

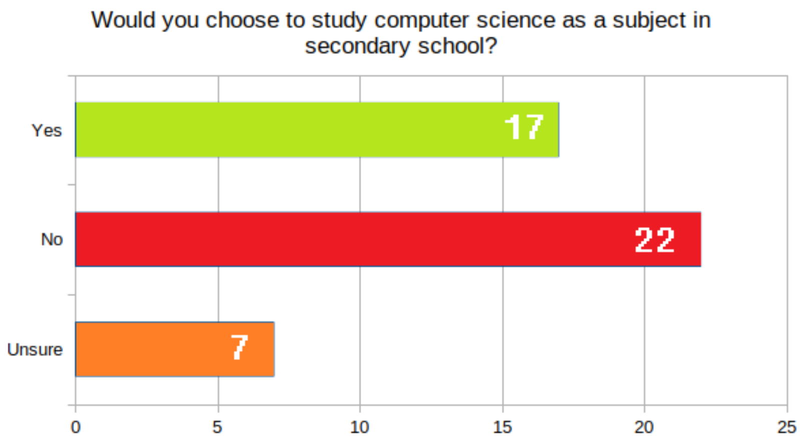


Figure 4.4: Would you choose to study computer science as a subject in secondary school?

The above graphs show that, whilst most pupils say that they enjoy computer science lessons, most do not want to study it further or see it as being a key part of their future careers. Whilst many people said that computational skills were important for *some* jobs, very few said that they were important for *most* jobs.

In the responses to whether or not children would like to study computer science further or work in a job related to computers, the reasons for answering “no” were often that the child had another career in mind, did not want a desk-based job or found computer science difficult or confusing.

4.3 Skills That Pupils Learn in Computer Science Lessons

The results in this section are intended to be used to answer the research question “what does computer science provision in Scottish primary schools involve?”

The only other question that pupils were asked to provide a response to was “what sort of skills have you learned?” It was immediately clear that there were many common themes in the answers to this question with certain terms popping up time and time again. The most common skills mentioned in the answers to this question are shown in the below table with the number of pupil participants who mentioned the skill. There were, in some cases, different wording for the same thing such as “coding” and “learned how to code” so, in these cases, all different wordings were included in the totals.

Skill	Number of Pupil Participants Who Mentioned Skill
Code / Coding	25
Microbit	12
Scratch	11
PowerPoint	10
Robotics	8
iPad	6
Online Safety	5
Sumdog	4
Google Classroom	2
Google Slides	2
Glow	2

Table 4.2: Frequently Mentioned Skills

Here is the data presented as a graph:

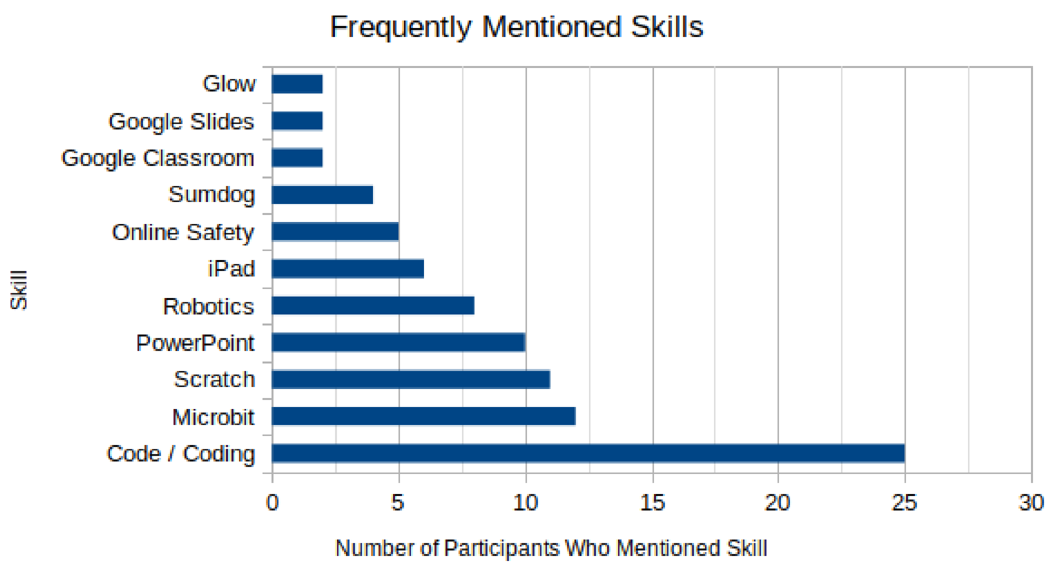


Figure 4.5: Frequently Mentioned Skills

It was thought that it would be interesting to compare schools and see how many of the four schools who took part had pupils who mentioned each of the skills. For this task, responses to teacher surveys were also included to get a clearer picture of which skills the different schools focus on rather than which skills pupils are likely to mention. The results are shown in the below table:

Skill	Schools With Participants Who Mentioned Skill (No. of Schools)
Code / Coding	S1, S2, S3 and S4 (4)
Scratch	S1, S2, S3 and S4 (4)
Microbit	S1, S3 and S4 (3)
PowerPoint	S1, S2 and S4 (3)
iPad	S1, S2 and S3 (3)
Google Classroom	S1, S3 and S4 (3)
Online Safety	S3 and S4 (2)
Sumdog	S1 and S4 (2)
Robotics	S2 and S3 (2)
Google Slides	S2 (1)
Glow	S2 (1)

Table 4.3: Schools With Participants Mentioning Each Skill

Coding was the most frequently mentioned skill by far across participants. Scratch, coding, Microbits and robotics can be seen as computational skills but the others mentioned all seem to be digital literacy skills or the use of specific tools on a computer. This would suggest that the distinction between the two is unclear for many.

Teachers were also asked about the type of skills learned in computing lessons. They were asked, "How much of ICT involves learning key computational constructs and how much involves learning to use specific software packages or platforms?" The responses are listed below:

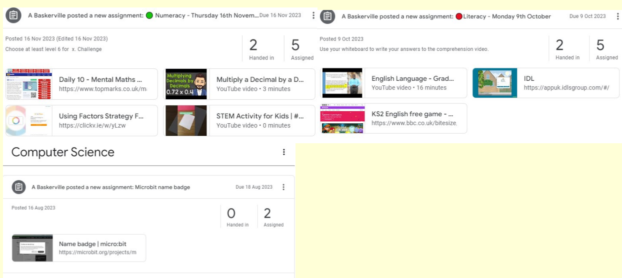
Teacher	School	Response
T1	S1	It is really important that the children learn key computational constructs e.g. saving, printing, using word/PPT/Excel/Google Classroom. This has obvious advantages especially those children who require to use technology within their day-to-day learning.
T2	S2	Heavily skewed towards digital literacy. Computer science depends on the confidence of the teacher.
T3	S2	I would say most (90%) of our digital life would be focused on the use of hardware and software to help us / pupils access their learning, do research, present their work or help them solve problems. Only around 10% would be on 'computing science' - coding or on programming. This, again, depends on the teacher.
T4	S3	The majority of the experiences and outcomes refer to knowledge and skills with less emphasis on actual software as each authority will have different access.
T5	S3	Daily use of ICT: • Google classroom Literacy tasks include video clips, quizzes, games, google forms, slides, docs, Jamboards, IDL spelling tasks, recording fluency/book reviews and sending to teacher through email, completing writing tasks on docs and attaching to emails etc. • Google classroom Numeracy tasks include video clips, quizzes, games, google forms, slides, docs, STEM challenges, build instructions, jamboards etc. • Blocks of learning on Micro:bits, with daily opportunities to choose to explore and create own programmes • Blocks of learning on Scratch, with daily opportunities to choose to explore and create own programmes • Use of programmable devices (Bee bot) – block of learning with options to choose to operate during showcasing skills / free choice Examples of how this is incorporated daily: 
T6	S3 and S4	There's more emphasis on software and platforms than on key computational constructs. We find that children almost know intuitively how to use new software and platforms. We use Google Classroom on a daily basis and the children are constantly finding new hacks while using this. In ICT there is a greater emphasis on Digital literacy than computer science, no doubt due to teacher confidence in teaching this. Learning relating to understanding and analysing computing technology is taught rarely (although we are trying hard to rectify this!)

Figure 4.6: Teacher Responses

It is clear from these responses that there tends to be a bigger emphasis on teaching digital literacy than on computational skills and knowledge such as algorithmic concepts and coding.

It is important that the skills learned in school are relevant and useful for further study, work and / or life in general. Teachers were asked, "Do you think the curriculum (and its implementation in [this school]) helps to prepare learners for further study of computer science and for the need for these skills in everyday work and life?" The responses are listed below:

Teacher	School	Response
T1	S1	I think it does to a certain degree. As primary teachers there is such a wide spread of subjects we have to cover and not all of us are confident or adept using technology in the classroom. We know that it is important for the children especially when thinking about the world of work. However, I think that technology advances quicker than we can keep up which may affect this. As discussed in Primary education there are so many things we have to cover in the curriculum.
T2	S2	Some teachers implement computer science well - more consistency needed. If there was a coherent progression framework developed - guidance and consistency across schools and local authorities.
T3	S2	I think it does help in general but that is very much dependent on the teacher and their knowledge and confidence in teaching computer science. With a more structured and consistent approach across the school (supported with time / training / tools) this would be much improved.
T4	S3	I believe it does but I also believe that primary school teachers are asked to teach skills that are well beyond their qualifications in many cases. Unless you are a teacher with a specific background in computer science some of the later 2nd level outcomes are fairly advanced.
T5	S3	At [our school], we strive to incorporate technologies into learning across the curriculum. In terms of skills for life, the children are able to record themselves and evaluate their skills using video. They can send and receive emails confidently, with attachments. Children are given daily opportunities to explore computational thinking processes (like following instructions) involved in problem solving tasks and STEM challenges, which are incorporated into their Maths programme. They are also confident in using Google Classroom and associated apps like Slides, Jamboard etc. This session, we have been using the new gen Micro:bits, where the children have programmed games, pedometers etc. This has ignited a genuine interest in a number of our learners, which we hope to continue to develop through our commitment to exploring new programmable devices like MARTY the robot.
T6	S3 and S4	Although we have recognised that we need to improve our learning and teaching on computer science, I still consider it to be the weakest area within the Technologies curriculum for us as a school. We have a focus on coding, e.g. using Scratch and Microbits, for example but could do more on computational language. We have opportunities to teach the required benchmarks for the outcome on computational thinking throughout all the different areas of STEM. In particular these computational skills and the problem solving element of computer science are useful skills for everyday life.

Figure 4.7: Teacher Responses

These responses suggest a lack of consistency in which skills are taught with some teachers and schools providing a higher quality of computer science lessons than others.

4.4 Availability of Resources Required for Delivering the Computer Science Curriculum

The results in this section are intended to be used to answer the research question "to what extent do teachers in Scottish primary schools feel that they have access to adequate training and resources to deliver the computer science curriculum?"

As discussed previously, the availability of resources in schools (be that staff, training, hardware, software or time) is one of the most important factors that affects computer science provision in schools. Therefore, the teachers were asked, "Do you have the resources (staffing, equipment and time) that you feel are necessary to deliver the computing curriculum? Are there any challenges here? How could additional resources help?" Their responses are listed below:

Teacher	School	Response
T1	S1	Available resources are always tricky because although we have iPads in each class there are only 8 and if we need more then we have to borrow from other classes. We have difficulties with connectivity and this can therefore be slow which affects the efficacy of the lesson. The resources are also much older than the children are perhaps used to as well. There is never enough staffing to support individuals or groups in a day-to-day lesson especially if something goes wrong with the technology. Additional resources would be great as long as they were up-to-date and we could sort out the connectivity throughout the school.
T2	S2	Got quite a lot of physical resources - one to one would be even better. Training + time. A digital leader role. Some teachers shy away from technology. Curriculum can be overcrowded. Integration of ICT into all areas of the curriculum needs time and money.
T3	S2	In general we are pretty well resourced with roughly 1 iPad between 3 pupils but more would definitely make it much easier. The biggest hurdle, in my opinion, is teacher knowledge and confidence and space / time within our curriculum. So, more training, time and tools would make things much easier.
T4	S3	We are very fortunate to be able to assign 1 chromebook per pupil which makes delivery of the curriculum much easier. Our challenge is our rural location and the issues this brings with poor connectivity.
T5	S3	We are lucky to have resources such as Micro:bits, Chromebooks (1 per child), iPads and desktop computers. In terms of programmable devices, we have Bee Bots and have invested in staff training on MARTY, which will see the school acquiring and utilising the MARTY resource. Currently time is built into the Maths timetable to cover computer science, but we are fortunate as staff can be flexible and build in opportunities to facilitate learning in computing science where possible when natural links present themselves. For example, Scratch is being used throughout curriculum - children made animations of the sinking of the Titanic etc. Challenges include my own knowledge of resources and my ability to use them! Computing Science currently features on school improvement plan and is a main focus for staff, pupils and parents this session.
T6	S3 and S4	As we are a small rural school we can be flexible with allocation of time. At [our school], computing science was on our [school quality improvement plan] this year (this decision was made after an audit on the Technologies [experiences and outcomes], so more time than ever has been allocated to it. Each child has access to their own chromebook, largely in part due to very small numbers and through grants and fundraising from Parent Councils we are able to have a healthy spend on ICT. The government also provided each school with free microbits, again we have one per child. ICT is completely integrated into our daily learning. We know we are in an extremely lucky position to have very few constraints to deliver the computing curriculum.

Figure 4.8: Teacher Responses

These responses are generally positive with teachers appearing to be satisfied overall. Internet connectivity can still be a challenge for some schools but there are plenty of devices available - as much as one per pupil in some cases - but schools would welcome more.

Additionally, to get a bit more detail, teachers were asked, "Is there enough support and guidance available for teachers to allow them to effectively deliver the computer science curriculum? Is there enough training? What does this training look like and do all teachers have it or only some?" The responses are listed below:

Teacher	School	Response
T1	S1	As discussed above, I think that in Primary education this is more challenging. We have a fully packed curriculum which all requires us to be 'experts' rather than in secondary when this would be the teacher's sole focus of their lessons. Training is available at times but this may not always be the priority of the teacher/school. Training would also be dependent on the teacher interest as well and whether they feel confident to take it forward. I know that I have had training on various aspects of technology but if I am not using it daily, it can be forgotten about quickly.
T2	S2	Time is the biggest issue - ever-changing priorities. Funding for courses. There are opportunities there. Training opportunities are optional. Again, people who lack confidence shy away.
T3	S2	There probably is enough relevant quality learning opportunities out there to support teachers in their digital training but unless you are keen to give over your own tie and are particularly motivated towards it, then most staff will not access these opportunities.
T4	S3	Teachers can access as much or as little training as they wish. However, time constraints and a very full curriculum means we aren't always able to fulfil all the training opportunities we would like to.
T5	S3	All teachers at [our school] have gone through Google Educator training Level 1 and have achieved this accreditation. This has allowed them to effectively use this resource daily in class. It is a vital part of our learning within a small multi-composite setting where learners are at a huge range of different levels in their learning. Training opportunities are found on the council's training portal but this is often quite an undertaking to locate appropriate training. Staff have attended twilight courses led by STEM officers who have recommended courses available, and this has been much more effective. It highlighted courses provided by SSERC which involve funded resources for the school to use following training. This has led to staff from the school signing up to the courses, normally one day out of school and an online session in school. It is then the responsibility of the trained member of staff to cascade this learning to other staff in the school. Below, is an example of what training looks like: **Course Format** Day 1: Face to Face all day @ SSERC HQ – 5 February 2024 – 9.30am - 4.30pm Day 2: Online training – live session – 11 March 2024 – 1.30pm - 3.30pm In addition, you will complete self-study activities in the form of a 'Gap Task' in the period of time between Days 1 and 2. As part of the course, you will receive a Marty V2 to keep for your setting, as well as access to the SSERC Lending library Marty V2s if you wish to expand the use of the resource in your setting. (Subject to availability and upon agreeing on the terms and conditions involved in the loan) **Programme** Through the face to face, live remote sessions and self-study elements of the course, we will introduce Marty as a tool to engage with computing science concepts and computational thinking in your setting. The full day face-to-face session will be based around an overview of the resource, some practical hands-on tasks to introduce Marty and considering how it can be used to cover Computing Science experiences and outcomes. We will also consider the online infrastructures created to support, cross curricular activities, unplugged CS, and how the Marty app can be used to engage learners at all levels through the RC sequencer, Marty Blocks Jr and Marty Blocks. After the introductory first live session, delegates will be expected to work through a self-study gap task to enhance their knowledge and understanding of Marty and how it can be used in their setting. During the course, Kevin Reid (Digital Skills Education Manager) will be available for support and can be contacted via chat, email or video calls. This course will also be run in partnership with Robotical, the company behind the creation of Marty, with Ben Henderson and Finlay Page supporting throughout.
T6	S3 and S4	At [our schools] we are all Level 1 Google Educators and received support for this from a mentor in a local learning community school who worked for [our local authority]. [Our local authority] has a range of training videos on all areas of ICT on their intranet and they also have a set of STEM ambassadors who deliver training in different Learning Communities. Recently, I have attended two on "Engineering Habits of Mind" and "Introduction to Coding Resources." These were both twilight sessions at [a nearby school], lasting around 2 hours each. We were able to try out different resources and worked through different tasks using Makedo (engineering) and Microbits (coding). Neither course was compulsory. The main reason I attended this course was I knew it was on our [school quality improvement plan] this year. Another colleague has also taken up training offered by SSERC on MARTY. This is full day training at their base in Fife.

Figure 4.9: Teacher Responses

The responses suggest that there is no shortage of optional training opportunities for teachers to help them to enhance their computer science knowledge and lessons. The problem seems to be the lack of time and motivation to take these training opportunities and to the inability to determine which opportunities would be of most benefit.

4.5 Approaches to the Delivery of the Computer Science Curriculum

The results in this section are also intended to be used to answer the research questions "to what extent do teachers in Scottish primary schools feel that they have access to adequate training and resources to deliver the computer science curriculum" and "what does computer science provision in Scottish primary schools involve?"

It was thought that it would be interesting to consider the different approaches towards the delivery of computer science lessons in schools. How does the use of technology help to deliver the computer science curriculum? Could computers become a distraction? How do commercially available tools help?

Teachers were asked, "Does the use of technology in schools help or hinder the progress of learners overall? Can computer science be taught without computers and what do you see as the advantages and disadvantages of this?" The responses are listed below:

Teacher	School	Response
T1	S1	I think technology definitely has a place in education especially as I have stated, for those children who find the physicality of writing tricky. This makes their lives so much easier. I don't think computer science can be taught without computers as children need to experience these skills for themselves and be able to develop them at their own pace. Plus children use technologies all the time at home (thinking of older children who have phones, iPads etc.) You learn what you live and often the children can teach the teacher a thing or two – speaking from my own experience as although I have a reasonable knowledge on the use of word/excel/ppt which I use every day, some other packages iMovie etc. the children are more advanced in their abilities than I am.
T2	S2	Use of tech in schools is a huge help to learner. Supports ASN, supports a sustainable approach, offers extension + challenge. Integral part of current education systems. You can certainly introduce computer science without tech but to develop and engage - pupils like to see an outcome that they can engage with.
T3	S2	In general technology helps in the learning for all within primary schools. With the novelty factor having gone for almost everyone, most children use IT as a learning tool and not a distraction. I think some of the basic concepts of computer science may be introduced without tech to progress and engage the learner then the tools are essential.
T4	S3	Technology is in constant use in my classroom alongside more traditional methods of teaching. I believe there is still a place for both. However, it is important to adapt to the world around you and to prepare learners for learning and life outwith the classroom where technology features so heavily. As previously mentioned currently all learners have their own chrome book but I have also taught successfully computer science where pupils had to share resources or even watch demonstrations then have a follow up task on paper while they waited for a shot on the 1 computer available to the whole class – not easy but can be done!
T5	S3	I believe that the use of technology in [our school] enhances the learners experiences and ensures that they are engaging with lesson content appropriate to their age and stage. It would be impossible for one teacher to direct a lesson which incorporated all stages at once, particularly in terms of numeracy and literacy levels. As highlighted previously, Google Classroom and the provision of other resources which engage learners at their own level, is vital within a multi-composite setting. I believe that elements of computing science could be taught without computers, particularly thinking about computational thinking processes in relation to sequences and steps in every day tasks. However, in my opinion, the relevance of this only truly falls into place when learners can apply this skill e.g. when exploring and coding real programmable devices.
T6	S3 and S4	I use technology daily in all curricular areas. Google Classroom and associated apps has been a gamechanger for learners of all abilities, as well as helps with classroom organisation. You can have some groups working on a digital task while you are direct teaching with others. Specialised apps are particularly useful for children with learning difficulties. Also. As children are exposed to so much technology at home nowadays, many require it to stay engaged with learning. It really helps bring your lesson alive, e.g. using beebots for directions, jamboards for collaboration etc. I think a lot of computational thinking can be done without computers. An example of this is P3 made a set of "If and Then" statements relating to a board game they made. Also the use of and creation of keys in Science for classification purposes. However, I think using computers for this purpose makes learning more real for the children.

Figure 4.10: Teacher Responses

It is clear that technology has become an important part of classroom life and is used daily. It can be very useful for enhancing learning and is not generally seen as a hindrance to learning or a distraction in the classroom. Whilst most teachers believe that devices are not essential when teaching basic computer science concepts, they believe that they enhance the experience for the pupils by allowing them to see concepts put into practice.

Teachers were also asked, "How do commercially available software packages affect the delivery of computer science education?" The responses are listed below:

Teacher	School	Response
T1	S1	This can depend on whether there has to be a subscription or not. It also depends on the GDPR of the app/software and if it is compliant with [local authority] guidance. Some which we would like to use are not which can be frustrating. I also think that once you get used to using certain packages such as Scratch etc. then you are more likely to use this more often.
T2	S2	Unsure of quality of commercial goods out there e.g. Scratch, Swift Playgrounds.
T3	S2	There seem to be quite a lot of commercial apps / platforms to help primary school children learn about computer science but it would be very difficult for me to gauge the quality of these 'tools' and if they target the [experiences and outcomes] well.
T4	S3	We are contracted to RM so have limited access to commercially available software. We try and use free software that is approved for use in schools.
T5	S3	Staff at [our school] use Google Classroom every day in order to set tasks for learners who are not being directly taught by the class teacher. It has been a fundamental element in ensuring learners continue to independently engage in age and stage appropriate learning whilst the teacher s directly teach other learners. All teachers at [our school] have gone through Google Educator training Level 1 and have achieved this accreditation. This has allowed them to effectively use this resource daily in class. It is a vital part of our learning within a small multi-composite setting where learners are at a huge range of different levels in their learning.
T6	S3 and S4	We are mostly reliant on free Apps or programmes which [our local authority] have bought in. We definitely need these commercial software packages to support out learning and teaching.

Figure 4.11: Teacher Responses

Teachers do not tend to look for applications to teach computer science themselves but will stick with what they already have access to on school devices and what they are used to. It is difficult to try out new apps as the quality of the different platforms is difficult for teachers to determine and there may be restrictions in place that prevent some applications from being used.

Chapter 5

Discussion

5.1 Interpretation of Results

It is clear from the data that the vast majority of pupils enjoy learning computer science at school. However, the reasons that were given for enjoying computer science were not particularly insightful. This was due to the nature of how the data was gathered; there was not time to look over all the answers that the children came up with and then ask for more detail. As a result, responses included reasons for enjoying computer science such as “it’s really fun” which were not very helpful.

What is, perhaps, unexpected is that despite most children saying that they enjoy computer science lessons, most are either unsure or do not want to study it as a subject in secondary school or embark on a computer science related career. This is concerning as society will need more people to study computer science and work in computing related jobs in the future.

When children did not want to study computer science in secondary school or work in a job related to computers, it was often because they saw the subject as too difficult. More often than not, those who did see the subject as being difficult still enjoyed computer science lessons which was very surprising. It is not clear why this is. Perhaps there are negative stereotypes and beliefs about computer science that children have picked up which they are repeating, despite actually enjoying the subject.

Whilst most realised that learning computational skills could be important for future employment, very few realised that most jobs require computational skills (at least a basic level of digital literacy) and that there are very few jobs that don’t. Only 3 participants said that they thought computational skills were important for life in general which is very concerning as computers have become extremely prevalent and touch many, if not most, aspects of modern life.

Learning to code forms a part of computer science lessons at all the schools involved in this study and this is a key skill in computing so it is unsurprising that this was mentioned at all the schools. Scratch and Micro-bits seem to be the tools of choice for teaching coding. Although coding lessons do take place at all the schools, there seems to be a greater focus on digital literacy and using software, rather than writing software.

Although it is important to learn the basics first, it could be argued that more time spent on learning to code would be beneficial as the ability to write code is becoming more and more important to employers and starting to learn this earlier will become increasingly important.

There is a lack of consistency in the skills that are taught and the quality of computer science lessons across schools and teachers. There is also inconsistency in the resources that are available in different schools with some having one device per pupil and others having to share devices. Internet connectivity is also patchy for some. A greater understanding of the difference between computational skills and digital literacy would be beneficial and a clear idea of which skills should be the focus.

There are many apps for teaching computer science and training opportunities for teachers but it can be unclear which opportunities to take, apps may be restricted by local authority rules and teachers may not have the time or interest in researching these. Training opportunities tend to be optional so teachers may believe that it is worth focusing on other priorities instead. This leads to a great inconsistency with some teachers delivering high quality computer science lessons whereas others avoid computer science where possible as they are concerned that they may not be teaching it properly.

Technology is well established in the classroom and is relied upon for daily activities. It is generally seen as a positive tool and is seen as vital if children are to grasp the concepts taught in computer science lessons. Teachers are not too concerned that devices may be a distraction to learning; they once were when they were first introduced but are now seen as a learning tool. A potential concern that was identified, however, is that schools could become too reliant on IT and struggle to function without it in the event that devices break or malfunction. It was concerning that some of the children involved in the research were not used to writing with pencil and paper and relied upon typing or having their responses written by a scribe. Whilst learning IT and computer science skills are important, this should come second to learning to read and write. It is understandable that those with Dyslexia or similar may find it easier to type on a laptop but this should not be the default and it was discussed at one of the schools how children often struggle when arriving at secondary school where there are not enough resources to provide one laptop per pupil and they are not used to writing on paper.

5.2 Wider Implications

It is important that teachers have a clear understanding of what computer science skills should be taught in schools so that children are prepared for further study and work that relies upon these skills. To encourage more learners to take computer science further in secondary school and beyond, it is important that they enjoy learning computer science - which they clearly do - but also that they see the value of it - which is not always the case.

Ensuring that schools are well resourced (with enough devices, access to software and strong internet connectivity) is important to ensure that schools do not get left behind and are able to teach the skills that are necessary for the future. Access to modern, up-to-date technology allows learners to see computer skills in action and helps to cement their understanding of computational constructs. It is important that children also learn, and are used to, the tradition of writing on paper and reading physical books as well and it is important and healthy to live without and minimise screen time for at least some of the school day.

5.3 Limitations

The sample size was relatively small and only took in four schools from two local authority areas. Whilst some overlap in the types of responses across schools and areas would suggest that the results give a good picture of primary schools across Scotland, taking in more schools in different parts of the country and would give a clearer picture by increasing the reliability of the data.

Due to the nature of gathering data from the children - asking them survey questions - there was not the time to follow up on their responses and get more detailed answers as time in the schools was limited and class sizes were often large. This meant that the responses often provided little more than yes/no data because reasons for enjoying computer science lessons such as “it’s fun” are not particularly meaningful.

The schools were rural schools and in areas with a Scottish Index of Multiple Deprivation (SIMD) which was at least 5 in all cases and at least 7 for three out of the four schools which suggests that key statistics regarding employment, health, crime and housing are positive overall in these areas. This is not a good representation of the country as a whole and a future study should look at schools in a wider range of areas.

At a high level, the aim was to find out which factors influence a child’s decision to take the study of computer science further. This study did not take demographic factors into account. One direction that this could have been taken in would have been to look at data regarding a child’s background (such as SIMD data, age and profession of parents, race, religion, gender, etc.) and link this to outcomes (such as the child’s subject choices in secondary school, exam results, further and higher education, career, etc.) This, however, is not the direction undertaken by this project due to the difficulty involved in collecting this data (much of it is highly sensitive and difficult to accurately collect, especially if we were to look at how current adults have been affected by these factors when in primary school which would have been many years ago).

Chapter 6

Conclusions and Bibliography

6.1 Findings

Responses to survey questions were gathered from teachers and pupils in primary schools across Scotland to gauge their experiences and opinions of computer science provision in their schools. The shape of computer science lessons (such as what skills are taught and whether there were enough resources provided) was considered as well as pupil attitudes towards learning computer science.

The key findings are listed below as answers to the original research questions:

To what extent do pupils in Scottish primary schools enjoy computer science lessons?

Most children (83%) enjoy computer science lessons. I would suggest further research to determine why children enjoy them and what parts of computer science they particularly enjoy. This could potentially mean that the less enjoyable parts could be improved.

To what extent do pupils in Scottish primary schools see the importance of learning computational skills?

More than half of children (63%) recognised the importance of computer skills for the world of work, although only 6 stated that most jobs require these skills, rather than just "lots" of jobs or "some" jobs.

Only a minority of children (24%) see themselves working in a job related to computers in the future.

Only one child thought that learning computational skills was unimportant.

To what extent are pupils in Scottish primary schools keen to pursue computer science further?

48% do not see themselves choosing to study computer science as a secondary school subject. 37% of children do see themselves choosing to study computer science as a secondary school subject and the rest are unsure.

Additionally, most children (52%) do not see themselves working in a job related to computers and half of the remainder are unsure.

To what extent do teachers in Scottish primary schools feel that they have access to adequate training and resources to deliver the computer science curriculum?

There are a wide range of resources and training opportunities available for teachers to improve their delivery of the computer science curriculum. Training is optional so is only accessed by teachers who are particularly passionate about computer science and it is difficult to know which opportunities are relevant and to fit this in as teachers have limited time.

Teachers will use software that they have easy access to and that they are used to when teaching computer science. They may not have access to the software they want to use due to restrictions and, on the contrary, they may not be aware of all the different apps available to them.

What does computer science provision in Scottish primary schools involve?

Although skills such as coding are taught, there is a far greater focus on digital literacy - i.e. basic IT skills - than there is on computational constructs. It is not clear if teachers and pupils know the difference between the two and this could perhaps be addressed in the training as mentioned above. Tools such as Scratch and Micro-bits are used and IT skills such as creating presentations and online safety are taught.

The use of digital technology in the classroom is definitely seen as benefiting learners overall and is essential for teaching computer science well as it allows children to see theoretical computational constructs in action. Devices such as iPads and Chromebooks are used with some schools having enough of these devices to provide one per pupil.

6.2 Suggestions

- Computer science lessons should have a bigger focus in the curriculum. Teachers, pupils and parents should understand its importance so that they are motivated to ensure it is given as much attention as other subjects may be getting and so that pupils are more likely to take if further and schools are more likely to provide opportunities for them to do this.
- Further research to determine why children don't particularly want to pursue computer science further yet enjoy computer science lessons overall. This may be because computer science is seen as a difficult subject or that these children already have another career in mind. Perhaps attitudes about computer science being a complicated subject, only for the very brightest, need to be changed by persuading parents and learners that the subject is both important and something that is no more difficult than mathematics, for example.
- A better understanding of what skills are important to focus on is required. I would suggest that more guidance is provided by the education authority to teachers of what is expected which could included suggestions of which software applications and resources can be used to teach each learning outcome and examples of what this might look like. Official, compulsory training courses should be provided to all primary school teachers that are required to teach computer science to

ensure that they are confident in doing so and that the standard is consistent across schools.

- There needs to be a greater focus on underlying computational constructs but not at the expense basic IT skills.
- Local authorities, perhaps with help from the Scottish Government, should look at how this can be improved and ensure that rural schools are not subject to temperamental internet connectivity. Schools should not become overly reliant on technology, however, and it is important that children learn to work and learn with books and paper as well as with websites and word processors.

6.3 Reflections

Whilst the project was a success overall, with all the stated aims met, here we consider how it could have been done differently or improved if a similar study were to be carried out again.

The first thing that could have been improved was the survey question design. The questions could have been split into more specific sub questions or worded better to yield better quality answers from respondents. This is especially the case for the pupils were asked as answers were rather vague in some cases. This is also the case for the teacher responses as well, however, as some teachers wrote much more than others and it is unclear whether the questions were fully understood in some cases - i.e. it was unclear whether teachers differentiated between the digital literacy and computer science and whether each question referred to computer science lessons or technology in a school setting in general.

The workshop that was delivered to classes alongside the research could also have been improved. An off the shelf workshop may have saved the time that was spent creating one and a workshop that used computers, rather than being unplugged, would have been better. It was thought that such an approach would be impractical due to differing access to devices in schools but more communication before the visits may have allowed for a solution.

Perhaps the biggest change that could have been made would have been to involve more schools. As discussed in the previous chapter, involving a greater number of participants across schools in different sorts of places (urban, rural, etc.) would ave given a far more accurate picture. Although there was a limited amount of time for the study, there was scope for more schools to be included as more schools could have been contacted.

6.4 Final Words and Bibliography

This has been an insightful study into the current state of computer science provision in Scottish primary schools and the factors that affect this. As discussed in the previous chapter, future studies could be carried out to get a clearer picture but this project on its own provides some useful and achievable suggestions for how computer science education can be improved so that Scotland has the skills it needs for an increasingly digital future.

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Appendix A

Parental Participant Information Sheet

Participant Information Sheet – for parents and guardians

Project title:	Understanding the Factors That Affect Computer Science Primary Education Provision in Scotland
Principal investigator:	Dr. Fiona McNeill, Reader in Computer Science Education, School of Informatics, University of Edinburgh
Researcher collecting data:	Mr Lloyd Dixon, Student, School of Informatics, University of Edinburgh

This information sheet is for parents and guardians. It explains the research project at the University of Edinburgh, in which we would like your child to participate. It gives information about the project in the form of questions you might have and their answers. If you have further questions, we are happy to discuss them and give you more information.

This study was certified according to the Informatics Research Ethics Process. Please take time to read the following
information carefully. A shortened version of this information will be given to your child should you agree to their participating in the project. You should keep this page for your records.

Who are the researchers?

The research is being carried out by Lloyd Dixon, a final year computer science student at the University of Edinburgh, as part of his honours project. The project is being supervised by Dr Fiona McNeill, Reader in Computer Science Education at the School of Informatics, University of Edinburgh. Both can be contacted by email using l.g.dixon-1@sms.ed.ac.uk and f.j.mcneill@ed.ac.uk.

What is the purpose of the study?

The aim of the project is to gain an understanding of computer science provision in primary schools. I will look at the challenges affecting this, as well the factors that enhance it. The research is in no way intended to assess schools on their computer science provision but rather to hear the views of children regarding computing and the factors that influence a school's ability to deliver CS provision.

How can my child help?

To get a feel for children's attitudes towards and experiences of computer science at school, we are asking senior primary school children to provide written answers to a short questionnaire.

Does my child have to take part?

No – participation in this study is entirely up to you and your child. You can withdraw your child from the study at any time, without giving a reason. Your child may also withdraw at any time by saying that s/he does not want to take part anymore. Your rights will not be affected. If you wish to withdraw, contact either Lloyd Dixon or Fiona McNeill. We will stop using your child's data in any publications or presentations submitted after you have withdrawn consent. However, we will keep copies of consent forms, and of your withdrawal request.

What will happen if my child takes part?

We will collect the child's written responses to the research questions asked during the session. These response sheets will be anonymous. The research will take place alongside a computation skills workshop. Any child who does not consent (or does not have parental consent) to take part in the research can still engage in the workshop without participating in the research element.

Are there any risks associated with taking part?

There are no risks associated with participation.

Are there any benefits associated with taking part?

Children will be able to benefit from a fun and engaging computational skills workshop and can ask questions about computer science as well as what it is like to study it at university. This applies regardless of participation in the research element.

What will happen to the results of this study?

The results of this study will be used as the basis for an undergraduate dissertation. The results may additionally be summarised in published articles, reports and presentations. Quotes or key findings will be anonymized: we will remove any information that could, in our assessment, allow anyone to identify your child. With your consent, information can also be used for future research. Anonymised data may be archived for a minimum of two years.

How will personal information be protected?

Your child's data will be processed in accordance with Data Protection Law. All information collected about your child will be kept strictly confidential. Your child's data will be referred to by a unique participant number rather than by name. Your child's data will only be viewed by the research team.

All paper records will be stored in a locked filing cabinet in the PI's office. Your consent information will be kept separately from your child's responses in order to minimise risk.

What are my and my child's data protection rights?

The University of Edinburgh is a Data Controller for the information you and your child provide. You have the right to access information held about your child. Your right of access can be exercised in accordance Data Protection Law. You also have other rights including rights of access, correction, erasure and objection. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit www.ico.org.uk. Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer at dpo@ed.ac.uk.

Who can I contact?

If you have any further questions about the study, please contact the lead researcher, Dr Fiona McNeill using f.j.mcneill@ed.ac.uk.

If you wish to make a complaint about the study, please contact inf-ethics@inf.ed.ac.uk. When you contact us, please provide the study title and detail the nature of your complaint.

Updated information.

If the research project changes in any way, an updated Participant Information Sheet will be made available on http://web.inf.ed.ac.uk/infweb/research/study-updates.

Alternative formats.

To request this document in an alternative format, such as large print or on coloured paper, please contact Lloyd Dixon using L.G.Dixon-1@sms.ed.ac.uk.

General information.

Once again, **this study is completely voluntary and you and your child are under no obligation to take part.** Even if you say yes now, you may withdraw your child from the study at any time and for any reason by contacting us. Your child may also withdraw at any time by say that s/he does not want to take part anymore.

For general information about how we use your child's data, go to: edin.ac/privacy-research

Thank you for taking the time to read this.

Appendix B

Child Participant Information Sheet

Participant Information Sheet

Project title:	Understanding the Factors That Affect Computer Science Primary Education Provision in Scotland
Principal investigator:	Dr. Fiona McNeill, Reader in Computer Science Education, School of Informatics, University of Edinburgh
Researcher collecting data:	Mr Lloyd Dixon, Student, School of Informatics, University of Edinburgh

Understanding the Factors That Affect Computer Science Primary Education Provision in Scotland

This page is for children. Some researchers are organising a **study at the University of Edinburgh**. It says who they are, and what they will do **during the study.**
They will ask you to help by answering a few questions. You can decide if you want to say "yes" or "no" to helping, and can **change your mind at any time**.

Who is organising the study?

These are the researchers. Their job is to find out a bit about what it's like to learn computer science in primary schools across Scotland. They will ask you to help by answering a few questions.

	
Lloyd	Fiona

How can I help?

THE UNIVERSITY *of* EDINBURGH
informatics

The goal of the project is for us to find out a bit about what it's like to learn computer science in primary schools across Scotland. We will have a bit of fun, learning about computers and how they work and ask a few questions to find out what you think of computer science lessons in school. We'll ask you to write down your responses to the questions so that we can look at all the responses from different schools at a later date. There are no right or wrong answers to the questions.

What will happen if I help?

We will collect your answers to the questions we ask and use these to help with our research. We will take great care with your pieces of paper by storing them securely. We won't be taking your name or any other personal details so nobody will know who has written what. We will keep your responses for two years but will get rid of them after that.

You can tell us if you want to stop doing any of the activities. You do not have to tell us why. Please tell us if you need the toilet, or if you want to take a break. You can also say you do not want to help any more, and that is OK. We will always listen to you.

What will happen after I have finished helping?

The researchers will learn a lot about what children think about computer science lessons from your answers to the questions. They will write about what they have learned, and use it to increase our understanding of computer science lessons in Scottish primary schools.

Do you want to ask a question?

It is OK to have more questions. You can ask the researchers as many questions as you want about the experiment. Ask your teacher or mum or dad to help you write an email with your question.

Appendix C

Parental Participants' Consent Form

Child's Name:________________

Participant Consent Form – for parents and guardians

Project title:	Understanding the Factors That Affect Computer Science Primary Education Provision in Scotland
Principal investigator:	Dr. Fiona McNeill, Reader in Computer Science Education, School of Informatics, University of Edinburgh
Researcher collecting data:	Mr Lloyd Dixon, Student, School of Informatics, University of Edinburgh

Please carefully read the following five statements then circle 'Yes' if you agree to these or 'No' if you do not:

1. **I confirm that I have read and understood the Participant Information Sheet for the above study, that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.**
2. **I understand that my child's participation is voluntary; that my child can withdraw or I can withdraw my child at any time without giving a reason. Withdrawing will not affect any of my or my child's rights.**
3. **I consent to my child's anonymised data being used in academic publications and presentations.**
4. **I understand that anonymised data can be stored for a minimum of two years**
5. **I agree to my child taking part in this study.**

I agree to the above five statements (please circle): Yes No

If you **give permission** for this study, please fill out the sections on the next page and **return this form to the researchers**.

If you **DO NOT** wish to give permission, **you do not need to do this**. We will not ask your child to participate

Child's Name:_______________

Full name of participating child: ______________________________

Child's date of birth (DD/MM/YYYY): ______________________________

Your relationship to the child: ______________________________

Your name (please print clearly): ______________________________

Contact telephone number: ______________________________

E-mail address: ______________________________

Signature: ______________________________

Date (DD/MM/YYYY) ______________________________

Name of person taking consent	Date dd/mm/yyyy	Signature

Appendix D

Child Participants' Consent Form

Project title:	Understanding the Factors That Affect Computer Science Primary Education Provision in Scotland	Name:		Date:	

Child Consent Form

Do you want to answer a few questions for us? You can say "yes" or "no". It is OK to say "no". It will not hurt the researchers' feelings. We will also be asking you parents if they are happy for you to take part.

- I can choose to write down my answers to the researcher's questions.
- I do not have to help if I don't want to.
- I can stop taking part or take a break if I want to. I do not have to say why.
- It is OK if I change my mind later, and say I don't want to help any more.
- It is OK if some activities are hard for me!
- There are no wrong answers to questions.
- Anything I can do is helpful.

Do you want to take part by answering a few questions for us

Yes	**No**

Write your name: ______________________ And age ______________

THANK YOU!

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